SC&A S. Cohen & Associates
An Employee-Owned Company

May 5, 2008

Mr. David Staudt
Center for Disease Control and Prevention
Acquisition and Assistance Field Branch
Post Office Box 18070
626 Cochrans Mill Road – B-140
Pittsburgh, PA 15236-0295

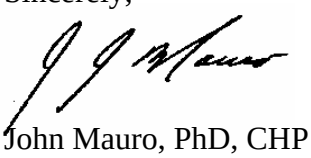
Re: Contract No. 200-2004-03805, Task Order 1: Transmittal of a letter report entitled, *A Draft Report for Consideration by the Advisory Board regarding the Closeout of Findings from Selected Site Profile Reviews*

Dear Mr. Staudt:

SC&A is pleased to submit to NIOSH and the Advisory Board its draft report, *A Draft Report for Consideration by the Advisory Board regarding the Closeout of Findings from Selected Site Profile Reviews.*

We would be pleased to discuss the report with NIOSH and the Board at your earliest convenience. If you have any comments or questions, please contact me at 732-530-0104.

Sincerely,



John Mauro, PhD, CHP
Project Manager

cc: P. Ziemer, Board Chairperson
Advisory Board Members
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Project File (ANIOS/001/30)

A DRAFT REPORT FOR CONSIDERATION BY THE ADVISORY BOARD REGARDING THE CLOSEOUT OF FINDINGS FROM SELECTED SITE PROFILE REVIEWS

Prepared by
SC&A, Inc.
May 5, 2008

In accordance with direction provided by the Advisory Board during the full Board meeting held in Tampa, Florida on April 7–9, 2008, SC&A investigated the feasibility of streamlining the closeout of findings in selected site profile reviews. During previous Advisory Board meetings, the Board and SC&A expressed concern that several draft site profile reviews that have been completed and delivered to NIOSH and the Board had not yet entered the issues resolution process nor had been assigned to a working group because of more pressing matters. One method suggested by SC&A to help expedite the closeout process for these site profile reviews and their associated findings is to determine which of the findings may have already been addressed or are in the process of being addressed in other venues, such as the issues resolution process for other site profile or SEC petition reviews, procedure reviews, and/or dose reconstruction reviews. In addition, some findings might be readily resolvable and/or have relatively modest dosimetric implications. As such, the resolution of these types of findings may only require a modest level of effort by SC&A, NIOSH, and the Board. This report identifies findings in eight site profiles reviews that SC&A considers candidates for expedited resolution, based on one of a number of criteria presented below.

Background

As of May 7, 2008, 28 draft site profile reviews have been prepared by SC&A and delivered to NIOSH and the Board or are currently in preparation. For the purposes of this report, it is convenient to sort these reports into the following categories:

- All work completed
- Draft reports delivered to NIOSH and the Board that are undergoing active issues resolution
- Draft reports delivered to NIOSH and the Board, but the issues resolution process has not yet begun
- Draft reports still in preparation at SC&A

The following table sorts the site profile reviews into these four categories. The nine site profile reviews listed in column 3 are the subject of this report.

Table 1. Categorization of Site Profile Reviews

All Work Completed*	Draft Reports Delivered and Undergoing Active Closeout	Draft Reports Delivered but Closeout has Not Yet Been Initiated	Draft Reports Being Prepared by SC&A
Bethlehem Steel	Savannah River	Idaho National Laboratory	Argonne National Laboratory-East
Mallinckrodt	Hanford	Los Alamos National Laboratory	Sandia
Iowa Army Ammunition Plant	Nevada Test Site	Oak Ridge National Laboratory	Weldon Springs
	Y-12	Paducah	Santa Susana
	Rocky Flats	K-25	
	Fernald	Lawrence Livermore National Laboratory	
	Mound	Pantex**	
	Linde	Portsmouth	
	Pinellas	Argonne National Laboratory –West	

* At any time, the Board at its discretion can initiate further investigations on any of these site profile reviews.
** Pantex is not explicitly included in this analysis at this time because it is undergoing review.

For completeness, it should be noted that SC&A has completed and delivered to NIOSH and the Board three special AWE site profile-type investigations, including TBD-6000 (a generic TBD dealing with uranium metal processing), Appendix BB to TBD-6000 (i.e., General Steel Industries and the betatron issue), and TBD-6001 (a generic TBD dealing with chemical processing of uranium ore and uranium). This work began under Task Order 3, was completed in draft form and delivered to NIOSH and the Board under Task Order 1, and the closeout process is about to begin under the direction of the procedures working group (Task Order 3), chaired by Ms. Wanda Munn.

There are a number of reasons for initiating this attempt to expedite the closeout process for the nine site profile reviews identified above in column 3. First, many of the site profile reviews have been held in abeyance for an extended period of time, awaiting Board review. In addition, the period of performance of SC&A's contract is coming to an end on October 1, 2008. Hence, it would be desirable to close out as many issues as possible before the end of this contract. In addition, substantial resources ($61,100 for each site profile review) have been set aside specifically to support the closeout of the nine site profile reviews. This budget was established based on experience gained in the closeout process for work completed through fiscal year 2007. Since that time, we have gained substantial experience in issues resolution, and it is appropriate to revisit the resources that might be needed to close out these site profiles. In addition, if a significant portion of the findings associated with these nine site profile reviews can be expeditiously resolved or assigned to a lower priority, some these resources could be made available to support the Board in other matters, such as new SEC petition reviews.

Suggested Criteria for the Classification and Disposition of the Findings

In the sections that follow, an attempt is made to assign each finding to one of the following five disposition classes.

(1) Closeout cannot be expedited because the issue is unique to the site, has potentially significant dosimetric implications, and experience gained from other site profile reviews would have limited applicability to the issue under consideration. The resolution of findings assigned to this category is anticipated to require a concerted effort by NIOSH, SC&A, and the Board, because they often deal with the completeness and adequacy of the records for use in dose reconstruction and developing coworker models.

(2) The basic issue has been or is in the process of being resolved in other venues. Findings assigned to this category may be of dosimetric importance but, since they are being addressed (at least in principle) in other venues, the level of effort required for their resolution in new site profile reviews should be reduced. Examples are issues related to the insensitivity of NTA film to neutron energies below 1 MeV, and lower limits of detection. Neutron-to-photon ratios may belong in this category if a general approach to when they can and cannot be used can be worked out. The Board may want to defer issue resolution to address the concern until after NIOSH has revised its site profile and/or exposure matrix.

(3) The issue is of generic concern and is being (or has been) addressed by NIOSH as a global issue, or might be best addressed as a global issue. Examples include issues related to highly insoluble ("Super S") plutonium, oronasal breathing, and ingestion of radionuclides when air concentration data are used to assess intakes.

(4) The issue is of relatively low significance dosimetrically, and its resolution might best be addressed during the next revision cycle for a given site profile. Examples include findings pertaining to clarification of the site profile and, in many cases, issues related to occupational environmental dose. The Board may want to defer issue resolution until after NIOSH has revised its site profile and/or exposure matrix to address the concern.

(5) The issue is dosimetrically significant, but should be readily resolvable because the data are available and appropriately conservative assumptions can be developed. Examples of findings that fall into this category include occupational medical doses and application of coworker models to different groups of workers (e.g., using the 95^{th} versus the 50^{th} percentile values for workers with routine and occasional exposure potential, respectively, and chemical form of the radionuclide). In some of these cases, a revision of the site profile may be needed, and in such cases, the Board may defer resolution of this issue until NIOSH has completed the revision of the site profile and/or exposure matrix.

For findings that SC&A has assigned to categories 2 through 5, there will likely be a need to discuss whether the Board and NIOSH concur with the finding, its categorization, and how it would, in fact, be addressed for the particular site profile under consideration. Hence, we believe that work still needs to be done with regard to such findings, but their resolution might be accomplished in an expedited manner.

It is also possible that some of the findings can be eliminated because NIOSH has already revised the site profile or plans to revise the site profile to address the issue. However, this determination will need to await NIOSH's review of this report and their formal disposition of pending issues. It should also be noted that only the Board is able to close out pending issues based on NIOSH's response. Some findings may also be partly or fully eliminated, because the issue was rendered moot by granting an SEC.

Conclusions

Should the Board concur with the basic categories and assignments made regarding each finding, we believe that the resources required to complete the closeout of the issues identified for these nine site profile reviews will be substantially less than originally anticipated. Specifically, we originally allocated $61,100 for the closeout of each site profile review, or a total of $549,900 for the closeout of all the issues associated with the nine site profile reviews.[1] We estimate that should this proposed strategy or some modification of this strategy be accepted by the Board and implemented, the issues resolution process might be achievable with about half of the resources currently allocated. However, SC&A notes that, in some cases, the approach defers rather than avoids consideration of issues, since the Board may want to revisit these issues after NIOSH has revised its site profile, especially if significant differences that affect dose reconstruction remain.

[1] This analysis did not explicitly address the site profile review for Pantex. However, based on the reviews of the other eight site profiles, we believe that the issues resolution process for the Pantex site profile would benefit from this process in a similar manner as the eight site profile reviews explicitly addressed in this report.

ARGONNE NATIONAL LABORATORY-WEST

Table 2 presents SC&A's consideration of the findings and observations associated with its review of the site profile for ANL-W. Of the 26 findings and observations, only 6 are assigned to category 1 and are anticipated to require considerable attention by NIOSH, SC&A, and the Board. In the opinion of SC&A, the other issues are either readily resolvable, have been resolved, or are being addressed under other venues.

Table 2. Argonne National Laboratory-West

Finding	SC&A Suggested Action for the Board to Consider	Suggested Disposition Category
Introduction The Introduction describes the purpose and scope of the ANL-W Site Profile. SC&A has no findings or observations regarding information provided in TBD-1.	No action required	NA
Site Description There is a need to include building schematics and basic design features of individual facilities that were operational in the 1950s and 1960s. A more detailed map of the ANL-W facilities is needed. TBD-2 provides insufficient data regarding number of personnel assigned to any given facility during the years of operation.	No action required	4
Occupational Medical Dose The frequency of occupationally related x-ray exams assumed in TBD-3 may underestimate the actual frequency of such exams for workers at ANL-W. NIOSH's assumption that photofluorographic (PFG) exams were not conducted in behalf of ANL-W workers lacks supportive evidence and is not claimant favorable.	This is a recurring comment with which NIOSH will concur or provide a basis upon which to take exception to the default guidance provided in OTIB-0006.[2] It is worth noting that NIOSH reissued TBD-3 on July 30, 2007.	5

[2] The information in the issues matrices presented here were copied directly from reports previously submitted to the Advisory Board or specific Work Group. Documents referenced in each of these tables, therefore, can be found in those documents. A separate reference section is not provided with this report.

Occupational Environmental Dose (1) For assessing environmental releases at the site, NIOSH primarily used data contained in a 1991 study entitled *Idaho National Engineering Laboratory Historical Dose Evaluation* (INELHDE) (DOE 1991). SC&A questions the completeness and accuracy of the INELHDE data and its use in TBD-4. (2) In 2003, SC&A and SENES Oak Ridge, Inc., critically reviewed INELHDE source terms, atmospheric dispersion models, and doses to the public from atmospheric releases associated with the Aircraft Nuclear Propulsion (ANP) Program and the Idaho Chemical Processing Plant (ICPP). This reassessment showed that for ANP emissions, the original INELHDE reported source terms may have been substantially underestimated. However, NIOSH did not acknowledge or consider the more recent data contained in this re-evaluation of the INELHDE. (3) NIOSH uses a mesoscale trajectory computer model for estimating atmospheric dispersion of radioactive releases. SC&A questions whether this model is appropriate for assessing onsite worker exposure. (4) SC&A considers NIOSH's selection of radionuclides for estimating onsite environmental doses from **operational** releases (chronic) to be incomplete and claimant unfavorable. (5) SC&A considers NIOSH's selection of radionuclides for estimating onsite environmental doses from **episodic** releases to be incomplete and claimant unfavorable. (6) The use of INELHDE data for assessing environmental doses to workers is technically incorrect at two levels. The first error involves NIOSH's assumption that only 9 of the 108 episodic releases were considered to impact the EBR-I facility. The second deficiency involves the omission of radiological events that occurred at the EBR-I location. (7) SC&A questions whether the INELHDE **fenceline dose model** used for dose modeling of onsite locations properly accounts for the reduced radioactive decay for short-lived radionuclides. (8) SC&A believes that the external environmental dose model for ANL-W facilities is based on erroneous and unsupported assumptions. As an example, NIOSH considers the extrapolation of **post**-operational fenceline data adequate and claimant favorable for estimating environmental doses for operational periods, when no monitoring was performed.	These findings are unique to ANL-W and INL in general and will need to be addressed by NIOSH. However, the dose implications are likely to be relatively small and therefore might be of substantially less concern than those associated with occupational external and internal doses. We believe that these issues should be readily resolvable during the next revision cycle of the site profile.	4

Observations: (1) The occupational environmental dose model in TBD-4 does not address intakes from resuspension of ground contaminants or fugitive emissions from contaminated wastes. (2) TBD-4 provides only a brief discussion of uncertainty for estimating occupational environmental doses for operational and episodic releases. SC&A considers this guidance to be less than adequate. The INELHDE report made assumptions regarding environmental releases from the Naval Reactor Facility (NRF) that were not based on actual data (actual data were classified at the time). In 2004, the NRF environmental release and emissions data were made available to INEEL; however, at this point in time, NIOSH has not revised their dose estimates using this newly released data.		
Occupational Internal Dose (1) Section 5.1.4 *Radioactive Nuclides of Concern and Solubility* of TBD-5 contains incorrect statements, assumptions, and recommendations. For example, SC&A considers NIOSH's list of "radionuclides of concern" to be incomplete and too restrictive. We also contest NIOSH's statement implying that the only soluble radionuclide of concern is Sr/Y-90. (2) Air-sampling data for use in dose reconstruction is misrepresented and misused. As an example, SC&A does not consider the use of a single set of fixed air-sampling data associated with highly controlled locations (i.e., limited contamination levels) as appropriate data for other facilities that operated at very different time periods. (3) SC&A finds the type and frequency of bioassay monitoring of ANL-W workers to be less than adequate for detecting and quantifying the presence of a large and variable mixture of radionuclides present at the site. (4) SC&A believes that the default intake values for missed dose cited in Table 5-12 of TBD-5 may underestimate body burdens and internal doses, and may be inappropriate for select cancer sites.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution.	1
Occupational External Dose (1) SC&A questions NIOSH's use of a minimum reporting level (MRL), as opposed to the use of a minimum detectable level (MDL), which is used at all other DOE facilities. For example, TBD-6 cites a MRL value of 10 mrem for a film dosimeter deep dose, which is a factor of 4 lower than the MDL value of 40 mrem cited by other DOE facility site profiles.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution. However, all but three of these issues have been or are being addressed under other venues (such	Items (1) through (3), item (5), item (6) and item (8) to be assigned to category 2. However items (4), (7) and (9)

(2) The guidance for deriving missed beta dose does not include the contribution of penetrating radiation to the skin and, therefore, underestimates the skin dose. (3) SC&A contests the assumption that the nuclear track emulsion, type A (NTA) dosimeter is sufficiently accurate and complete for use in reconstructing neutron doses. (4) TBD-6 lacks any data that would provide a timeframe regarding when NTA film was used for monitoring workers at ANL-W. (5) Documentation reveals that the assignment of NTA dosimetry to workers was limited and film badges were not routinely read. (6) NIOSH has inaccurately characterized the NTA dosimeter. First, their use of a 400 keV threshold energy for neutrons is unrealistic. It is generally accepted that the threshold energy for neutrons is about 1 MeV. Second, their use of an MRL value of 14 mrem must be questioned when compared to a MDL value of 80 mrem cited in the Hanford Site Profile. (7) NIOSH's assumptions regarding facilities with potential neutron exposure are inappropriate and exclude 9 reactors that operated in the 1950s and 1960s. (8) TBD-6 provides conflicting statements regarding the angular dependence of neutron dosimeters. (9) In 1976, neutron albedo dosimeters were introduced at ANL-W. Because neutron energy spectra are highly variable and facility-specific, a Facility Neutron Correction Factor (FNCF) must be applied to the albedo badges. However, SC&A finds the FNCF values to be incomplete, since they were based on a single timeframe as reported in 1981.	as the Hanford site profile and SEC petition reviews). Hence, though they require a response by NIOSH, their resolution should be readily achievable. However items (4), (7) and (9) are unique to the site, are potentially important dosimetrically, and will require special attention.	should be assigned to category (1)

IDAHO NATIONAL LABORATORY

Table 3 summarizes each of the findings contained in SC&A's site profile review. Note that out of the 11 findings plus 10 opportunities for improvement (many of which are simply an extension of the 11 findings), 11 were assigned to disposition category No. 1.

Table 3. Idaho National Laboratory

Finding	SC&A Suggested Action for the Board to Consider	Suggested Disposition Category
Finding 1 (Issue 15): SL-1 Accident Dose Reconstructions (Section 5.1.3) – The TBDs do not evaluate the potential missed internal and external doses or the associated uncertainties for the over 1,000 rescue and cleanup workers involved with the SL-1 accident that occurred in January 1961. There was a high potential for significant exposures, because the equipment used and the radiological control policies in place in that era were not as advanced and protective as those in current use. The TBDs should develop adjustment factors related to stay time, dose field estimates, internal dose results, external dose readings, and contamination level estimates. NIOSH did not evaluate potential missed neutron doses for the first responders and rescue workers of the accident.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution.	1
Finding 2 (Issues 29 and 30): Missed Neutron Dose (Sections 5.1.4.2.2 and 5.1.4.2.3) – The TBD presumes that neutron exposures at INL's reactors are not a problem and, therefore, are adequately addressed. But INL had a total of 52 reactors most of which were experimental/ prototype in design, which typically operated with high-power densities and with minimum shielding and neutron moderation. It is, therefore, unjustified to presume that there are no missed neutron doses. In addition, there are deficiencies associated with neutron calibrations. Due to the use of the PoBe source for neutron calibration, dosimeters would significantly under-measure neutron doses from sources with lower energy spectra. NIOSH should re-evaluate the entire approach in the TBD to account for potential missed neutron doses.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1
Finding 3 (Issues 27 and 28): Minimum Reporting Levels (Sections 5.1.4.1.12 and 5.1.4.2.1) – NIOSH does not provide adequate information supporting the use of chosen detection threshold levels to represent the MRL values for gamma film badges and TLDs. Most significantly, NIOSH's approach for determining the MRL values for NTA emulsion film is not thorough and supported. For example, NIOSH uses 10 neutron readings in one data sheet from March 1958 to determine the MRL values for the period between 1951 and 1957, and 6 neutron readings to represent all neutron measurements between 1959 and 1976. Furthermore, the use of MRL/2 as the missed external dose for dose reconstruction per OCAS-IG-001 is not claimant-favorable for claims where the probability of causation value is close to 50%. In addition, NIOSH's MRL values of 14 mrem and 20 mrem appear low and are inconsistent with generic values given for NTA dosimeters, as well as values cited by other DOE facilities with similar neutron source terms and detectors. NIOSH should re-evaluate the MRL values used and provide more supportable default values.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution. However, these issues have been or are being addressed under other venues (such as the Hanford site profile and SEC petition reviews). Hence, though they require a response by	2

	NIOSH, their resolution should be achievable once that response is forthcoming.	
Finding 4 (Issue 17): Penetrating and Non-Penetrating Doses (Section 5.1.4.1.2) – The procedures and algorithms used in the film badge dosimetry service in the early days underestimated the Hp(10) dose, because the low-energy photons reaching the dosimeter were considered beta radiation. Surprisingly, the film service then added this beta dose (to the skin) to the "deep" dose; a practice that is claimant favorable. However, the TBD also correctly requires the dose reconstructor to consider only the "deep dose" as Hp(10), but in doing so, the low-energy photon contribution to Hp(10) is lost. To be claimant favorable, INL calculated the beta dose and the gamma dose, summed these two together, and recorded the result in the worker files as a whole-body dose. The current dose reconstruction process is applying the gamma dose correctly as the effective dose. The problem is that this gamma dose is not claimant favorable, as the information on dose due to low-energy gammas (E < 100 keV) has been lost. NIOSH should re-evaluate the missed gamma dose due to the deficiencies in the procedures and algorithms.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution. However, these issues have been or are being addressed under other venues (such as the Hanford site profile and SEC petition reviews). Hence, though they require a response by NIOSH, their resolution should be readily achievable.	2
Finding 5 (Issue 1): Routine Airborne Releases (Section 5.1.1.1) – For airborne emissions from routine facility operations, NIOSH relies heavily on two previous works: (1) *Idaho National Engineering Laboratory Historical Data Evaluation* (INELHDE, DOE 1991a); and (2) *Identification and Prioritization of Radionuclide Releases from the Idaho National Engineering and Environmental Laboratory*, Final Report (RAC 2002). SC&A found that the source terms provided require improvement for use in determining the worker intake from airborne releases at different INL facilities. The data NIOSH uses do not take into account the deficiencies in the environmental monitoring equipment and their locations, and, in addition, NIOSH does not assess the uncertainties associated with the meteorological dispersion model used for the INL site. Most importantly, the source terms do not account for worker inhalation of resuspended contaminated soils and materials around the INL facilities.	These findings are unique to INL and will need to be addressed by NIOSH. However, the dose implications are small and therefore are of substantially less concern than those associated with occupational external and internal doses. We believe that these issues are readily resolvable during the next revision cycle of the site profile	4
Finding 6 (Issue 2): Episodic Airborne Releases (Section 5.1.1.2) – For airborne releases from episodic events (such as criticality and special tests), NIOSH again relies on the two primary documents, INELHDE and RAC 2002, for determining onsite concentrations of radionuclides. In a previous study (SC&A 2003), SC&A determined that the airborne releases associated with several of the Initial Engine Tests of the Aircraft Nuclear Propulsion (ANP) Program were likely to have been underestimated by factors ranging from 2 to 7. Also, NIOSH did not evaluate the uncertainties associated with the deficiencies in air monitoring equipment.	These findings are unique to INL and will need to be addressed by NIOSH. However, the dose implications are relatively small and therefore are of substantially less concern than those associated with occupational external and internal doses. We believe	4 /2

	that these issues are readily resolvable during the next revision cycle of the site profile. A possible exception to this judgment is skin exposure to hot particles, which is being addressed under other venues.	
Finding 7 (Issue 3): Direct Gamma Exposures (Section 5.1.1.3) – For direct gamma exposure from environmental releases, NIOSH used fence-line TLD measurement data from Environmental Monitoring Data Reports (EMDRs) between 1972 and 1983. SC&A believes that these TLD measurements are not adequate for reconstructing direct gamma doses to personnel working outdoors at and around a specific INL facility inside the fence-line boundary. The NIOSH approach assumes all outdoor workers at a facility would receive an average direct gamma dose from a normalized ground concentration of radionuclides. If the assumption were valid, the fence-line TLD results should be multiplied by a weighting factor to account for uncertainties in TLD sensitivity and geometry. NIOSH has not done that in the TBD. However, NIOSH's assumptions are not claimant favorable, because they do not take into account the most bounding scenarios; (1) personnel working outdoors may become immersed in the plume of routine or episodic releases from the facility stack, (2) personnel working outdoors may inhale resuspended cumulative ground radionuclide depositions or windblown contaminated soils from any neighboring dry ponds, and (3) the cumulative ground concentrations inside the fence line are generally higher than those near the fence line. The fence-line TLDs are too far from the bounding source terms to represent the actual direct gamma doses received by the outdoor workers. Therefore, this TBD approach does not appear to be claimant favorable. In addition, NIOSH should re-examine the direct gamma dose values, because some of these values presented in Table 4-13 of the TBD appear to be much lower than the recent INL-published values.	These findings are unique to INL and will need to be addressed by NIOSH. However, the dose implications are relatively small and therefore are of substantially less concern than those associated with occupational external and internal doses. We believe that these issues are resolvable during the next revision cycle of the site profile	4
Finding 8 (Issues 4, 16 and 31): Completeness and Quality of INL Radiological Protection, Personnel Dosimetry, and Record Keeping Programs (Sections 5.1.2.1, 5.1.4.1.1, and 5.1.4.2.4) – The tone of the TBDs strongly suggests that NIOSH (i.e., the TBD authors) had full confidence in the radiological protection programs, the internal dosimetry programs, and the dosimetry record keeping systems at the INL site, in the past and at the present. The identification and determination of missed internal and external dose for workers are heavily influenced by this assumption of confidence, but SC&A found this premise to be unsupported after examining several critical DOE-HQ Tiger Team and DNFSB site audit reports. In addition, many site experts interviewed by SC&A indicated that there were significant deficiencies and inconsistencies in radiation work practices throughout the operating history of the INL facilities. These observations jeopardize the validity of the TBD approaches in reconstructing missed worker internal and external doses.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution.	1
Finding 9 (Issues 5, 23 and 34): High-Risk Jobs (Sections 5.1.2.2, 5.1.4.8, and 5.1.4.2.7) – Site experts interviewed by SC&A classified INL as an "acute dose" site, with a significant number of facilities, operations, experiments, and occurrences providing the possibility of personnel receiving dangerous levels of radiation. However, NIOSH did not comprehensively evaluate the facility and field data to identify and separate out the high-risk or high-dose jobs for worker internal and external exposures. For example, the TBD does not evaluate	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution.	1

the potential missed external dose (extremity, bladder, lens, or prostate) received by a pipefitter, who worked on a reactor vessel or process waste tank in a tight space environment where the dosimeter measurements would not be effective and representative due to angular dependence or bodily shielding. This information is essential for dose reconstructors to fill in the data gap when dose records in a claimant's file are not complete.		
Finding 10 (Issue 8): High-Fired Plutonium and Uranium Intakes (Section 5.1.2.5) – The Occupational Internal Dose TBD did not evaluate the hazard associated with high-fired plutonium and uranium at the INTEC (ICPP) and RWMC facilities. High fired Pu-238, Pu-239, and uranium are not easily dissolvable, nor do they readily break into very small particles. They also emit some gamma rays and neutrons. Similar to the treatment of recycled uranium, NIOSH should evaluate the lung dose for intake of high-fired uranium and plutonium oxide particulates (alveolar deposition).	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution. However, these issues have been or are being addressed under other venues (such as the Rocky Flats site profile and SEC petition reviews). Hence, though they require a response by NIOSH, their resolution should be readily achievable. One issue related to this matter is exposure to super S uranium, which we believe should be a matter addressed by NIOSH as a global issue.	2/3
Finding 11 (Issue 11): Non-Occupational Worker Elimination of DU Background (Section 5.1.2.8) – The derivation of the background value of 0.16 µg/L used for subtraction from each urinalysis result of uranium prior to assessment of occupational internal dose for SMC radiation workers is not technically sound. The baseline background (population) intake value was determined by a study of urine samples submitted by non-radiation workers at the SMC facility. A better approach would be to use the urine excretion samples by non-INL people in the Idaho Falls area. This approach would not create a suspected bias due to uranium intake through various pathways (inhalation and ingestion) by non-radiation workers while working at the SMC facility. During the site expert interview, the dosimetry staff indicated that they tried to use residents from the Idaho Falls area, but none were willing to sign a liability waiver form. In a subsequent study, the dosimetry staff used sixteen non-radiation workers from the INL CFA facility. In addition, this background value is much higher than the national survey data. NIOSH should consider this subtraction from urinalysis results as a missed internal dose.	These findings are unique to INL and will need to be addressed by NIOSH. However, the dose implications are relatively small and therefore are of substantially less concern than those associated with occupational external and internal doses. We believe that these issues are readily resolvable during the next revision cycle of the site profile	4
Opportunities for Improvement: These comments are included here for completeness. However, many are an extension of the 11 findings presented and discussed above.		

Incomplete Dose Records in Worker Files: NIOSH should look into the possibility of many missing dose records in worker files. From interviews of retired, past, and current workers, and also from audit reports (DOE-HQ and DNFSB), there appear to be many incident reports, occurrence reports, contamination reports, and worker uptake reports that were not included in the worker records. Most of these reports were kept, historically, at the INL facilities. NIOSH holds the position that the dosimetry records reflect accurately all the doses workers received while working at INL. The suspected incompleteness of the worker records is a serious issue, since it may lead to significant underestimation of workers' radiation dose.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1
Use of Untrained Workers: NIOSH should look into the worker utilization practices at INL in the early years (from 1950s to 1980s). From interviews of retired, past, and current workers, it appears that INL often sent workers, even untrained ones (e.g., secretaries, yardmen, etc.), from one INL facility to perform emergency or high-dose radiation work in another INL facility. After these workers reached their weekly or bi-weekly dose limit, in most cases 200 mrem, they would be sent back to their original workplace. For example, INTEC (ICPP) is one of the facilities that required frequent utilization of workers from other INL facilities to augment the work force, due to its high contamination and high radiation level (acute dose) environment. Several site experts interviewed indicated that they personally had the experience of being sent to INTEC to be "burned" to their dose limit. In addition, some workers interviewed indicated that they had experienced that the doses they received after being "burned" at the other facilities were frequently not recorded in their worker exposure files.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1
Angular Dependence Correction Factor for External Dosimeter: NIOSH should provide angular dependence (anatomic geometry) correction factors for external gamma doses, particularly for low-photon energies, where the angular dependence of the sensitivity of the dosimeter is most pronounced. These correction factors are used to account for, for example, the bias introduced by a dosimeter worn at the neck level and the higher doses received by tissues/organs below the waist.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution. However, these issues have been or are being addressed under other venues (such as the Hanford site profile and SEC petition reviews). Hence, though they require a response by NIOSH, their resolution should be readily achievable.	2
Breathing Rate: In the INL occupational environmental dose evaluation (TBD Section 4.2.1), NIOSH uses an at-rest breathing rate, which is not claimant favorable.[3]	This is a generic issue that is being addressed by NIOSH as a global issue.	3

[3] See Attachment 1, Occupational Environmental Dose, Question/Response No. 7, of this report for further discussion of the at-rest breathing rate assumption.

Plutonium Monitoring: NIOSH should provide historical information on the plutonium analysis methods used at the INL site. It is entirely possible that selective plutonium monitoring of workers was used at INL until 1980. Without this information, the dose reconstructors would not be able to assign missed internal dose, due to plutonium intakes in the time period before 1980.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1
Dose Calculation Example: NIOSH should provide an example (or examples) in the TBD text of a hypothetical dose reconstruction using recorded records, missed dose assignment, and dose assignments when dosimeters read zero dose.	Such an example will help to clarify the TBD but not have dosimetric significance.	4
Consistent Air Dispersion Model: NIOSH should use a consistent methodology for calculation of occupational dose that is appropriate for application to onsite workers. In addition, the components of environmental dose should be consistent among the DOE facilities evaluated. For routine releases, the INL Occupational Environmental Dose TBD uses the MESODIF model, employing an objective regional trajectory computational scheme combined with the Gaussian diffusion equation for a continuous point source. It is a forward time-marching Gaussian plume model in which successive, small plume elements (or puffs) are advected throughout the computational area. For episodic releases, the TBD used the RSAC program primarily for calculating onsite meteorological dispersion parameters for the various airborne release incidents. RSAC provides the option to use various types of meteorological diffusion models and parameters applicable at INL, all of which are based on the Gaussian plume model. In the case of Hanford Site and SRS, for example, a RATCHET puff model and the Gaussian model were used, respectively.	These findings are unique to INL and will need to be addressed by NIOSH. However, the dose implications are relatively small and therefore are of substantially less concern than those associated with occupational external and internal doses. We believe that these issues are resolvable during the next revision cycle of the site profile	4
Recycled Uranium and Plutonium: The dose contribution from trace radionuclides in recycled uranium and plutonium should be evaluated in terms of dose to particular organs of concern and the relative impact on internal dose reconstruction. NIOSH should evaluate the lack of formal policies for considering trace radionuclides in recycled uranium and plutonium, and develop bounding conditions that can be applied at all applicable DOE facilities, including INTEC (formerly ICPP) at the INL site.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1
Beta/Gamma Dosimeter Adjustments and Uncertainties: A method to consistently account for laboratory, radiological, and environmental uncertainties in dosimeter readings should be developed and appropriately applied to recorded dosimeter results, so that it is clear what sigma value should be entered into Interactive RadioEpidemiological Program (IREP) Parameter 2.	These findings are unique to INL and will need to be addressed by NIOSH. However, the dose implications are small and therefore are of substantially less concern than those associated with occupational external and internal doses.	4

	We believe that these issues are readily resolvable during the next revision cycle of the site profile	
Tank Farm Worker: NIOSH should complete an evaluation of the relative hazards associated with work at the Tank Farms and the completeness of monitoring related to Tank Farm workers, including subcontractor and construction workers.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1
Use of Site Expert Input: NIOSH should make a greater effort to take into account site expert information and to investigate worker accounts. First-hand experience and association with the INL facilities enable site experts and workers to provide original perspectives and information concerning site practices and exposure histories that may not appear in the official records.	This issue has no direct dosimetric implications, but this suggestion could improve the site profile and hence potentially indirectly affect.dose estimates in case of significant new information. We believe this issue is best addressed by NIOSH in a future revision of the site profile.	4
Missed Dose and Off-normal Practices: NIOSH should evaluate the significance of off-normal practices for missed dose by analysis of film badge data and site expert interviews. This is essential to determine if there were areas or periods where badges may not have been consistently worn when the actual dose was near the administrative control limit.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1
Data Uncertainty: The statutory requirement of a claimant-favorable dose reconstruction process is achieved by (1) giving the benefit of doubt when there are unknowns, and (2) defining uncertainties for measured data and selecting the 99th percentile values of a Monte Carlo distribution. In the site profile TBDs, it is often found that lower percentile values are used instead of the 99th percentile values as default assumptions for missed dose calculations. NIOSH should re-examine all the data uncertainty values used in the TBDs to ensure that this statutory requirement of claimant-favorable dose reconstruction is met.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1

K-25 SITE

Table 4 summarizes each of the findings contained in SC&A's site profile review. As may be noted, out of the 12 findings, 5 secondary findings, plus 11 opportunities for improvement (many of which are simply an extension of the findings), 17 were assigned to disposition category No. 1.

Table 4. K-25

Finding	SC&A Suggested Action for the Board to Consider	Suggested Disposition Category
Finding 1: More guidance is needed on appropriate enrichment assumptions when interpreting uranium bioassay mass concentration data. The K-25 Occupational Internal Dose TBD (Thomas 2006) needs to provide more guidance on the appropriate enrichment to assume when interpreting uranium bioassay mass concentration data, and the enrichment assumed for the default isotopic distribution may not be appropriate or claimant favorable.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1
Finding 2: No default absorption (solubility) classes for any of the intakes are identified. Absorption classes for two important forms of uranium (UO_3 and U_3O_8) listed are incorrect. There is no discussion on high-fired uranium oxides or Special Class Y (S) material that would have different biokinetics than traditional Class S uranium compounds	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1
Finding 3: The default isotopic distribution does not appear to be claimant favorable. It does not contain Pu-238, Pu-240, Pu-241, and Pu-242; Cm-242 and Cm-244; assumes only low enriched (2%) uranium; and the Tc-99 ratio is questionably low. The Site Description, as well as the Internal Dose TBD, describe the use of higher enrichments and identify 3% as the predominant enrichment at the site, as discussed in the finding above, along with the fact that higher enrichment would lead to higher activity intakes and doses when interpreting uranium urine mass concentrations. There needs to be a strong justification for the assumptions regarding enrichment, as adopted by NIOSH, because they do not appear to be claimant favorable or correct.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1
Finding 4: The TBD is inconsistent or lacks complete information on radionuclides for K-25 facilities. There is a general inconsistency or lack of complete radionuclide guidance and information for facilities shown in the tables of the TBD. Several major radionuclides are not shown in source terms at various buildings in Table 5-4 (Thomas 2006), Source Term Summary by Location. Table 5-2, principal radionuclides found at uranium facilities and gaseous diffusion plants, list Th-230, Am-241, Cm-242, and Cm-244, and the default isotopic distribution in Table 5-6 lists Th-230 and Am-241, yet these radionuclides are not shown as part of the source term in any buildings listed in Table 5-4.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1
Finding 5: Lack of information regarding incidents may be a problem for accurate and claimant-favorable internal dose reconstructions. The lack of information on incidents that could have caused	SC&A considers these significant findings and will require	1

significant intakes of radionuclides could hinder accurate interpretation of bioassay results and identification of intakes by unmonitored or inadequately monitored workers. There are no incidents identified in this TBD. There were likely several incidents which have incident investigation information that would help dose reconstructors perform accurate and claimant-favorable intake and dose assessments. Interpretation of bioassay data can be assisted by the use of incident records information and, if no bioassay data are available for an unmonitored or inadequately monitored claimant that may have been involved in an incident, then other types of data from the investigation may be used for dose assessment.	considerable attention by NIOSH and the Board for their resolution	
Finding 6: Coworker data use and approach for unmonitored employees may not be appropriate or claimant favorable. NIOSH's use of the median bioassay data values from 1948 to 1988 for uranium intake rates and 1978 to 1988 data for Tc-99 intake rates may not be reasonable or claimant favorable for several reasons. Because there was undoubtedly some variation of intake rates around the median values, it does not appear to be claimant favorable to assume that a claimant's intake was a median intake, as opposed to a higher value such as the 84th percentile value. NIOSH needs to determine if the work processes (such as production level/throughput), exposure conditions, and radiological controls (engineering, administrative, personal protective equipment (PPE)) for the 1945–1947 period were similar to the periods that followed it.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1
Finding 7: Uranium cylinder storage yard dose may be underestimated. Section 6.7.3 of the Occupational External Dose TBD (Miles 2006) states that the neutron dosimeters in use "were generally insensitive to the low neutron dose rates at K-25…" In addition, as discussed elsewhere in this review, the dosimeters were insensitive to **any** dose rate due to neutrons below the NTA cutoff (somewhere between 0.5 and 1.0 MeV.) In spite of this, DRs are instructed to add missed neutron dose only for workers in the cylinder yards. There will have been pervasive, low-level neutron fields in other areas of the plant due to the alpha-N reaction, spontaneous fission, the presence of trace levels of transuranics in some feed stocks, and possible incidents or "slow cooker" events. Given these facts, SC&A recommends that all areas of the plant be evaluated to determine an appropriate missed dose component for neutron exposure. NIOSH should evaluate the advisability of using the PGDP recommended 200 mrem/2,000 hr as the basis for a more claimant-favorable dose estimate for K-25 workers.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1
Finding 8: Until 1980, some dosimeters were only processed upon request, resulting in ambiguity regarding the construction of doses in the early years. Until 1980, the TBD (Miles 2006) states that dosimeters were only processed upon request. Another TBD statement points out that ORNL provided K-25 dosimeter and processing technical support starting in 1945. It is unclear from these two statements whether dosimeters were routinely processed for workers or only done in some random frequency. If the latter is true, many workers may have missed dose due to lack of processing or recording. SC&A recommends that this issue be investigated and appropriate data be collected to address this missed dose if NIOSH finds that it did occur. The Occupational External Dose TBD (Miles 2006, pg. 10) states that "From 1945 to 1979, ORNL processed dosimeters only on request," yet there is no discussion as to the meaning of this statement. For example, who was able to make such a request, and on what basis? Were any random dosimeters selected to check for unanticipated exposures? What was entered in the record if a dosimeter was processed that	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1

revealed a worker had been receiving an exposure over an extended period? SC&A recommends that this issue be investigated and data collected in situations such as the percentage of issued badges that were processed, the procedures for selecting which badges to process, the procedures for handling positive results, and the implementation of a QA program if any, etc.		
Finding 9: Chronic neutron exposure opportunities may have been overlooked for the early years. For health physics and safety coverage during the early years, it seems that little attention was paid to the possibility of neutron exposures. While it is possible that this was because there were no significant neutron fields, it is also possible that limited staff, inexperience, inadequate instrumentation, and a generally more relaxed attitude to chronic exposure levels may have resulted in safety staff overlooking or ignoring neutron exposure potential. SC&A suggests that this issue should be revisited and a determination made as to whether some categories of workers could have been exposed to chronic low-level neutron fields.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1
Finding 10: Potential exposures to Tc-99 betas were not recorded by dosimeters and are not addressed elsewhere in the TBD. It is also likely that the film badges used in the 1945 to 1979 period did not detect Tc-99. (Details on wrapping and cover materials in mg/cm^2 would be helpful.) It is asserted that only skin contamination could have given rise to significant beta exposure due to Tc-99, yet this claim is unsupported by any discussion of typical quantities of Tc-99 that might be present or any measurements or calculations of dose rates. The potential for exposure to beta fields needs to be more fully evaluated, with a parallel consideration of the dosimetry in use at the time and the potential for unreported or under-reported dose.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1
Finding 11: Reliance on a single neutron-to-photon ratio for the entire plant is questionable. Reliance on a single neutron-to-photon ratio for the entire plant geography and history and a ratio that additionally is based on a measurement at another facility is questionable. The K-25 plant had a number of potential sources of neutron exposure that will have varied over time as processes, facilities, procedures, impurities, and enrichments changed. Additional research and analysis is recommended to evaluate the neutron-to-photon ratio(s) that should be used to estimate missed neutron doses over the K-25 plant history. SC&A recommends that careful consideration be given to situations where the photon component of the field may have been effectively shielded by process equipment and pipe work, leaving a neutron component of exposure that is not accompanied by a significant photon component. This would undermine the application of the ratio method for these situations.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1
Finding 12: All beta dosimetry was based on a uranium slab calibration. Given that it is likely that at least some workers were routinely exposed to Tc-99, and given that the dosimeters will have partly or completely missed this lower energy beta, SC&A recommends that an evaluation be performed to determine the degree to which Tc-99 dose was under-reported or missed entirely. The use of only a uranium slab calibration may well have missed these lower energy betas.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1

Secondary Findings: Secondary findings typically are of potential limited dosimetric significance, but are included here for completeness.		
Finding 13: There is a lack of guidance on bioassay interpretation. There is a lack of guidance on bioassay interpretation regarding appropriate assumptions for intake assessments. The TBD needs to either provide more specific guidance to the dose reconstructor on several parameters that must be chosen or adjusted for intake and dose assessment, or reference the documents that will provide this guidance. **Finding 14: There is no comparison between measured and predicted ambient radiation dose data.** The PGDP Occupational Environmental TBD, ORAUT-TKBS-0019-4 (East 2004) states that since 1962, "At PGDP all personnel wore film badges…" The ORNL Occupational Environmental TBD, ORAUT-TKBS-0012-4 (Burns 2004) states, "ORNL went to a take home badge (i.e., security badge and dosimeter combined) in the early 1950s…" It is reasonable to postulate that given similar activities to a sister site (PGDP) and being a part of the Oak Ridge Reservation (ORR), K-25 employed a similar personnel dosimetry arrangement for workers. A comparison between personnel dosimetry data (measured) with estimates based on ambient environmental exposures (predicted) would prove useful to validate the methods for reconstructing external environmental doses. **Finding 15: The TBD does not provide a consistent time period for the processing of RU at K-25.** The potential radionuclide contaminants in RU (Tc-99, Np-237, Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, Am-241, Cm-242, and Cm-244) can give a significant increase in the dose from intakes of RU process material compared to natural uranium ore sources that do not contain these radionuclide contaminants. The Occupational Internal Dose TBD (Thomas 2006) does identify a default isotopic distribution that contains some of these contaminants to assume for intakes in Table 5-6; however, it does not make it clear for which years to assume this default. The TBD should identify specific time periods that RU and its default isotopic distribution are to be assumed in intake assessment for possible claimant-favorable exposures. **Finding 16: The TBD fails to adequately define frequency and assess all types of x-rays in occupational medical exposure.** Initial guidance on medical exposure and dose guidelines, as presented in Revision 2 of ORAUT-OTIB-0006 (Kathren 2003), provides basic guidelines that the dose reconstructor can use to ensure that all occupational medical exposures are reasonably included in determining the overall dose estimations for claimants. Unfortunately, the interpretation, to date, by the contractor (ORAU) has not been applied conservatively to be claimant favorable. The Occupational Medical Dose TBD (Turner 2006) assumes an interpretation that has been considered and applied at other sites, such as the Mound Plant, Los Alamos National Laboratory (LANL), Paducah, and Pinellas. It is assumed that occupationally related medical exposures are included in dose reconstruction for pre-employment, annual, health monitoring examinations, and post-employment chest x-rays. Although NIOSH has stated that they rely on the K-25 Site to provide all medical records information (Attachment 4), an interview with a K-25 medical x-ray technologist, there since 1957 (Attachment 2, Medical X-ray Procedures section), indicated that the data provided may not contain information retired to microfiche. In the early period, workers with potential for exposure to uranium dust inhalation were reported in the TBD (Turner 2006, Table 3-1) to have often	These findings are unique to K-25 and will need to be addressed by NIOSH. For findings 13, 14, 16, and 17, the dose implications are relatively small and/or easily resolved and therefore are of substantially less concern than those associated with the primary findings. They should be readily resolvable during the next revision cycle of the site profile. However, SC&A considers Finding 15 significant and will likely require considerable attention by NIOSH and the Board for its resolution.	**1 for findings 15** **5 for findings 13, 16 and 17** **4 for findings 14 and 17.**

received monthly chest x-rays. NIOSH needs to review the microfiche to verify the frequency of chest x-rays in the early years, and what the appropriate number of chest x-rays for inclusion in dose reconstruction is, for workers exposed to uranium dust. This would need to be developed for those workers whose individual medical records do not document the frequency of chest x-rays. **Finding 17: Techniques and protocols increase uncertainty of dose conversion factors (DCFs) listed in the TBD.** The Occupational Medical Dose TBD (Turner 2006) provides little documentation to support the assumed techniques and protocols applied to calculate the dose, which is mainly derived from ICRP Publication 34 (ICRP 1982). The TBD states that a posterior-anterior (PA) chest x-ray was typically the only view taken until the early 1950s. It is an undocumented assumption in the TBD that exams required only a PA view. SC&A has inquired whether a definitive protocol existed to validate that chest exams possibly included PA views and lateral (LAT) views on a limited basis. NIOSH has acknowledged in other TBD reviews that the lack of verifiable protocols is a generic problem at many sites, has planned to search all available records, and will include pertinent records and references in any future revision of this section of the TBD. The Occupational Medical Dose TBD is also deficient in that little documentation exists to validate x-ray protocols, equipment maintenance, and upkeep records.		
Opportunities for Improvement. These comments are included here for completeness. However, many are an extension of the findings presented and discussed above. (1) There is ambiguity in the Internal Dosimetry TBD (Thomas 2006) about ending of RU processing. The Site Description TBD (Szalinski 2006b) states in one section that RU was processed through 1977, and through 1984 in another section; however, the Internal Dose TBD identifies that 1976 was the last year of using RU for feed material. These TBDs need to be in agreement. The lack of considering that RU was also used in later periods could lead to an incorrect intake assessment and unfavorable determination for the claimant. NIOSH, in its response to SC&A's Internal Dose section question 9, which is included in Attachment 3 of this report, states that the reference that they used to identify the period that RU was received at K-25 states that it was 1952 through 1988 (BJC 2000), and that they will revise the appropriate section of the TBD for clarity. In the conference call (Attachment 4, Internal Dosimetry, question 9), NIOSH stated that all intakes of uranium will assume that RU was involved from 1952 through the present, and will use the default isotopic distribution in the Internal Dose TBD (Table 5-6) for assessed intakes. (2) Use of ICRP 23 (ICRP 1974) Reference Man anatomical and physiological data may be questionable, because this document has been updated with ICRP 89 data (ICRP 2002). A determination should be made on the applicability of using the larger daily urine excretion volume from ICRP 89 for the conversion of urine bioassay concentration data (μg U/liter) to 24-hour excretion activity that is used to calculate intakes. The ICRP 89 volume (1.6 liters for men and 1.2 liters for women) is larger than the volume recommended in ICRP 23 (1.4 liters for men	These findings are unique to K-25 and will need to be addressed by NIOSH. For items 2, 4, 6, 7, 8, and 11 the dose implications are very small and/or easily resolved and therefore are of substantially less concern than those associated with the primary findings and are readily resolvable during the next revision cycle of the site profile. Item 2 is a generic item that has potential applicability to all sites. However, SC&A considers item 1, 5, 9, and 10 significant and will likely require considerable attention by NIOSH and the Board for its resolution.	4 for items 3, 4, 6, 7, 8, and 11. 2 for item 3. 1 for items 1, 5, 9, and 10.

and 1.0 liters for women). Using the larger volumes will increase the intakes and doses determined from concentration (e.g., mass or activity per liter) bioassay data interpretation for internal dose assessment. If NIOSH does not believe that the larger volumes are applicable, it should state this and defend the use of the smaller volumes. (3) There is no discussion on the respiratory protection program—air sampling or other radiological control practices—that would help provide potentially valuable information for internal dose reconstruction. This information provides a general overview and possibly specific data on the conditions that claimants were exposed to and the methods employed to minimize or limit intakes of radionuclides. This information may be useful if a dose reconstructor must make a professional judgment decision on the potential for intakes to occur. Another important piece of information that may be extracted from this is the level of knowledge of a claimant's work locations, which would help identify their specific exposure conditions. There also is no discussion of the cascade improvement/cascade upgrade programs in the 1970s, which may have involved increased exposure problems (mentioned in the site expert's interview in Attachment 2). In addition to this basic program information, NIOSH needs to determine if the site has done any airborne radionuclide particle size and/or lung solubility analyses for the radionuclides in the source terms of buildings, and then provide any applicable information to dose reconstructors. NIOSH, in its response to SC&A's Internal Dose section question 5 (Attachment 3), states that the primary method of evaluation for dose reconstructions is use of individual monitoring data, and, if it is necessary, area-monitoring information will be reviewed. In its response to question 3 of this attachment, NIOSH states that particle size distributions are specific to operations and conditions in the locations, and it is not reasonable to assume that a measurement in one location is universally applicable to other locations. However, it notes that dose reconstructors may use site-specific information if it is contrary to the 5-micrometer default activity median aerodynamic diameter (AMAD) assumption. (4) Table 5-7 (Thomas 2006) identifies in-vitro MDCs, yet incorrectly labels these as being in mg/L units in its heading, and no fecal bioassay MDCs are identified. The units do not need to be identified in the heading of Table 5-7 of the Internal Dose TBD, because each bioassay MDC unit is identified in the table next to its numerical value (some in mass and some in activity concentration units). The type of samples these MDCs apply to is not identified specifically in the table, but from reading the text, it can be assumed that these are for urine bioassay, because it is the only in-vitro bioassay discussed. No fecal bioassay is identified, which infers that fecal bioassay data are not available. During the site interview and document search, a research paper was obtained that indicated fecal sampling was performed for a period		

from 1964–1966 at the Uranium Recovery Facility (Schultz 1966), and this was reported to NIOSH in the conference call (Attachment 4, Internal Dosimetry, question 2). NIOSH should discuss the availability of any fecal bioassay data. (5) A discussion of the determination for potential radium and thorium sources is needed to identify if dose assessment for workplace-related radon exposures is warranted. Although K-25 was primarily a uranium-processing site, it was claimed in a project meeting (NIOSH 2005) that there were some special research missions at the site. NIOSH should look for any information that could indicate the significant use of radium or thorium sources. If any sources are found, NIOSH should then discuss the internal dosimetry effort (including radon dose assessment) that may be needed to account for these. NIOSH, in its response to SC&A's Internal Dose section question 8 (Attachment 3), states that, "No information on the presence of radium sources at the site is currently available." The site expert interviews indicated that radium was a significant radionuclide in K-1024, K-1030, and K-1035 (Attachment 2); therefore, it is recommended that NIOSH investigate this possibility, and any potential radium and radon doses that could have resulted. (6) Occupational Medical Dose TBD (Turner 2006) provides little documentation to support the assumed techniques and protocols applied to calculate the dose, which is mainly derived from ICRP Publication 34 (ICRP 1982). The TBD provides a summary on the use of PA and LAT chest x-rays. NIOSH should attempt to find additional data to validate that the process described leads to the most claimant-favorable dose for occupationally related chest x-rays. (7) Figure 4-1 of the Occupational Environmental Dose TBD (East 2006) shows major buildings and environmental monitoring stations relative to release points. It would be valuable to include wind rose data to validate the chosen monitoring stations. Also include the discussed administrative area in relation to these locations. Table 4D-4 provides estimated average gamma radiation levels for two perimeter K-25 stations. For the years 1973–1985, asterisks need to be included denoting data derived from empirical site measurements. (8) Photographs showing typical facilities, equipment, and processes would be helpful. Photographs showing typical facilities, equipment, and processes would assist dose reconstructors and reviewers unfamiliar with the K-25 facilities in understanding the layout, inherent shielding, and distances commonly encountered by workers. Any photos of the dosimeters in use and associated dosimeter processing facilities and equipment would also be helpful.		

(9) A discussion of major incidents is needed. A discussion of major incidents throughout the site history and how unusual doses were added to the record over the extended time period under review would be helpful. (10) A discussion of the range and type of non-standard operations would be helpful. A discussion of the range and type of non-standard operations, such as plant upgrades, maintenance, research and development (R&D), etc., would be helpful. For example, while Tc-99 recovery is mentioned, it is unclear to the reader what this entails. (11) The Site Description TBD needs a comprehensive list of buildings. Site interviews with a number of workers make it clear that a number of buildings are not addressed in the site profile. K-25 Site Expert Interviewees (Attachment 2, Production/Operations section) identified numerous buildings including K-101, K-131, K-631, and others. SC&A recommends that NIOSH prepare a comprehensive list of all the buildings on the site and use this to identify work areas with potential for missed dose. The table in Attachment 2 should be helpful to the dose reconstructor when reviewing a claimant's work area for potential higher external or internal dose. This is important, as there could be an opportunity for exposure to internal and external hazards, even if the building is clean. There is documentation of contaminated equipment being transferred to inactive areas for repairs or modification during the life of the K-25 plant.		

LOS ALAMOS NATIONAL LABORATORY

Table 5 summarizes each of the findings contained in SC&A's site profile review. As may be noted, out of the 10 findings plus 3 opportunities for improvement, 9 were assigned to disposition category No. 1.

Table 5. Los Alamos National Laboratory

Finding	SC&A Suggested Action for the Board to Consider	Suggested Disposition Category
Finding 1: Site profile does not adequately address data insufficiency for impact and implications to early worker dose reconstruction. Information available for dose reconstruction in the early years is limited, inadequate, or in some cases not available. The internal dosimetry TBD approach is to use data from a later era to retrospectively assign dose, or to apply a hypothetical chronic intake for plutonium, polonium, and uranium when bioassay data are unavailable. Bioassay monitoring was typically limited to workers directly handling radionuclides, or as was often the case in the early years, had not yet been developed. Internal monitoring data for many radionuclides handled are not available until as late as the 1960s. The current TBD does not consider potential internal dose from radionuclides other than plutonium and polonium, for which bioassay data were available during the 1943–1946 timeframe. The incompleteness of external dosimetry records and the lack of adequate documentation regarding job categories and assignments raise questions regarding the feasibility of assigning co-worker or average doses. Likewise, the lack of complete photon dosimetry data in the early days brings into question the ability to compute neutron dose by using the n-p ratio method, an approach that has been proposed by NIOSH.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution.	**1**
Finding 2: **Inadequate consideration has been given in the site profile to potential exposure and missed dose from secondary radionuclides.** Numerous radionuclides were handled at LANL ranging in quantities from fractions of a gram to kilograms. Exposure to a number of these radionuclides was not given adequate, or in some cases, any consideration in the internal dosimetry TBD, although some are listed as facility-specific radionuclides handled in particular technical areas. The dose reconstructor was directed to rely on the claimant interviews for identification of potential exposure to non-traditional radionuclides (i.e., other than plutonium, uranium, tritium, and polonium). Other radionuclides handled at LANL included radium, thorium, actinium, protactinium, americium, neptunium, curium, lanthanum, barium, yttrium, and other fission products; and alpha emitters and beta emitters associated with accelerator production and weapons development. Inadequate guidance is given for assignment of dose from Sr-90, Cs-137, Ba/La-140, P-32, C-14, Pa-231, radioiodine, tritides, and thorium. No clear guidance is provided on dose estimation for radium, actinium, neptunium, curium, yttrium, tantalum, and radionuclides created as a part of the medical isotope program.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**

Finding 3: Dose estimation is not addressed for LANL personnel assigned to weapons testing. Exposure conditions related to LANL personnel participation in weapons and safety testing have not been considered in the LANL site profile. LANL sponsored numerous nuclear weapons tests, including atmospheric, underwater, and underground testing in the U.S. and at the PPG. Groups of LANL personnel were present at testing of LANL-designed weapons and weapons components. LANL was responsible for monitoring at the Trinity test and for tests at the PPG. The NTS provided dosimetry support to LANL personnel present for testing. The significance and potential dose contribution from LANL personnel participation in weapons and safety testing has not been considered in the site profile, nor has it been established how (or whether, in all cases) these recorded doses were integrated into LANL personnel dose records. The NTS site profile has not been referenced for determination of missed dose at the test site itself. No TBDs currently exist to provide background information and guidance on how to assess potential missed dose at Trinity, Amchitka, or the PPG. The exposure conditions during these activities will differ from those received at the LANL site itself, and should be specifically addressed.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**
Finding 4: Neutron dose reconstruction approach in TBD may result in underestimated dose. The current external dose TBD (Widner 2005) addresses neutron dose reconstruction using the NTA film dose data, and provides some correction factors and instructions for doing so. While some facility-specific neutron energy bands are provided in the TBD (e.g. on pages 47 and 72), in some facilities, the entire spectrum is essentially below the practical 1-MeV detection limits of NTA film used in the workers' badges. It is not clear that the dose reconstructor would have sufficiently detailed correction factors or instructions to correct for the unmonitored neutron doses resulting from neutrons with less than 1 MeV of energy at the numerous facilities at LANL that produced neutron exposures through the years. Furthermore, NIOSH has recently recommended using n-p ratio values instead of the NTA film dose data for neutron DR. If this method is used, then the photon doses and the n-p ratio values used would need to be verified. It will be difficult to find statistically valid photon dose values during 1943 to 1949 since relatively few workers were badged and a significant number of the results for those that were badged were not recorded and retained for future use. Additionally, dependable n-p ratio values will be difficult to obtain and verify as applicable to the many difference exposure conditions that existed in the early years.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution. However, these issues have been or are being addressed under other venues (such as the Hanford site profile and SEC petition reviews). Hence, though they require a response by NIOSH, their resolution should be achievable provided that NIOSH puts forth an across the complex set of criteria for n/p ratio use and what kinds of data are and are not acceptable for estimating neutron doses from n/p ratios.	**2**
Finding 5: **TBD does not adequately address missed plutonium internal doses prior to 1970 due to absence of lung counters.** Many of the workers prior to the early 1970s were not lung counted, since lung counters were first developed for LANL monitoring in that timeframe. This may lead to uptakes that were never detected or monitored. Section 5.2.1 of the TBD provides a section on "Missed Intakes" (Buddenbaum 2004, pg. 14); however, it does not adequately describe the approach NIOSH intends to use to reconstruct a claimant-favorable dose for those individuals. Subsequent discussions with NIOSH regarding their intention to apply a dose of approximately one-third of the average internal dose of workers enrolled in the "UPPU" club (a group of volunteers who have regularly submitted urine samples for	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**

plutonium bioassay over the years) raises the concern that this assumed value is much less than the sensitivity of bioassay techniques in place and therefore would not be claimant favorable.		
Finding 6: Completeness and accuracy of dosimetry records are not substantiated. SC&A review of the LANL dosimetry records cited in the site profile from the standpoint of their adequacy and completeness, as well as their inclusion of known sources of LANL worker radiation dose information indicate some gaps that need to be addressed. For example, total reliance on the LANL Bioassay Repository database, for which verification and validation has only been partially completed, may raise questions regarding the completeness and accuracy of internal dose estimates. It was also found that radiological information included in available individual worker medical files, including hazard reports, whole body and extremity dose information, nasal count data, personnel exposure record – airborne contamination reports, and incident reports, all represent useful data that need to be reflected in dose reconstruction. Similarly, some LANL workers participated in human radiation experiments up through the 1960s and should be given credit for radiation doses recorded in those records. Finally, while accidents and incidents are listed in the site profile, the site profile does not adequately address the significance of such incidents, how they may have contributed to worker dose, and how they would be addressed by dose reconstruction.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**
Finding 7: TBD does not address potentially missed Am-241 intakes prior to the mid-1990s. The dose contribution of Am-241 in-growth within the body after uptake of plutonium could be significant. The Occupational Internal Dose TBD, ORAUT-TKBS-0010-5 (Argall 2004) states in Section 5.2.2, page 22, that "there is an indication that workers participated in the americium bioassay program only if there was a potential of exposure to pure americium." Thus, many plutonium workers unmonitored for americium may have significant missed dose that needs to be closely evaluated by job categories and locations if claimant-favorable americium doses from plutonium uptakes are to be calculated during the dose reconstruction process.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution. However, these issues have been or are being addressed under other venues (such as the Rocky Flats site profile and SEC petition reviews). Hence, though they require a response by NIOSH, their resolution should be readily achievable once they are addressed at Rocky Flats.	**2**
Finding 8: Internal dose TBD lacks a clear means to assign dose to unmonitored workers. Given the historic inadequacies in LANL's bioassay program even into the 1960s and 1970s, it is clear why NIOSH concluded in the Occupational Internal Dose TBD (Argall 2004) that "the experiences of workers with monitored intakes cannot be used to develop a scenario [i.e., co-worker model] for workers who were not monitored;" but it is less clear how NIOSH intends to "derive potential intakes from removable contamination levels, tolerance and MAC air concentration levels, and airborne concentrations of significant radionuclides" (Argall 2004). First, such data is not necessarily available for many pertinent radionuclides to which workers were exposed (e.g., both primary and secondary radionuclides) and for many specific job locations; second, it is not clear, as emphasized by the TBD itself, who may have been	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**

exposed to potential internal source terms given the paucity of radiation controls at the site and lack of routine bioassaying of potentially exposed workers that existed well into the 1960s and 1970s; and third, the TBD is speculative about whether bioassay was performed for short-term workers, such as students and postdoctoral researchers. SC&A finds that for a long period extending into the 1960s, the TBD (Argall 2004) does not provide a plausible approach for assigning missed internal dose to unmonitored LANL workers, nor does it appear to be plausible to do so except for a few select radionuclides, such as plutonium and polonium.		
Finding 9: TBD does not adequately address potential dose contribution from external high-radiation exposures to unbadged workers. SC&A is concerned regarding the stated approach in the Occupational External Dose TBD, ORAUT-TKBS-0010-6 (Widner 2005) of assigning doses from the median values of co-workers or missed annual doses based on MDL values (in the 100s of mrem range) to unmonitored workers, when LANL's operational history is replete with instances where the potential existed for exposures in the **rem/hr** range. Sources and incidents that likely contribute to the potential for high exposures are not always adequately addressed and the resulting doses accounted for in the TBD. Sources of relatively high radiation fields that represented a significant potential for worker radiation exposure are not thoroughly discussed. Some examples include the following: early experimental accelerators and n-p sources; the reactors and the Omega Stack at TA-2 (Omega Site); the radioactive lanthanum experiments; the pulsed high-energy x-ray machines, the operations at LAPRE I and II; the spent fuel/hot cell operations; and neutron doses in and surrounding TA-18 (Pajarito Laboratory) during critical assembly operations. Assignment of the median gamma, and derived neutron doses from n-p ratio values, as recommended by the TBD, would lead to underestimating an unmonitored worker's dose that had the potential of exposure to these sources of radiation.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**
Finding 10: Unmonitored exposures of Zia Company maintenance, construction, and facility support workers, as well as LANL security guards, not sufficiently addressed. The Zia Company was the principal subcontractor to LANL from 1946 to June 1986. During this timeframe, approximately 15,000 workers were employed to provide a broad range of site-wide maintenance, construction, janitorial, waste management, and facility support activities, much of it involving potential radiation exposure. While the internal dose TBD provides cursory information regarding Zia employees (e.g., on page 12, Table 5A-11 is referenced as providing a list of criteria and bioassay exempt job categories for plutonium bioassay), little information is provided regarding what is characterized in the TBD as a "separate" monitoring program. This is of particular concern, because Zia workers were involved in almost all of the radiological operations at the laboratory during most of its history, and were frequently called upon to conduct jobs involving potentially significant internal and external radiation exposure potential including decontamination, radioactive waste disposal, and "hot" maintenance. While the Zia monitoring program later had a computer program that "locked out" (i.e., administratively restricted) access to plutonium areas for workers not bioassayed within 425 days, it is not clear from the TBD when this program was enacted, and how this measure would have precluded workers from receiving uptakes and discontinuing employment or moving to other radiological areas and therefore not be bioassayed. The site profile does not provide the requisite basis for determining what the potential missed and unmonitored dose may have been for the Zia	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**

workforce given the spectrum of radiation sources involved. Similar concerns apply to how dose estimation will be handled for unmonitored or inadequately monitored LANL security guards who likewise had site-wide access and were frequently in locations where potential internal and external radiation exposures were likely.		
Opportunities for Improvement. These comments are included here for completeness. However, many are an extension of the 11 findings presented and discussed above.		
(1) Based on the March 21, 2006, conference call with NIOSH on external dosimetry (see Attachment 4), NIOSH intends to reissue the Occupational External Dose TBD, ORAUT-TKBS-0010-6 (Widner 2005), after input from Dr. Ken Silver (a LANL site expert) has been carefully studied and after SC&A concerns have been reviewed and resolved, where possible. During the conference call, it was learned that ORAU plans to revise all sections based on the review outcomes. (2) There is an inconsistency in the collective doses reported by LANL and those reported to DOE in annual dose reports. The numbers used in the LANL site profile were based on a 2004 internal LANL document that bears no "LA -" technical report number. As noted in comments submitted by Dr. Silver (Silver 2005, pg. 42 and Figure 2), many times these collective doses were lower than those reported to DOE. (3) There are several areas for improvement in regards to what appears in the External Dose TBD, ORAUT-TKBS-0010-6 (Widner 2005) to be an over-simplification of important issues that could impact dose reconstruction. The three main issues are: • Lack of dose measurements and their associated records (especially in the early years). • Sources of high exposure potential and their affects on unmonitored and missed doses. • Validation of n-p ratio values and the reliability of the photon doses; both of which will be used in neutron DR. The current version of the Occupational Environmental Dose TBD, ORAUT-TKBS-0010-4 (Cehn and McDowell-Boyer 2004), was published with various gaps in information before 1971. NIOSH has advised this was done to allow processing of selected LANL claims.	**Items 1 and 2 appear to be readily resolvable, but item 3 appears to require explicit considerations.**	**4 for item 2.** **2 for item 1.** **1 for item 3.**

LAWRENCE LIVERMORE NATIONAL LABORATORY

Table 6 summarizes each of the findings contained in SC&A's site profile review. As may be noted, out of the 12 findings plus 5 opportunities for improvement, 10 were assigned to disposition category No. 1.

Table 6. Lawrence Livermore National Laboratory

Finding	SC&A Suggested Action for the Board to Consider	Suggested Disposition Category
Finding 1: Dose estimation for LLNL personnel assigned to weapons testing has not been adequately considered. Exposure conditions related to LLNL personnel participation in weapons and safety testing, and subcritical or reactor experiments have not been considered in the LLNL site profile. This involves numerous LLNL-sponsored nuclear weapons tests, including atmospheric, underwater, and underground testing in the U.S. and at PPG. Hundreds of personnel were involved in weapons testing and the Plowshare program. The significance and potential dose contribution due to LLNL personnel participation in testing has not been considered in the site profile, which is of particular concern for those test sites without existing TBDs (e.g., Amchitka, Hattiesburg, PPG, etc.). NTS eventually became the repository for the PPG and NTS dosimetry results; however, dose records or evidence that they have been requested is not available for all claimants. There is no apparent explanation provided for the benefit of the dose reconstructor on when and how doses from testing should be considered. Scientists and support personnel were responsible for re-entries to collect diagnostic equipment, cloud sampling after atmospheric tests, and processing of core and air filter samples. They worked side by side with workers in Alaska, at the NTS during atmospheric testing, and at PPG during underwater and atmospheric testing. NIOSH has identified problems with dose reconstruction for both NTS and PPG. The TBD does not provide background information and guidance on how to assess potential missed dose for exposure during weapons tests, subcriticality test shots and experiments, and the Plowshare program at testing sites across the United States. There is no information on how dose reconstruction issues previously identified at the testing sites (e.g., from past respective site profile and Special Exposure Cohort (SEC) reviews) will be addressed.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**
Finding 2: Inadequate consideration has been given in the site profile to potential exposure received at Site 300. The site profile is incomplete in its description of activities occurring at Site 300 and the potential radiological exposure conditions associated with these activities. Minimal dose reconstruction guidance is provided for internal and environmental occupational dose. The assumption of semi-annual bioassay monitoring is in conflict with information provided by former Site 300 employees and, in some cases, results available in dosimetry files and electronic dosimetry databases. The LLNL Site Profile indicates that the sources of radiation exposure at Site 300 include accelerators, DU, activation products from accelerators, tritium, and radiography sources when in use. Batzel (1976b) indicated that the guidelines allowed for experiments with natural uranium, DU, natural thorium, tritium, and beryllium.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**

Sewell (1959) specifically authorized the thorium hydrodynamics program at Site 300 in 1959. No method for assessment of environmental dose from alpha emitters and tritium is available prior to 1961 and 1972, respectively. Potential extremity exposures may have occurred during hand contact with thorium and thorium alloy. An evaluation of non-hydroshot activities at Site 300 is minimally covered in the TBD, although workers were potentially exposed as a part of these activities. Further evaluation of the implemented monitoring for this area and its adequacy for the radionuclides involved in tests is necessary. Varying levels of personal protective equipment (PPE) were worn and bioassay was not routine, according to employees interviewed. In some cases, no protective clothing and/or respirators were used, and it is important to establish when this occurred. The work activities at the site appear to have had the potential for internal exposure, with some doubt that any bioassays were taken for monitoring such exposure.		
Finding 3: Completeness, accuracy, and availability of data used in dose reconstruction, and as a basis for the internal coworker approach, not adequately addressed in the TBD. Information available for dose reconstruction, especially for those involved in testing and special projects, is limited, inadequate, and sometimes not available. There are major issues with verifying the accuracy and usefulness of the data in MAPPER used for the coworker internal dose assessment method. Regarding the MAPPER database, LLNL staff members have indicated that some bioassays cannot be confidently associated with a specific person, and there are ambiguities in some analytes reported. These LLNL staff members indicated that large negative results are included for later periods, letters in the sample type column do not always indicate whether the sample was urine or fecal, and overall, that sample volume and mass must be interpreted carefully. There is very little discussion in the TBD about the quality of the earlier data (1950s–1960s). With the inconsistencies inherent in MAPPER, the use of these data for the internal dose coworker model is suspect and needs to be evaluated. During SC&A's review of classified documents, additional bioassay results were discovered that lead to questions regarding the adequacy of information currently being provided in the claimant files. These additional bioassay results found in classified records, not available for the dose reconstructor's use, could have an important effect on dose reconstruction of the individual claimant's dose. In light of these shortcomings, the verification process for determining the completeness and consistency of the internal dosimetry information provided in hard copy to dose reconstructors by the site needs to be addressed.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**
Finding 4: **The Occupational Internal Dose TBD (Berger and Szalinski 2005) has given inadequate consideration for the impact to worker dose from secondary radionuclides**. Numerous radionuclides were handled at LLNL, ranging from microcurie to curie quantities. These have included radium, Th-228, Th-232, Am-241, U-233, Cm-244, C-252, Pu-238, C-14, Na-22, P-32, S-35, I-125, I-131, Sr-90, N-13, and O-15, along with other fission products and activation products. Much of the bioassay data in the database are identified as "gross alpha" and "gross beta" results, and NIOSH has not identified which, if any, of these secondary radionuclides may be associated with these data. NIOSH has commented that the next revision of the Internal Dose TBD will contain guidance on the interpretation of gross alpha, gross beta, and fission product bioassay results. NIOSH needs to determine if there are potential exposures to these radionuclides that cannot be reconstructed accurately, due to inadequacies with the available radionuclide-specific information. These may be similar to the inadequacies cited in NIOSH's SEC evaluation report for	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**

Los Alamos National Laboratory (LANL) (NIOSH 2007). Radium is not identified (DOE 2004) as being used in any buildings or projects to a great extent; however, there is evidence that it may have been present at the site in some abundance. Exposure to a number of these radionuclides was not given adequate or, in some cases, any consideration in the internal dosimetry TBD, although some are listed as facility-specific radionuclides handled in particular technical areas.		
Finding 5: There is limited guidance on the interpretation of bioassay data for intakes of tritium, metal tritides, or organically bound tritium. While OTIB-0066 (ORAUT 2007g) was issued while the SC&A review was underway, and provided generic guidance on the calculation of dose from intakes of special tritium compounds, it only partially addresses some of the issues discussed below. According to the Site Description TBD (ORAUT-TKBS-0035-2), Building 331 (Hydrogen/Tritium Research Facility) had the bulk of the tritium inventory in elemental form or metal hydrides. Metal hydrides of tritium are special chemical forms for tritium, and are also called metal tritides (MT). These MTs are somewhat insoluble forms of tritium compounds (Inkret et al. 1999, Cheng et al. 1997) that do not exhibit similar biokinetic behavior to the more common forms of tritium, such as tritiated water (HTO) or elemental tritium. Tritium from MTs does not enter the systemic compartment as quickly as HTO after inhalation and, therefore, the interpretation of tritium urine bioassay data cannot be treated with standard tritium excretion models (McConville and Woods 1995). Due to being relatively insoluble, inhaled MTs deliver the highest component of dose contribution to the lungs. Tritium from these particles also can convert to organically bound tritium forms (OBTs) from contact with lung tissue and further complicate the metabolic process (DOE 2004). OBTs were not discussed in the TBD. It has been determined that OBTs cause a significantly larger dose than tritium, more routinely found in the form of tritiated water (HTO) (DOE 2004). Not addressing MTs or OBTs could lead to underestimating doses. Bounding techniques proposed in OTIB-0066 (ORAUT 2007g) cannot be effectively developed and applied without some basic understanding of the compounds handled and the extent to which individuals were exposed.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**
Finding 6: The Internal Dose TBD does not identify the possible chemical forms of the airborne radionuclides to which workers are exposed. The TBD is lacking information that allows for the identification of the possible chemical forms of the airborne radionuclides to which workers could have been exposed. This is needed in order to give guidance on the solubility (absorption) class to use (F, M, or S) for inhalation and intake dose assessment. The Occupational Internal Dose TBD (Berger and Szalinski 2005) states, "Other variables such as particle sizes and clearance classes can be readily reconstructed from historical records." No specific references are made to these historical records. There is no discussion on the potential for exposures to very insoluble and slowly absorbed high-fired plutonium. NIOSH has recently issued OTIB-0049 (ORAUT 2007b), which provides some assistance to the dose reconstructor with respect to high-fired plutonium; however, the LLNL TBDs do not identify the potential for this existing at the site.	Though this issue is important dosimetrically, it should be readily resolvable since it simply requires agreement on the most appropriate claimant favorable assumptions that should be used.	**5**
Finding 7: The Internal Dose TBD has not adequately identified and reviewed applicable bioassay frequencies and detection levels. In many cases, the information given for bioassay frequencies and detection levels is not useful, because of inaccuracy or lack of information. In the table showing bioassay frequencies, several in-vitro bioassays lack identification of radionuclides analyzed, and the frequency of	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**

whole-body counts (WBCs) for a period is missing. In addition, the table showing bioassay detection levels include values for in-vitro bioassay that disagree with historical site documents. Doses may not be calculated accurately without this information, and may not be claimant favorable. While the collective origins of these apparent discrepancies are not clear, more complete and validated information should be made available to dose reconstructors.		
Finding 8: No approaches are provided for determining the internal doses to workers that were unmonitored or inadequately monitored for plutonium, tritium, or other radionuclides. The *Internal Dosimetry Coworker Data for Lawrence Livermore National Laboratory*, OTIB-0065 (ORAUT 2007e), provides an approach for determining internal dose only for uranium intakes by unmonitored or inadequately monitored workers, but does not address plutonium, tritium, or other radionuclides. This includes workers that were exposed to radionuclides prior to any bioassay monitoring (appears to be <1960) and those not monitored or inadequately monitored after applicable bioassay became available. If additional guidance is available from other sources, it is not referenced in the TBD.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**
Finding 9: Criteria for Badging not sufficiently Defined in the External Dose TBD. LLNL is a large, complex site that has been in operation for over 50 years, with workers occupying several physical locations (LLNL proper, Site 300, PPG, and NTS). The Occupational External Dose TBD states that the personnel dosimetry records are generally available for all periods at LLNL for workers that had the potential for exposure to radiation (Thomas and Szalinski 2007, pg. 7). However, the TBD does not sufficiently define what workers were monitored, and what criteria were used to select those workers to allow determination of the adequacy of badging through the years. The use of the criterion that those with "significant potential for radiation exposure" were monitored could have left some workers unmonitored that, by later knowledge and standards, should have been monitored. For example, Nolan (1958) states that changes in the badging program of 1958 "…has brought to light exposures to personnel that were not being recorded and exposures of which we were unaware." The LLNL badging criterion for beta/photon radiation during the period 1952–1957 was that those workers with significant potential for radiation exposure were badged. Then in 1958, it was decided to provide beta/photon badges to all workers entering the site, regardless of exposure potential, as discussed in the External Dose TBD. This total badging policy is somewhat different than the criterion that is listed in Table 6-5 on page 14 of the TBD, where for 1952–present, it states that "All employees **with significant measurable exposure potential** were monitored continuously" [emphasis added]. This criterion would not necessarily include all workers entering the site. The latter statement is supported by gaps in monitoring, as noted on page 15 and annotation [7] of the TBD. The badging policy for neutron monitoring is even less defined than for beta/photons. It is not evident from the TBD that there were technically defined monitoring policies for neutrons, to ensure adequate external dose monitoring. Apparently, the badging policy for neutrons has been the same from 1952 to the present. This policy is that neutron badges are provided to workers where significant neutron exposures are possible, as noted on page 10 of the TBD. No definition of "significant" has been provided. Additionally,	Though this issue is important dosimetrically, it should be readily resolvable since it simply requires agreement on the most appropriate claimant-favorable assumptions that should be used for co-worker models. (if Findings 10, 11, and 12 are resolved, this finding should be readily resolvable).	5, conditional on resolving findings 10, 11, and 12.

the TBD concludes that if a worker was not badged for neutrons, there is no potential for neutron exposure. In view of the fact that so little is known about neutron badging policies and details concerning neutron fields (especially during the early years), there is no technical justification for concluding that unmonitored workers could not have been exposed to neutrons (Nolan 1958). This concern applies to both TLD neutron monitoring and when the dose reconstructor is to assign neutron dose using n/p values when NTA films were used.		
Finding 10: Insufficient Dose Data Analysis is Provided in the External Dose TBD. The External Dose TBD (Thomas and Szalinski 2007) does not provide the dose data analysis that is necessary to evaluate the adequacy of the dose data for the workers. It is stated that 95% of the workers were badged during 1952–1957. However, it is not clear from the TBD if this includes subcontractor, temporary workers, and the like. Additionally, no breakdown of the number of badges and workers by year was provided. It does not state if 95% of the workers were badged for beta/photon and neutrons, or just beta/photon. There are also no analyses of the recorded doses, such as maximum/means/minimum, and the number of zeros/blanks that occurred on a yearly basis. This type of data analysis should be presented and discussed in the site-specific Occupational External Dose TBD, or a site-related OTIB to determine if the workers were adequately monitored, and if there were any weak points in the monitoring programs that could result in unmonitored doses. Additionally, this information is necessary to verify any coworker model and/or data tables developed to assign dose to unmonitored workers, or to fill in gaps in monitored workers' dose records. Dose data analysis is especially important concerning neutron monitoring, because this type of information is necessary to (1) evaluate the adequacy of TLD neutron monitoring during 1970–present, and (2) to analyze the sufficiency of neutron badging during 1952–1969, because the dose reconstructor will use NTA badging as a guide to determine if the worker should be assigned neutron dose using the n/p method. Additionally, information concerning n/p data (or alternate methods) that will be used for assigning neutron doses during the period that NTA film was used needs to be provided.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**
Finding 11: Lack of Dosimetry Characterization Information Provided in the External Dose TBD. Throughout the Occupational External Dose TBD (Thomas and Szalinski 2007), the dose data records are presented as containing the correct dose received by the worker; however, a number of technical issues are not considered in this assumption. Lawrence Berkeley National Laboratory (LBNL) provided the dosimetry from 1952–1955; however, no details of calibration, response as a function of energy, geometry, mixed fields, or other pertinent parameters were provided. This was still an era when film dosimetry was being developed and some problems existed in dosimetry. Additionally, these response functions were not covered after 1955, when LLNL provided the dosimetry. These concerns apply to both beta/photon film and the derivation of applicable n/p values for assigning neutron dose instead of using NTA film results. Page 8 of the TBD (Thomas and Szalinski 2007) states that the dose reconstructor can compare earlier dosimetry systems to current systems to evaluate their performance. However, this is an area that should be addressed in detail in the TBD, and not a task relegated to the dose reconstructor. In addition to	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**

adjustment factors, dose uncertainties are not sufficiently addressed in the TBD. The recommendation on page 14 of the TBD that no adjustments be made to the beta/photon dose readings would indicate that the dosimetry system measured the correct external dose within a few percent for all radiation fields at all locations for the entire time period of 1952 to the present. This is most likely not the case, especially during the 1950s and 1960s. The only adjustment to the neutron doses was the recommendation on page 14 of the TBD, which was to multiply the recorded dose by a factor of 1.91 to account for the ICRP 60 (ICRP 1990) weighting factors. There are a number of areas concerning neutron dosimetry that are lacking in the present TBD and need to be addressed. These areas include neutron energy spectra, derivation/verification of n/p values; TLD and CR-39 response to different neutron energy spectra at LLNL; and calibration details. The very important task of deriving appropriate n/p values for LLNL was not provided in the TBD; instead, the results of a study done at the SRS (Scalsky 2005) were recommended. (The study at SRS was dependent on a study done at the Hanford site). The TBD recommends using the SRS n/p geometric mean (GM) value of 1.0, with geometric standard deviation (GSD) of 3.0, and an upper 95th percentile of 6.1. This value was stated without any documented analysis, supportive evidence, or determination of compatibility of neutron exposures between SRS and/or Hanford and LLNL. LLNL was one of the DOE centers for dosimetry development. From the available LLNL documents and publications (for example, Hankins 1975, Hankins 1976, and Slaughter and Reuppel 1977), it appears that much more pertinent information could be included in the TBD to assist in evaluating neutron fields and external doses to workers.		
Finding 12: Lack of an External Dose Coworker Model. The Occupational External Dose TBD (Thomas and Szalinski 2007) does not provide any coworker data/model/tables for use by the dose reconstructor in assigning doses to unmonitored workers, except to refer the dose reconstructor to Table 6E-2 in the LANL TBD (Widner 2005). Also, no TIB has been issued to date that covers unmonitored LLNL workers' external dose assignments using coworker data. This applies to beta, photon, and neutron radiation doses. Additionally, for an unmonitored worker (who has been deemed to have a low potential for exposure), it is recommended in the TBD that only the environmental dose be assigned. This would result in zero doses being assigned from any other radiation exposures, and could result in an underestimate of total dose. The TBD needs to be expanded to include, or reference made to a TIB that contains, detailed information that can assist the dose reconstructor in assigning technically sound external doses to undermonitored or unmonitored workers at LLNL.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**
Opportunities for Improvement These comments are included here for completeness. However, many are an extension of the findings presented and discussed above.		
(1) In the Occupational Internal Dose TBD (Berger and Szalinski 2005, Section 5.3.2, pg. 19), there are conflicting statements on how sampling was done. The first paragraph states the following: *The practice of offsite collection of samples, which takes place approximately 24 to*	All items seem to be readily resolvable as part of an update of the TBD, and assuming the above findings are also resolved.	4 for items 1, 2, and 5 5 for item 3.

	48 hours after leaving the site, not only minimizes the possibility of sample cross-contamination, but also ensures sample collection after the transfer of the rapid clearance component. Some LLNL employees might have been asked to submit samples after 1 or 2 days off from work; there could be notation of that instruction on the analytical record. The next paragraph states the following: *LLNL typically collected urine samples in the workplace, usually on a Wednesday. Therefore, contamination of samples from worker's hands or clothing cannot be ruled out as a contributor to any given result.* The first paragraph may have been discussing radionuclides other than tritium and the second paragraph was possibly about tritium, but this, or any other distinction, is not specified. Therefore, the section is confusing, apparently contradictory, and needs to be clarified to help the internal dose reconstructor.		3 for item 4.
(2)	In Section 5.3.2 of the Occupational Internal Dose TBD (Berger and Szalinski 2005), it states that, "Uncertainties associated with bioassay measurements were not stated in the records." Table 5-6 in this section, Bioassay record codes, states that column numbers 50–51 have the "Error," which is "One standard deviation as a percentage of the result." Therefore, it appears that the bioassay record could have the one standard deviation uncertainty expressed as a percent of the result value, which would allow the uncertainty to be calculated by multiplying the fractional value of the percent by the result.		
(3)	In Section 5.3.2 (Berger and Szalinski 2005), it states that, "If a data set shows an unusually high urinalysis result for a given radionuclide, and if follow-up samples were not consistent with the high result, dose reconstructors can consider the high result an outlier and disregard it." However, if the result is not obviously an outlier, it is claimant-favorable to assume the result is real. This guidance on identifying a high result as an "outlier" appears to be something that should have come from general guidance that is applicable to most, if not all, internal dose reconstructions done by NIOSH. It is very brief and not detailed enough guidance to ensure a dose reconstructor will perform consistent and claimant-favorable intake assessments. If there is more detailed guidance in a general bioassay interpretation procedure applicable to this data, then citing the reference (and possibly discussing it in more detail) is necessary. The above discussion is applicable to all parts of the TBD that address guidance from general procedures that are applicable to more than just LLNL or any other specific site. NIOSH should compare statements in the TBD to their recent generic guidance document for internal dose reconstruction, OTIB-0060 (ORAUT 2007c), and revise as necessary.		

(4) The TBD (Berger and Szalinski 2005) does not cite ICRP Publication 23, *Reference Man* (ICRP 1974), in the text, but it lists the document in the references. This publication has been updated and the TBD should list the replacement in the references (ICRP 2002). The update has larger volumes for daily urine excretion (1.6 liters/day for men, and 1.2 liters/day for women), and this is needed when converting urine bioassay radionuclide concentrations (pCi/liter, µg/liter, etc.) accurately to 24-hour sample activity results. If NIOSH does not agree that these updated urine excretion volumes are applicable to this dose reconstruction, it should be discussed. (5) The current version of the LLNL Occupational Environmental Dose TBD, ORAUT-TKBS-0035-4 (Thomas 2005), was published without air monitoring data prior to 1961 and tritium air monitoring data prior to 1972. The TBD (Thomas 2005, pg. 15) states that, "Efforts are currently in progress to develop estimated intakes for these missed periods and may be presented in a future revision of this TBD." Methods for exposure assessment should be developed for the early years. In the Occupational Medical Dose TBD (Turner 2005), NIOSH may need to focus additional attention to finding other sources that might shed more light on aspects such as operating parameters, screens used, film types, filtration used, number of retakes to produce a quality image, maintenance regimens, type and amount of collimation, and development parameters to better determine if these factors may have resulted in a greater uncertainty than envisioned in the TBD and, therefore, may have resulted in a greater dose per x-ray than is assumed in NCRP 1989 tables.		

PADUCAH

Table 7 summarizes each of the findings contained in SC&A's site profile review. As may be noted, out of the 21 findings, 7 were assigned to disposition category No. 1

Table 7. Paducah

Finding	SC&A Suggested Action for the Board to Consider	Suggested Disposition Category
Finding 1: Uranium Enrichment Levels Achieved at PGDP could be Higher than 2%. The Site Description TBD (Turpin 2006, pg. 7) states that PGDP enriched feed material (UF_6) up to about 2.5% ^{235}U. However, the default enrichment level specified in the Occupational Internal Dose TBD (Berger 2004) is only 2%. Although the assayed specific activity of ^{235}U in the cascade product is consistent with this enrichment level, the maximum assayed specific activity of ^{234}U is over 50% higher than the default activity of this isotope The higher activities provide the potential for higher radiation doses from ^{234}U and perhaps from ^{235}U than those calculated using the methodology prescribed in the TBD.	This finding has only significant dosimetric implications but should be readily resolvable by selecting an appropriately conservative assumption regarding enrichment for each worker.	**5**
Finding 2: The Number of Workers Assigned a Zero Dose should be Disclosed When Reporting the Mean of the Distribution of Doses. The average recorded doses in Tables 2-2 and 2-3 of the Site Description TBD (Turpin 2006, pg. 11) are biased low and mean little without knowing the numbers of workers assigned dose values of zero when their measured dose was less than the minimum detectable level (MDL).	This finding has only modest dosimetric implications and should be readily resolvable by selecting an appropriately conservative assumption regarding enrichment for each worker.	**4**
Finding 3: The TBD Needs to Consider Operations Other than Gaseous Diffusion. There is no mention in the Site Description TBD (Turpin 2006) of the smelting operations that took place in Building C-746B or the smelting of diffusion barriers (including K-25 and Portsmouth barriers) during the cascade improvement and upgrade programs. These activities need to be described, since they could have resulted in significant doses to some workers. Paducah participated in the "Work for Others" (WFO) program providing assistance to other DOE sites. There is no mention of this program in the TBD and how this may affect the dose reconstructions in terms of radionuclides.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**
Finding 4: The TBD Fails to Adequately Define and Assess Occupational Medical Exposure. The guidelines, as presented by Kathren (2003), go a long way in assuring that all occupational medical exposures are reasonably included in determining the overall dose estimations for claimants. Unfortunately,	This finding has modest dosimetric implications but should be readily resolvable by selecting an appropriately	**5**

these guidelines have not been applied in the TBD in a claimant-favorable manner	conservative assumption regarding enrichment for each worker.	
Finding 5: Contamination Control and Skin and Extremity Dose. The TBDs do not provide enough information regarding the radiological controls in place (or lack thereof) for the operations at PGDP that pose the potential for exposures. Especially in the early days, lack of adequate radiological controls could lead to worker doses that may be missed in the process of dose reconstruction, particularly for unmonitored workers. Such workers may not be identifiable without this understanding of the effectiveness of the radiological controls in place and for work practices where significant dose was possible. Contamination control was a significant problem and should be examined for its relevance to skin dose. This should be considered in the context of dose reconstruction. Some method for assignment of extremity dose should be developed where this area is affected by cancer.	This is a recurring issue at many sites and is being addressed as part of the issues resolution process for many other site profiles.	**2**
Finding 6: Onsite Environmental Exposures are based on Site Boundary Data. The TBD purports to describe "potential exposures from ambient sources while working outside the process buildings," but the ambient monitoring data in the document are for measurements at the site boundaries and beyond. There are no corroborating data provided to demonstrate that these measurements are consistent with the levels that workers might experience while working at the site outside the process buildings. Two additional sources of ambient exposure include the burning of contaminated material in onsite pits (i.e., routine and incidentally), and the alleged intentional releases that occurred in the 1950s.	This finding has relatively modest dosimetric implications and should be readily resolvable by selecting an appropriately conservative assumption regarding enrichment for each worker.	**4**
Finding 7: Inadequate Characterization of the Source Term for Internal Exposures. A critical issue is the specification of the source term for the internal exposures. The Internal Occupational Dose TBD (Berger 2004) does not fully utilize information presented in two key documents. One is the exposure assessment of workers at the PGDP (PACE/Utah 2000), which emphasized exposures to neptunium and plutonium. The other is the draft report on recycled uranium mass balance (BJC 2001), which is cited as a source of information by Turpin (2006), but is not mentioned by Berger.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**
Finding 8: Isotopic Fractions for Various Enrichments are not Properly Characterized in the TBD. An examination of the data in Table 5-2 of the TBD reveals a number of discrepancies. The most glaring one is the specific activity of ^{235}U in 93% enriched feed. A direct calculation yields an activity of 7.44E-2 Bq/µg, a factor of 10 higher than the listed value of 7.38E-3 Bq/µg.	This is an important issue dosimetrically, but should be readily resolvable based on an appropriately conservative assumption based on the available data.	**5**
Finding 9: The Default Isotopic Distribution in Table 5-4 Ignores Many Isotopes Associated with Recycled Uranium. Table 5-4 of the TBD lists default specific activities to be used when only total uranium results are	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for	**1**

available. This guidance ignores the information presented by Bechtel-Jacobs Corporation (BJC 2001, Table 2.4-1), which lists maximum concentrations of ^{99}Tc, ^{237}Np, and plutonium for 11 different operations at various facilities in the PGDP in various time periods. NIOSH should evaluate these data for use in the dose reconstructions of workers involved in these operations.	their resolution	
Finding 10: Particle Size of Inhaled Aerosols Assumed in the TBD is not Entirely Claimant Favorable. In Table 5-5 of the TBD, the particle size for inhaled aerosols is specified as 5 µm Aerodynamic Medial Activity Diameter (AMAD). Such a particle-size assignment is not supported by the data, nor is it claimant favorable, because particle sizes significantly less than 5 µm AMAD are cited in the supporting literature.	This is of only modest importance dosimetrically, but should be readily resolvable based on an appropriately conservative assumption based on the available data.	**5**
Finding 11: The List and Quantities of Transuranics Addressed in the TBD are not Complete or Claimant Favorable. Table 5-5 of the TBD limits transuranics (TRU) to ^{237}Np and ^{239}Pu. However, the TRU in the Hanford reactor tails and other sources include ^{238}Pu, ^{240}Pu, and ^{241}Am. In addition, information about the occurrence of TRU nuclides at different facilities is presented by PACE/Utah (2000, Appendix D), which lists various radiological data that need to be taken into consideration in the TBD.	1	**1**
Finding 12: Lung Clearance Types need to be clearly Defined and Claimant Favorable. The Lung Clearance Types, referred to as "Absorption Type" in Table 5-5, should be consistent with the chemical forms of each radionuclide. In case of uncertainty, the most claimant-favorable assumption should be adopted. The TBD is not always clear which chemical form and/or clearance type the dose reconstructor should assign to each element.	This is an important issue dosimetrically, but it should be readily resolved by selecting an appropriately conservative assumption regarding chemical form as applied to each worker and taking advantage of precedent set at other sites.	**5**

Finding 13: Radionuclide Intakes based on Bioassay Data Need to Take into Consideration Frequency of Sample Collection. Table 5-6 of the TBD lists the frequency of in-vitro measurements at various facilities at the PGDP during various time periods. The frequencies range from once every 4 weeks to once a year. The last row of the table lists a default frequency of once every 4 weeks. Since the interval between measurements could have been as long as 1 year, this default assumption is not claimant favorable. The longer the interval over which the intakes occurred, be they chronic or acute, the lower the urine concentration for a given total intake. Conversely, the longer the elapsed time (for acute intakes) or exposure duration (for chronic) for a given urine concentration, the greater the derived intake.	This is an important issue dosimetrically, but it should be readily resolved by selecting an appropriately conservative assumption regarding chemical form as applied to each worker and taking advantage of precedent set at other sites.	**5**
Finding 14: Minimum Detectable Concentrations are not Clearly Defined. In many cases, we could not verify the listed MDCs. For example, the MDC for total uranium by in-house fluorimetry is listed as 10 µg/L. None of documents cited as data sources for this table list that value; both PACE/Utah (2000) and SAIC (1999) cite typical MDCs of 5 µg/L. The MDC for natural uranium assayed at ORNL from 1999 to the present is in error; the source document (SAIC 1999) lists the MDC at 0.06 µg/sample, while Table 5-7 lists it as 0.06 mg (60 µg), a 1000-fold discrepancy. The latter value is clearly inconsistent with the value of 5 µg/L for kinetic phosphorescence analysis (KPA), used in 1977–1982. Table 5-7 lists a default detection level of 0.27 pCi/L for urinalysis of individual isotopes of actinide elements (Th, U, Pu, and Am). The TBD cites ICRP Publication 54 (Annals of the ICRP Vol. 19 No. 1–3) , *Individual Monitoring for Intakes of Radionuclides by Workers: Design and Interpretation* (Oxford: Pergamon Press) as the source of these data, which are based on alpha spectroscopy.[4] However, Table 5-7 lists higher levels—1 pCi/L for Pu isotopes and 0.3 pCi/L for uranium isotopes. If the dose reconstructor does not know the analytical method involved, this default assumption is neither claimant favorable nor scientifically correct.	This is of only modest importance dosimetrically, but should be readily resolvable based on an appropriately conservative assumption based on the available data.	**4**
Finding 15: Day of Sample Collection needs to be Taken into Consideration When Deriving Intakes based on Urine Analyses. Section 5.3.3 of the TBD states the following: > The practice of offsite collection of samples that takes place 24 to 48 hr after leaving the plant not only minimizes the possibility of sample cross-contamination, but it ensures that samples are collected after the transfer of the rapid clearance component. Some PGDP employees	This issue is of modest significance dosimetrically and is being addressed under other venues.	**2**

[4] We also note that ICRP Publication 54 has been replaced by ICRP Publication 78: *Individual Monitoring for Internal Exposure of Workers - Annals of the ICRP Volume 27/3-4, Replacement of ICRP Publication 54*, 1998 (Oxford:Pergamon Press).

were asked to collect samples after 1 or 2 days off from work; if so, that collection instruction was sometimes noted on the analytical record. The TBD fails to note that this practice would lead to a lowering of the calculated intakes, nor does it instruct dose reconstructors to be alert to any cases for which urine samples were collected after the worker was off work for any period of time. Appropriate adjustments to the calculated intake should be made to compensate for the lowered concentration in the urine following an absence from work.		
Finding 16: Additional Significant Incidents with Internal Dose Potential Need to be Discussed. Significant information that could be useful to dose reconstructors is not included in the TBD. This information includes statements by workers that urine specimens were collected within 30 minutes of an incident or accident, with a potential for elevated exposure. Such a short time period does not allow for equilibrium between the inhaled activity and the concentration in the urine, most likely resulting in a false negative. Follow-up samples were collected from workers who did show elevated levels of radioactive materials in the urine. More important are the statements of former workers that the bioassays performed following such incidents were not always recorded in the database. Thus, the doses from such incidents may not be in the worker exposure records.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**
Finding 17: The Coworker Model for Applying Bioassay Data to Unmonitored Workers is neither Scientifically Valid nor Claimant Favorable. In the coworker models used by NIOSH, workers are not classified by their jobs or by the buildings where they performed their work. In the TIB describing the coworker model for internal dosimetry (Ikenberry 2005), there is no attempt to sort the urinalysis results by job assignment or location to determine if there were any correlations between the uranium concentration in the urine and the building or department where the job was performed. In order to apply the coworker model to unmonitored workers, NIOSH needs to demonstrate that there is a low probability that any unmonitored worker could have higher exposures than the monitored workers taken as a group. Ikenberry (2005) fails to do so.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**
Finding 18: The Method of Converting Mass Concentrations of Uranium in Urine to 24-hour Excretions of Activity of Uranium Isotopes is neither Scientifically Valid nor Claimant Favorable. The TIB describing the coworker model for internal dosimetry (Ikenberry 2005) uses the non-claimant-favorable assumption about the specific activities of uranium isotopes presented in the internal dose TBD (Berger 2004). The default specific activity should be increased from 0.0389 Bq/µg to 0.0541 Bq/µg. The daily excretion of urine should be updated to reflect the latest ICRP (2002) recommendations: 1.6 L/d for male workers and 1.2 L/d for females.	This issue is of only modest significance dosimetrically and should be readily resolvable based on the available data.	**5**

Finding 19: Shallow Dose from Beta Emitters may have been Underestimated. According to the Occupational External Dose TBD (Turner 2005), the film badges used to derive skin doses from beta emitters employed a minimum absorber thickness of 80 mg/cm^2 between the film and the source, but the film badges appear to have been calibrated with a uranium slab without the absorber. Under these conditions, a large portion of the skin dose from weak betas emitted by uranium would not be detected, and the skin dose significantly underestimated.	This issue is being addressed under other venues.	**2**
Finding 20: Questionable Assumptions for Assigning Skin and Deep Dose for Unmonitored Workers Prior to 1960 by means of Coworker Data. SC&A is concerned that the coworker model described in the Occupational External Dose TBD (Turner 2005) is based on the assumption that prior to 1960, the population of ". . . monitored individuals represents those with the highest exposure potential." It is SC&A's contention that these monitoring data reflect a badging practice that not only included all worker categories (regardless of their potential for exposure), but furthermore diluted the average dose within a given worker category by rotating badge assignments. However, this issue appears to have been resolved with the issuance of ORAUT-OTIB-0031 (Merwin 2005).	It appears that this issue might have been addressed in OTIB-0031. This will need to be confirmed as part of the review process. However, for the purpose of this report, we are assuming that this issue is being addressed generically.	**3**
Finding 21: Assessment of Neutron Exposures at PGDP Appears to have been Underestimated. The principal sources of neutron exposures at PGDP involve the α, n reaction with fluorine compounds (UF_4, UF_6) and exposures to radionuclides that undergo spontaneous fission (i.e., TRU). However, based on the Occupational External Dose TBD (Turner 2005), it appears that reliable monitoring of neutron exposures did not begin until 1998, and NIOSH had to account for missed neutron dose based on worker activities and models that employ neutron-to-photon ratios. SC&A is concerned that the coworker model may not be dependable for exposures prior to 1961, due to a paucity of photon dosimetry at that time. Another document is the draft report on recycled uranium mass balance (BJC 2001), which is cited as a source of information by Turpin (2006), but is not mentioned in this TBD. That report breaks down the potential exposures to three contaminants in recycled uranium—^{99}Tc, ^{237}Np, and plutonium—into 11 types of activities and operations at the PGDP, and lists the maximum concentrations of each of these constituents (BJC 2001, Table 2.4-1).	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**

PORTSMOUTH

Table 8 summarizes each of the findings contained in SC&A's site profile review. As may be noted, out of the 14 findings, 8 were assigned to disposition category No. 1.

Table 8. Portsmouth

Finding	SC&A Suggested Action for the Board to Consider	Suggested Disposition Category
1. TBD-1 (Introduction). The Introduction describes the purpose and scope of the PORTS Site Profile. SC&A has no findings regarding information provided in TBD-1.	NA	
2. TBD-2 (Site Description). The Site Description TBD provides critical information regarding the historical and current status of facilities, processes, source terms, etc., at PORTS. SC&A's review identified the following finding: Finding 4.2.1. Based on site experts interviewed by SC&A, TBD-2 failed to identify/characterize several buildings/locations at PORTS that had the potential for worker exposures.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	1
3. TBD-3 (Occupational Medical Dose). The Occupational Medical Dose TBD provides guidance for reconstructing doses from diagnostic x-ray procedures required as a condition of employment. SC&A's evaluation of TBD-3 identified the following findings: Finding 4.3.1. At PORTS, available records that identify the use of photofluorography are incomplete and do not define a timeframe for its use. Although the TBD identifies two timeframes to dose reconstructors (1954–1960 versus 1954–1957), the **shorter timeframe** was selected and was based on a single record with a recorded date of October 1957. SC&A views the justification for the shorter time period (i.e., 1954–1957) as technically unsound, whimsical at best, and claimant unfavorable.	Though this could have significant dosimetric implications, it should be resolvable by making appropriately conservative assumptions, as delineated in OTIB-0006.	5
4. TBD-4 (Occupational Environmental Dose). TBD-4 provides data for the reconstruction of doses to unmonitored workers exposed onsite internally and externally from environmental releases. SC&A's review identified the following three findings with regard to **external** occupational environmental dose: Finding 4.4-1. Use of the generic ambient environmental dose of 35.9 mrem/y is too restrictive for **non-compensable** claims and claimant unfavorable.	This issue has only modest dosimetric implications and should be readily resolvable with the next revision of the TBD.	**4**
Finding 4.4-2. The default ambient environmental dose of 267 mrem/y to workers exposed at the Cylinder Storage Yards is without technical basis and may be too low.	SC&A considers these significant findings and will require	**1**

	considerable attention by NIOSH and the Board for their resolution	
Finding 4.4-3. Ambient environmental doses are confined to the deep dose that may significantly underestimate the potential shallow dose to the skin.	This issue has only modest dosimetric implications and should be readily resolvable with the next revision of the TBD. However, the skin dose could be considerable, and thus a portion of this finding is considered category 5.	**4/5**
5. TBD-5 (Occupational Internal Dose). At PORTS, internal exposure is dominated by uranium that existed over a wide range of enrichment. Other radionuclides of concern included transuranics and contaminants associated with recycled uranium. SC&A's review of TBD-5 identified the following six findings: Finding 4.5-1. TBD-5 provides activity values for transuranic (TRU) elements and Tc-99 in reactor tails processed at PORTS. Values cited for Tc-99 were understated by **several orders of magnitude.**	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**
Finding 4.5-2. Inconsistent bioassay protocols were employed that significantly affect the interpretation of urine bioassay data used for dose reconstruction.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**
Finding 4.5-3. Current guidance for estimating internal exposure to recycled uranium (RU) contaminants is unachievable and/or inappropriate.	This issue is being addressed globally by NIOSH. However, we will need to ensure that once NIOSH establishes its generic evaluation of RU issues, that work is applied appropriately to this site.	**3**
Finding 4.5-4. Empirical data suggest that the generic default value of 3.5% enrichment for uranium is inappropriate/claimant unfavorable for large segments of worker groupings.	Whether this issue can be resolved depends on available data on worker locations relative to enrichment handled.	**1**
Finding 4.5-5. TBD-5 contains contradictory/erroneous data and guidance that instructs the use of an incorrect minimum detectable concentration (MDC) value.	This issue is of only modest significance dosimetrically and should be resolvable with the next issue of the TBD.	**4**

Finding 4.5-6. Mobile In Vivo Radiation Monitoring Laboratory (MIVRML) chest counts for the detection of uranium, TRUs, and fission products are subject to significant limitations and uncertainties.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**
6. TBD-6 (Occupational External Dose). At PORTS, radiation fields contributing to external radiation included photons, neutrons, and betas. SC&A's review of TBD-6 identified the following four findings: Finding 4.6-1. The assumed LOD value for shallow dose (as defined by the two-element film dosimeter used between 1954 and 1980) lacks technical support and is not claimant favorable.	This issue is of only modest significance dosimetrically and should be resolvable with the next issue of the TBD.	**4**
Finding 4.6-2. Unmonitored shallow doses derived from coworker data suffer deficiencies that are likely the result of dosimeter design limitations and/or process policies.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**
Finding 4.6-3. External exposures to localized skin and to extremities were inadequately monitored, and guidance to dose reconstructors is too subjective and arbitrary.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**
Finding 4.6-4. Before 1992, PORTS failed to monitor workers for neutron exposures. Current guidance to account for unmonitored neutron exposures is incomplete.	SC&A considers these significant findings and will require considerable attention by NIOSH and the Board for their resolution	**1**

OAK RIDGE NATIONAL LABORATORY – X-10 SITE

Table 9 summarizes each of the findings contained in SC&A's site profile review. As may be noted, out of the 10 findings, 4 were assigned to disposition category No. 1.

Table 9. Oak Ridge National Laboratory - X-10 Site

Finding	SC&A Suggested Action for the Board to Consider	Suggested Disposition Category
Finding 1: Incomplete Dose Data for the Earlier Years. Information available for dose reconstruction in the early years is limited, inadequate, or in some cases, not available. External beta/gamma monitoring with film badges did not occur until June 1944, while routine neutron monitoring was not available until 1949. The neutron dose is reliant on application of a neutron-proton (n-p) ratio to the photon dose, yet the TBD questions the dose results from 1943–1944. Bioassay was not routinely available prior to 1949, and then only for a few radionuclides. Table 5A-2, page 39, of the Occupational Internal Dose TBD (Bollenbacher et al. 2006) provides minimum detectable activity (MDA) values that have been determined for gross alpha, gross beta, and 16 radionuclides found in urinalysis sampling, and gross alpha and 4 radionuclides found in fecal sampling. A method for identifying workers and assigning missed dose for those potentially exposed to all the assorted radionuclides for which MDAs have been determined (Table 5A-2, page 39) is lacking in this document. No consideration was given to early issues with significant beta exposures, which caused skin erythema. Consideration of dose from uranium particle releases and their subsequent deposition on the skin was not evaluated in the TBD. For 1944–1947, the TBD relies on air sampling data; however, very little information is provided related to its collection and analysis. Further evaluation should be provided to make sure this approach is bounding for unmonitored acute and chronic intakes.	This issue has substantial dosimetric implications and there are questions regarding data adequacy.	**1**
Finding 2: Inadequate Consideration of Missed Dose from Other Radionuclides. Although it acknowledges their existence, the Occupational Internal Dosimetry TBD ORAUT-TKBS-0012-5 (Bollenbacher et al. 2006) does not adequately address potential doses from secondary or so-called "exotic" radionuclides. The focus of the TBD is on "radionuclides likely to produce a measurable internal dose," including uranium, activation products, fission products, and transuranics. Numerous radionuclides were handled at ORNL ranging in quantities from fractions of a gram to kilograms. Radionuclides for which coworker dose is assigned included strontium, uranium, plutonium, Am-241, Cs-137, Ce-144, and Ru-106 (Kennedy 2005). Potential exposures to reactor- and accelerator-produced radionuclides have not been adequately considered. The TBD does not try to ascertain when radionuclides were present, in what quantities they were handled, and whether there were suitable methods available for monitoring these radionuclides.	This issue has substantial dosimetric implications and there are questions regarding data adequacy.	**1**

Finding 3: Problems with Neutron Doses. In view of several statements made in the Occupational External Dose TBD (Burns and Mohrbacher 2004), the use of NTA film to monitor neutron doses at ORNL raises several areas of concern. For example, page 23 of the TBD mentions that neutron energy spectra and neutron exposure data before the late 1980s are sparse, and that information is particularly lacking for many of the reactors that operated at ORNL early in its history. If n-p values are used instead of NTA dose records, these concerns are still valid, because using n-p values depends on a detailed knowledge of the gamma and neutron doses, and neutron energy spectra at each work location as a function of time.	This issue is of substantial dosimtric concern. However, it is being addressed in other venues and given the availability of data, should be readily resolvable, provided that NIOSH addresses the general issue of whether and when n/p data can be used..	**2/5**
Finding 4: Lack of Information Concerning Selection of Workers for Badging. The Occupational External Dose TBD (Burns and Mohrbacher 2004) does not provide sufficient details concerning who was badged and when, to ensure that workers were sufficiently monitored to allow for technically sound dose reconstruction. Page 11 of the TBD states that initially only employees required to work in restricted areas more than 3 days per week were issued beta-gamma monitoring, and that as late as 1956, there were no strict enforcement policies concerning the wearing of monitoring badges. Apparently, the workers that entered restricted areas only 1 or 2 days per week did not receive badges or any dose of record. Table 6-2, page 16, of the TBD provides a list of the characteristics of dosimeters from 1944 to present worn by *radiation* workers at ORNL, but does not describe what defined a radiation worker. The TBD needs to further refine who was (and was not) monitored and how those selections were made in order to be able to determine the adequacy of the dose records.	This issue has substantial dosimetric implications and there are questions regarding data adequacy.	**1**
Finding 5: Lack of Dose Assignment Procedure for Unmonitored Worker. The Occupational External Dose TBD (Burns and Mohrbacher 2004) does not provide a defined procedure to assign dose to unmonitored workers. Section 6.5.1 briefly mentions limits of detection (LOD) and provides Table 6-24, page 69, listing the LOD and exchange frequency as a function of time. However, this should only be applied to the dose missed by the dosimeter worn by a worker, not the dose missed because a worker was not badged. This applies to neutron as well as photon and beta doses. During these early years, an unmonitored worker could have received dose without management or the worker being fully aware of the hazards. The TBD needs to provide technically sound dose reconstruction procedures for assigning doses to unmonitored workers, especially in the early years (1943–1960s), when radiation hazards were not always recognized or effectively addressed.	This issue has substantial dosimetric implication, but should be readily resolvable once data adequacy issues, as described above, are addressed.	**5**
Finding 6: Lack of Data Validation and Verification. The validation and verification of the data used in dose reconstruction has not adequately been completed. There are indications that additional bioassay data exist that are not reflected in the database obtained by ORAU for the calculation of MDAs. For example, we became aware that the ORNL has not fully consolidated all the occupational exposure records, indicating that some records may not be complete. Also, the completeness and accuracy of the external dosimetry data may require further verification to ensure field-recorded dose results were integrated into occupational exposure records (OERs). This adds to uncertainty of these data. Finally, the environmental air sampling data ratios used in the development of co-worker dose from Ru-106, Ce-144, and Cs-137 should be further justified.	This issue has substantial dosimetric implications and there are questions regarding data adequacy.	**1**

Finding 7: The TBD Fails to Adequately Define and Assess Occupational Medical Exposure. The current medical exposure and dose guidelines, as presented in (Kathren 2003), go a long way in assuring that all occupational medical exposures are reasonably included in determining the overall dose estimations for claimants. Unfortunately, the interpretation to date by the contractor (ORAU) has not been applied too conservatively to be claimant favorable. The occupational medical dose TBD (Fleming 2006a) assumes an interpretation that also has been considered and applied at other sites, such as the Mound Plant and Los Alamos National Laboratory (LANL), Paducah, and Pinellas. To this extent, the assumption that medical procedures are limited to only one pre-employment chest x-ray and chest x-rays that are part of routine physical exams may substantially underestimate worker medical exposure when evaluating occupational medical exposure.	This issue has substantial dosimetric implications, but should be readily resolvable give the current state of knowledge regarding occupational medical doses.	**5**
Finding 8: Techniques and Protocols Increase Uncertainty of DCFs listed in the TBD. The Occupational Medical Dose TBD (Fleming 2006a) provides little documentation to support the assumed techniques and protocols applied to calculate the dose, which is mainly derived from NCRP Report 102. The TBD states that a posterior-anterior (PA) chest x-ray was typically the only view taken. It is an undocumented assumption in the TBD that exams required only a PA view. SC&A has inquired whether definitive protocol existed to validate that chest exams possibly included PA views and lateral (LAT) views on a limited basis. NIOSH has acknowledged in other TBD reviews that the lack of verifiable protocols is a generic problem at many sites, has planned to search all available records, and will include pertinent records and references in any future revision of this section of the TBD. The Occupational Medical Dose TBD is also deficient in that little documentation exists to validate x-ray protocols, equipment maintenance, and upkeep records.	This issue has substantial dosimetric implications, but should be readily resolvable give the current state of knowledge regarding occupational medical doses.	**5**
Finding 9: Frequency and Type of X-ray Exposure is Uncertain. The Occupational Medical Dose TBD in Section 3 provides no documentation or references to support the assumption that only a limited group of workers received annual x-ray exams after 1970. To the contrary, up until about 1985, most DOE sites performed chest x-rays almost on a voluntary basis. DOE medical program reviews documented during the early 1990s showed many sites still used chest radiography as a general screening exam. Most workers accepted chest x-rays, even though the job did not require it. Also, the assumption that workers in special exposure categories, such as beryllium workers, were given chest x-rays only as part of their routine physical is not well-documented and not consistent with special screening guidelines. The TBD applies no conservative assumption to cover such exams.	This issue has substantial dosimetric implications, but should be readily resolvable give the current state of knowledge regarding occupational medical doses.	**5**
Finding 10: Inadequate Consideration of Environmental Dose from Radionuclides Other than I-131 and Tritium. The Occupational Environmental Dose TBD (Fleming 2006a) focuses on onsite airborne I-131 concentration, onsite airborne concentration of MFPs, onsite airborne concentrations of tritium, and onsite exposure rate data. Reactors' releases and waste farms data are not adequately considered	This issue may or may not have relatively modest dosimetric implications and should be resolvable in the next revision of the TBD.	**4/5**