various cells. It is not readily comprehensible or user-friendly. There are no help pages to assist dose reconstructors in walking through data entry, default values and parameters selection, and dose calculation process. We also understand that there is no accompanying manual to the spreadsheet. While we know that the spreadsheet is intended for viewing and use only by the cognoscenti performing claimant reviews, some guidance and explanation should be provided to ensure that it is being used correctly.

Observation 2: The four authors of the INL TBDs and TIB are the most site-specific experienced and knowledgeable technical experts working on the development of the INL site profile. These four authors were intimately involved in the development, management, and implementation of the INL Radiological and Dosimetry programs in the past and the present. They understandably demonstrate confidence in the INL radiological protection programs. They relied heavily on their own experience and knowledge, and past INL environmental reports and dosimetry records in developing the TBDs, and used many of the reports that they personally authored as reference material. They did not interview any present or retired workers before they completed their work. They did not review any safety-related audit reports conducted by DOE-HQ and DNFSB, but they did interview some of the current INL staff and requested all dosimetry records.

6.0 OVERALL ADEQUACY OF THE INL SITE PROFILE AS A BASIS FOR DOSE RECONSTRUCTION

The SC&A site profile review procedure calls for both a "vertical" assessment of a site profile for purposes of evaluating specific issues of adequacy and completeness, and a "horizontal" assessment of how the profile satisfies its intended purpose and scope. This section addresses the latter objective by evaluating (1) how, and to what extent, the site profile satisfies each of the five objectives defined by the Advisory Board for ascertaining adequacy; (2) the usability of the site profile for its intended purpose (i.e., to provide a generalized technical resource for the dose reconstructor when individual dose records are unavailable); and (3) generic technical or policy issues that transcend any single site profile that need to be addressed by the Advisory Board and NIOSH. As mentioned in the Introduction, the practice of addressing the same items from several different perspectives has led to some redundancy in the report.

6.1 SATISFYING THE FIVE OBJECTIVES

The SC&A review procedure, as approved by the Advisory Board, requires that each site profile be evaluated against five measures of adequacy; (1) completeness of data sources, (2) technical accuracy, (3) adequacy of data, (4) site profile consistency, and (5) regulatory compliance. The SC&A review of the INL site profile finds that the profile generally satisfies these objectives, although several shortcomings and potential issues of varying significance need to be addressed. Many of the issues involve a lack of sufficient conservatism in key assumptions or estimation approaches, incomplete analyses of data, or incomplete reflection of operational or dosimetric history. Key issues are summarized below and in Table 6-1 (which is a duplicate of Table 1-1), which provides a matrix representation of the identified issues sorted according to the SC&A findings and observations. Detailed evaluation and discussion of these issues is provided elsewhere in this report.

An "X" in the table indicates significant shortfalls in meeting the corresponding review objectives for the indicated topics in the INL site profile. These shortfalls have been discussed either within the text of the findings themselves, or, in many cases, in special sections that address one or more of these shortfalls. The first column of the table indicates the primary place within the report that treats each issue. The last column of the table presents three categories of potential related regulatory non-compliance concern for the listed issues. These three categories are defined again briefly as follows:

- Category 1: Least challenged by any deficiencies in available dose/monitoring data are dose reconstructions for which even a partial assessment (or minimized dose(s)) corresponds to a probability of causation (POC) value in excess of 50%, and assures compensability to the claimant.

- Category 2: The use of upper bound values is limited to those instances where the resultant maximized doses yield POC values below 50%, which are not compensated. For this second category, the dose reconstructor needs only to ensure that all potential internal and external exposure pathways have been considered.

- Category 3: The most complex and challenging dose reconstruction represents claims where the case cannot be dealt with under one of the previous two categories and a detailed analysis is required.

Table 6-1: Issue Matrix for the INL Site Profile

Descriptions (a)	Issue Classification	Objective 1: Completeness Of Data	Objective 2: Technical Accuracy	Objective 3: Adequacy of Data	Objective 4: Site Profile Consistency	Objective 5: Regulatory Compliance (b)
Issue 1: (5.1.1.1) Routine Airborne Releases	Finding (5)	X	X	X	X	Category 2
Issue 2: (5.1.1.2) Episodic Airborne Release	Finding (6)	X	X	X	X	Category 2
Issue 3: (5.1.1.3) Direct Gamma Exposures	Finding (7)	X	X	X	X	Category 2
Issue 4: (5.1.2.1) Completeness and Quality of INL Internal Dosimetry Programs	Finding (8)	X	X	X	X	Category 3
Issue 5: (5.1.2.2) High-Risk Jobs (Internal Exposure)	Finding (9)	X				Category 1
Issue 6: (5.1.2.3) Calibration of Internal Dosimetry Analytical and Monitoring Equipment	Observation		X		X	
Issue 7: (5.1.2.4) Changes of Internal Dose Limits	Observation		X			
Issue 8: (5.1.2.5) High Fired Plutonium and Uranium Intakes	Finding (10)	X				Category 1
Issue 9: (5.1.2.6) Skin and Facial Contamination	Observation	X				Category 3
Issue 10: (5.1.2.7) Breathing Rates	Observation	X				
Issue 11: (5.1.2.8) Non-Occupational Worker Elimination of DU Background	Finding (11)	X	X	X		Category 2
Issue 12: (5.1.2.9) Unmonitored Workers	Observation	X				
Issue 13: (5.1.2.10) Naval Reactor Facility Workers	Observation	X				Category 2
Issue 14: (5.1.2.11) Plutonium Monitoring	Observation	X	X	X		Category 1
Issue 15: (5.1.3) SL-1 Accident Dose Reconstructions	Finding (1)	X	X	X		
Issue 16: (5.1.4.1.1) Completeness and Quality of INL Beta/Gamma Dosimetry and Record Keeping Programs	Finding (8)	X		X	X	Category 3
Issue 17: (5.1.4.1.2) Penetrating and Non-Penetrating Doses	Finding (4)	X	X	X	X	Category 3
Issue 18: (5.1.4.1.3) Correction For Beta Doses	Observation		X		X	
Issue 19: (5.1.4.1.4) Angular Dependence Correction Factor for Gamma Dose	Observation	X				
Issue 20: (5.1.4.1.5) Restating Beta Dose As Gamma Dose	Observation		X			
Issue 21: (5.1.4.1.6) Photon Spectrum Split	Observation		X		X	
Issue 22: (5.1.4.1.7) Immersion Dose	Observation	X	X	X		
Issue 23: (5.1.4.1.8) High-Risk Jobs (Beta/Gamma Exposure)	Finding (9)	X				Category 1
Issue 24: (5.1.4.1.9) Extremity Dose	Observation	X				Category 2
Issue 25: (5.1.4.1.10) Discrepancies between PIC and Film Reading	Observation	X				
Issue 26: (5.1.4.1.11) Minimum	Observation			X	X	

Table 6-1: Issue Matrix for the INL Site Profile

Descriptions (a)	Issue Classification	Objective 1: Completeness Of Data	Objective 2: Technical Accuracy	Objective 3: Adequacy of Data	Objective 4: Site Profile Consistency	Objective 5: Regulatory Compliance (b)
Detection Limit						
Issue 27: (5.1.4.1.12) Minimum Reporting Level (Beta/Gamma)	Finding (3)	X	X	X		Category 2
Issue 28: (5.1.4.2.1) Minimum Reporting Level (Neutron)	Finding (3)	X	X	X		Category 2
Issue 29: (5.1.4.2.2) Failure to Properly Address Neutron Exposures	Finding (2)	X	X	X	X	Category 1
Issue 30: (5.1.4.2.3) Neutron Calibration Deficiencies	Finding (2)	X	X	X		Category 3
Issue 31: (5.1.4.2.4) Completeness and Quality of INL Neutron Dosimetry and Record Keeping Programs	Finding (8)	X	X	X	X	Category 3
Issue 32: (5.1.4.2.5) Uncertainty Estimation for Neutron Doses	Observation	X	X	X		
Issue 33: (5.1.4.2.6) Neutron Organ Dose	Observation	X				
Issue 34: (5.1.4.2.7) High-Risk Jobs (Neutron Exposure)	Finding (9)	X				Category 1
Issue 35: (5.1.4.2.8) Multiplying Factors for Missed Neutron Dose	Observation	X	X	X	X	Category 3

Table Notes:

(a) Report section numbers discussing the issues are given after the issue number.

(b) Category 1: Least challenged by any deficiencies in available dose/monitoring data are dose reconstructions for which even a partial assessment (or minimized dose(s)) corresponds to a probability of causation (POC) value in excess of 50%, and assures compensability to the claimant.

Category 2: The use of upper bound values is limited to those instances where the resultant maximized doses yield POC values below 50%, which are not compensated. For this second category, the dose reconstructor needs only to ensure that all potential internal and external exposure pathways have been considered.

Category 3: The most complex and challenging dose reconstruction represents claims where the case cannot be dealt with under one of the two other categories.

6.1.1 Objective 1: Completeness of Data Sources

The breadth of data sources used as a basis for the INL Site Profile is evident in the 287 reports, papers, and other documents cited as references, including a number of authoritative historical documents dating back to the start of site operations in the early 1950s. Based on a review of the INL Site Description TBD (Rohrig 2004s), it is evident that NIOSH effectively compiled and characterized activities and operations at 14 areas and 101 facilities and processes. In fact, this review cites the breadth of operational data provided in several places as a strength. Also noteworthy is the use of the minimum reporting levels as a simple approach (Taulbee 2002) for calculating missed external doses for workers that are provided in Attachment 6B of the Occupational External Dose TBD (Rohrig 2004e). Notwithstanding the general excellence of the data sources, SC&A identified a number of areas to be deficient:

(1) The workers interviewed by SC&A as part of the site expert interview process (Attachments 2 and 3) characterized the site as having areas and jobs capable of delivering acute doses to workers. SC&A found that the TBDs lack separate characterization and in-depth consideration of high-risk/dose (acute) jobs at INL facilities. Although extensive descriptions of key operations and processing facilities are included

in the TBD, high-risk or high-dose jobs in the INL facilities have not been evaluated and potential missed doses are not considered.

(2) SC&A found a lack of characterization of potential missed neutron exposures to workers at the INL reactors in the Occupational External Dose TBD, even though INL had a total of 52 reactors, most of which were experimental/prototype in design. These reactors often were built with high power densities and with minimum shielding and neutron moderation. It is inadequate to presume that there are no missed neutron doses at INL reactors.

(3) SC&A found a lack of characterization of contaminated soil or materials stored outdoors at INL facilities, such as RWMC or ICPP, in the Occupational Environmental Dose TBD. For example, dry contaminated evaporation ponds at the reactor and fuel processing facilities are not characterized. The contaminated soils or materials that are present may be resuspended by blowing winds and vehicular activities, and inhaled by unmonitored employees working outside the facility buildings. In addition, the TBD did not evaluate the adequacy of the environmental monitoring instrumentation and validity of its collected data.

(4) SC&A found a lack of characterization of potential worker exposures at the High-Level Liquid Waste Tank Farms (at TAN, ICPP, and TRA), and in remediation and waste management in general. The list of radionuclides provided for those operations is incomplete and increases the potential for missed dose.

(5) The authors of the TBDs demonstrate their general confidence with the radiological protection practices, environmental monitoring programs, internal dosimetry programs, external dosimetry programs, analytical laboratory programs, quality assurance programs, and above all, the dosimetry record-keeping systems at INL over the entire operating history. Perhaps as a consequence, the TBDs do not consider potential missed doses due to deficient work practices and missing worker dose records. NIOSH did not request and review field data and facility specific records, including field log books, RWPs, PEQs, incident reports, occurrence reports, and contamination reports that may provide data and information for missed worker doses. It is important for NIOSH to validate that all pertinent records (such as incident report, personnel contamination reports, over-exposure reports, doses received at other DOE facilities due to temporary assignments, and other records essential for the dose reconstruction) are included in the worker files provided by DOE to the claimants.

(6) SC&A also found an inadequate characterization of worker internal exposures. The site profile evaluated the recorded worker internal doses only for the period between 1992 and 2000, which does not cover the more problematic early years of the INL site operation from 1949 to 1991. Instead, the TBD evaluated urinalysis results for 1959, 1960, and 1961, and whole-body counting results for 1963. The TBD also provides in vitro for urine samples and in-vivo MDAs for the entire site history. These data are not sufficient to provide any comparison or support for the missed worker internal doses.

(7) The TBDs do not characterize or provide any information on the potential missed worker doses due to extremity exposure, skin contamination, facial contamination, and ingestion. Many of these potential missed worker doses could be found at various facilities, such as ICPP and SMC.

(8) The TBDs also lack characterization of the potential missed internal and external doses for the hundreds of rescue and cleanup workers involved with the SL-1 accident that occurred in January 1961. It is a fact that the equipment used and the radiological control policies in that era were not as advanced and protective as those currently available. The TBDs should provide adjustment factors for stay-time used, dose field estimates, internal dose results, external dose readings, and contamination level estimates.

6.1.2 Objective 2: Technical Accuracy

There are a number of issues identified in the course of this review that may be classified as deficiencies in technical accuracy:

(1) 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 employees working at the SMC facility. A better approach would be to use urine samples from non-INL people in the Idaho Falls area, far removed from any sources of radioactivity. 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 interviews, the dosimetry staff indicated that they tried to use residents from the Idaho Falls area, but no one was willing to sign a liability waiver form. In a subsequent study, they used 16 non-radiation workers from the CFA. In addition, the selected background value (0.16 µg/L) is significantly higher than the national average background value.

(2) There are deficiencies in the neutron calibration program at INL. Due to the use of a PoBe source for neutron calibrations, dosimeters would significantly under measure neutron doses from sources with lower energy spectra. These deficiencies could cause significant missed neutron doses.

(3) The technical accuracy of the approach suggested for estimating missed internal doses for workers exposed to plutonium or uranium whose intakes (mainly inhalation) were assessed mainly by in-vivo counts is not scientifically established. The approach is not persuasive in view of the varying age and isotopic composition of plutonium or uranium at the INL site (similar to Hanford).

(4) The overall approach of the Occupational Internal Dose TBD is to use the significant radionuclides for ICPP processed fuels as the most limiting (bounding) source terms for the calculation of missed worker internal doses. These source terms were suggested to be well-tagged with beta-emitting radionuclides, which allowed beta/gamma-detecting

CAMs to be used at ICPP. As a result, all possible alpha contamination or internal exposures would have been detected and monitored. In reality, there are facilities and areas at INL, such as the calciners, where alphas sources predominate and beta-emitting radionuclides cannot be used as a tag. Hence, the overall approach reported in the TBD is not sound and bounding, because it ignores the fact that there were shortcomings in the earlier CAM systems and also deficiencies in the internal exposure control work practices at ICPP and other INL facilities. Many site experts interviewed indicated that there were significant incidents where internal over-exposures and personnel contamination occurred at INL facilities that were not monitored or documented.

(5) The MESODIF model (mesoscale isopleths) used in the Occupational Environmental Dose TBD to determine the ground radionuclide concentrations from airborne releases due to routine operations or episodic events from INL facilities was found to be deficient by the DOE-HQ Tiger Team in 1991 (DOE-HQ 1991). These concentrations were used to calculate the default worker intake values in different INL facilities. Therefore, the validity of default intake values provided in Tables 4-1 through 4-12 is jeopardized. NIOSH should evaluate the deficiencies in the model and determine the associated uncertainties. Specifically, the TBD did not evaluate the doses to workers outdoors associated with episodic releases to the atmosphere.

(6) The Occupational Environmental Dose TBD uses the fence-line TLD results provided in the environmental monitoring data reports to determine the direct gamma doses from airborne releases and their cumulative ground depositions to personnel working outdoors. This approach assumes all workers working outdoors at a specific facility would receive an average direct gamma dose from normalized ground concentrations. If the assumption were valid, the fence-line TLD results should be adjusted by multiplying a weighting factor to account for uncertainties in TLD sensitivity and geometry. However, this approach is not entirely valid, because it does not take into account the most limiting scenarios, i.e., (1) outdoor workers may become immersed in the plume of routine or episodic releases from the facility stack; (2) outdoor workers may inhale resuspended cumulative ground radionuclide depositions; and (3) the cumulative ground concentrations inside the fence line are generally higher than that 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 is not claimant favorable.

(7) The approach in calculating the missed external doses (both gamma and neutron) by using the minimum reporting level equation is not claimant favorable. This suggested approach is based on OCAS-IG-001 (Taulbee 2002), which assumes a statistical average dose value (MRL/2) for all workers. However, the dose reconstruction for a particular worker, especially in a compensable case (with cancer), should use the bounding dose value (i.e., MRL instead of MRL/2). In addition, the development of the MRL values was not comprehensive in the Occupational External Dose TBD, and 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 dosimeters.

6.1.3 Objective 3: Adequacy of Data

(1) Questions regarding data adequacy, where they arise in the SC&A evaluation, have largely focused on the adequacy of available facility release data and fence line TLD dose values for estimating occupational environmental doses to unmonitored outdoor workers, who may have been immersed in release plumes, inhaled resuspended contaminated soils, and exposed to direct gamma radiation from accumulated ground depositions.

(2) Since the Occupational Internal Dose TBD does not use dosimetry data, SC&A focused on the adequacy of processed fuel characteristic data for estimating missed internal doses to unmonitored workers, who more likely have had missed doses due to inconsistent monitoring in the field in the early monitoring programs, from high-risk jobs, or unplanned intake or contamination incidents. The same is true for missed gamma and neutron doses.

(3) SC&A also found that the TBDs do not fully explore and develop procedures and guidelines to dose reconstructors that would lead them to focus on gaps in environmental, internal, and external doses that could lead to a significant underestimate of worker dose. Input from interviewed site experts indicates that there were situations where reactor workers were not provided neutron dosimeters or were not monitored on a continual basis, and where processing facility workers were not monitored when they had positive nose smears. Data either presented in the TBDs, or on which the TBDs are based, cannot be considered adequate unless an evaluation is conducted of the comprehensiveness of the neutron-monitoring and bioassay programs, and to what extent existing dose estimation assumptions and methodologies address this potential missed dose.

(4) The lack of actual worker bioassay data during the 1949−1991 period represents an important area in which adequacy of data is of concern. There are no data provided in the TBD concerning bioassay of high-fired plutonium and uranium. There may be workers with potentially high exposures during that period that cannot be adequately reconstructed, especially when worst-case dose reconstructions are required. Lack of knowledge of uncertainties in the actual bioassay techniques and instruments used to quantify internal dose and the minimum detectable activity (MDAs) represents an area of data inadequacy that can lead to significant underestimates of worker dose in this period.

(5) The source term list of radionuclides provided for the current and past environmental restoration and waste management projects at INL is incomplete and may contribute to missed dose. Risks of exposure to radionuclides that workers have encountered when retrieving and processing RWMC's stored TRU waste have not been adequately addressed.

(6) INL documented worker exposure incidents and unusual occurrences in facility record files. Although INL has significant quantities of personnel monitoring data, as well as field radiological control data, there are considerable gaps in the information. In many cases, some of this information may not be kept in the worker exposure files. In addition, there are problems with the adequacy of data, particularly with regard to worker intake,

high beta exposure, and extremity dose for high-risk (dose) jobs in some facilities, such as ICPP and reactors.

(7) INL maintained worker exposure records by including (some) dosimetry results and facility incident reports in the worker files. There are problems with the completeness of these worker files, however, with regard to worker intake results, external dose results, extremity doses, and contamination reports.

6.1.4 Objective 4: Consistency Among Site Profiles

(1) While INL, Hanford, and the Savannah River Site (SRS) had some missions that were similar, marked distinctions existed and continue to exist in facility design, operations, operational history, and radiological practice. NIOSH has appreciated this distinction and tailored its TBD assumptions and analytic approaches to the unique histories and conditions at the three sites, while mirroring those assumptions and approaches where justified. Both the Hanford and SRS site profiles predate the INL site profile; therefore, NIOSH benefited greatly from the early efforts at Hanford and SRS, and was able to remedy many of the apparent inconsistencies, especially in the SRS TBDs.

(2) Attachment 4 of this SC&A report provides, in tabular form (Tables A1–A4), an evaluation and comparison of the default assumptions for each element of exposure (i.e., occupational medical dose, occupational internal dose, occupational external dose, and occupational environmental dose) of INL, Hanford, and Savannah River. The lapses in consistency noted by SC&A include inconsistent methodologies and assumptions regarding external, internal, and environmental dose for almost identical monitoring and exposure conditions at the three sites. This comparison shows that the INL TBDs did not provide as much characterization of the default internal dose parameters and external exposure factors as the Hanford and SRS TBDs.

(3) An extensive comparison was performed by SC&A to compare and contrast the methodologies used in the INL, Hanford, and SRS TBDs to determine external dose. This comparison focuses on the methodologies and assumptions associated with dose assessments and the derivation of values used to obtain a POC for individual claimants. A detailed analysis is provided in Table A-4 of Attachment 4 to this report. This table notes where the INL, Hanford, and SRS site profiles differ or agree on a number of important assumptions. In summary, where inconsistent approaches or methods exist, they typically represent some lapses present in the INL TBD, despite NIOSH's experience with Hanford, SRS, and earlier reviews.

6.1.5 Objective 5: Regulatory Compliance

NIOSH has complied with the hierarchy of data required under 42 CFR Part 82 and its implementation guides. However, SC&A has identified some significant shortcomings of the data used in the review process of the INL Site Profile that may lead to dose reconstructions that are not claimant favorable. It is especially crucial for NIOSH to re-evaluate the technical basis of the missed dose assumptions used in the TBDs.

6.2 USABILITY OF SITE PROFILE FOR INTENDED PURPOSE

SC&A has identified seven criteria that reflect the intent of the Energy Employees Occupational Illness Compensation Program Act of 2000, the Final Rule, and the regulatory requirements of 42 CFR Part 82 for dose reconstruction. Because the purpose of a site profile is to support the dose reconstruction process, it is critical that the site profile assumptions, analytic approaches, and procedural directions be clear, accurate, complete, and auditable (i.e., sufficiently documented). SC&A used the following seven objectives to guide its review of the INL site profile to determine whether it meets these criteria:

- Objective 1 − Determine the degree to which procedures support a process that is expeditious and timely for dose reconstruction

- Objective 2 − Determine whether procedures provide adequate guidance to be efficient in select instances where a more detailed approach to dose reconstruction would not affect the outcome

- Objective 3 − Assess the extent to which procedures account for all potential exposures and ensure that resultant doses are complete and are based on adequate data

- Objective 4 − Assess procedures for providing a consistent approach to dose reconstruction, regardless of claimants' exposures by time and employment locations

- Objective 5 − Evaluate procedures with regard to fairness and the extent to which the claimant is given the benefit of the doubt when there are unknowns and uncertainties concerning radiation exposures

- Objective 6 − Evaluate procedures for their approach to quantifying the uncertainty distribution of annual dose estimates that is consistent with and supports a DOL POC estimate at the upper 99% confidence level

- Objective 7 − Assess the scientific and technical quality of methods and guidance contained in procedures to ensure that they reflect the proper balance between current/consensus scientific methods and dose reconstruction efficiency

The following addresses these objectives:

(1) The INL site profile does a very good job in the Occupational Medical Dose TBD in assessing the potential organ doses to workers who received medical x-ray examination over the entire operating history. The default organ dose values can be easily identified and used from Table 3A-1 (Rohrig 2004m). One potential opportunity to improve the validity of the dose assessment is to include a multiplying factor accounting for uncertainties in equipment parameters.

(2) The INL Occupational Environmental Dose TBD presents a thorough compilation of the airborne releases from routine operations and episodic events at INL facilities. The TBD

also compiles extensive information on the fence line direct gamma doses for different INL facilities. The default worker inhalation intake and direct gamma doses to workers can be determined and used from Tables 4-1 through 4-13 (Peterson 2004). The missed environmental doses from the airborne releases and fence line gamma doses should not be significant. However, the TBD has not considered several important potential missed environmental dose streams, including unmonitored workers inhaling resuspended contaminated soils or materials.

(3) The INL Occupational Internal Dose TBD (Rich and Wenzel 2004) does not mention the use of ORAUT-OTIB-0011 (Siebert 2004) for calculating doses from tritium and estimating missed doses from this nuclide. There was a small amount of tritium produced at INL facilities in early years. Dose reconstructors should be alerted to the use of this technical information bulletin (TIB).

(4) The INL TBD does not address the opportunity to use surrogate (i.e., reference mix) radionuclides when data are not available for a less commonly encountered radionuclide and thus the 95^{th} percentile cannot be applied in estimating the upper bounds of a like dose.

(5) The INL Internal Dose TBD does not mention the use of an approach recommended for other similar DOE facilities when determining maximum dose. This approach is provided by NIOSH in ORAUT OTIB-0002 (Rollins 2004).

(6) The Occupational Internal Dose TBD does not provide bioassay data for the operating years before 1992. For the purpose of compiling data needed to reconstruct internal doses based on historical operation, NIOSH amassed a considerable amount of data describing radionuclides and operations at the various facilities and their associated processes. However, NIOSH does not give adequate (or explicit) guidance to dose reconstructors on how to navigate through the complex mix of radionuclides required to reconstruct historical internal exposures to workers. There are opportunities for improvement in the data sets and instructions to the dose reconstructors with respect to reconstructing internal exposures.

(7) The INL Occupational External Dose TBD does not provide external dose data for the operating history of the INL site. For the purpose of compiling data needed to reconstruct external doses (gamma, beta, and neutron), NIOSH evaluates the MRL values of different dosimetry systems (films, TLDs, and neutron dosimeters) used at INL facilities. In addition, the TBD provides information on external radiation fields at different facilities. However, NIOSH does not give guidance to dose reconstructors on how to use these data to reconstruct historical external exposures to workers from high-risk jobs, unplanned over-exposure incidents, and deficient monitoring in the field. There are opportunities for improvement in the data sets and instructions to the dose reconstructors with respect to reconstructing external exposures. One important opportunity for improvement is to include instructions to the dose reconstructors on how to treat missed beta exposures.

(8) The INL Occupational External Dose TBD does not provide guidance to dose reconstructors in assessing missed neutron doses at INL reactors.

6.3 UNRESOLVED POLICY OR GENERIC TECHNICAL ISSUES

A number of issues were identified that are common to the INL, Hanford, and SRS site profiles and, in some cases, represent potential generic policy issues that transcend any individual site profile. These issues may involve the interpretation of existing standards, how certain critical worker populations should be profiled for historic radiation exposure (e.g., construction workers and early workers), and how exposure itself should be analyzed (e.g., treatment of incidents and statistical treatment of dose distributions). NIOSH indicates that it may develop separate TIBs in order to address some of these generic issues. The following presents those issues identified in the INL Site Profile Review that SC&A believes represent transcendent issues that need to be considered by NIOSH as unresolved policy or generic technical issues.

(1) Direction on the applicability and usability of the TBDs and/or TIBs to individual dose reconstructions is absent.

(2) Adequacy and completeness of worker records are essential to claimant-favorable dose reconstructions. None of the site profiles address this issue or give direction on resolving missing records.

(3) Site expert testimony indicates that many workers moved from one plant to the next on the same site, creating a complicating factor in determining overall exposure. Establishment of an accurate worker history is crucial in such cases. This will be especially difficult to accomplish in cases of family-member claimants, where the survivors cannot be expected to have a good grasp of where the worker was stationed and when.

(4) Statistical techniques used in the application of the data to individual workers should be considered. However, using statistical averages may not be claimant favorable, since in most compensable cases, they would not provide the upper bound for missed worker doses.

(5) Dose from impurities and/or daughter products in radioactive material received and processed at sites should be assessed.

(6) Assumptions on solubility, breathing rate, and ingestion should be addressed.

(7) A correction factor for external gamma doses should be considered to account for angular dependence of dosimeter sensitivities.

(8) Direction with respect to consideration of incidents and high-risk (dose) jobs in individual dose reconstructions should be provided.

(9) Availability of monitoring records for subcontractor and/or visitors and potential exposure while working on or visiting a facility should be ascertained.

(10) Dose to construction workers and other early workers should be assessed.

(11) Unique exposure conditions for decontamination and decommissioning workers should be considered. The relative impact of each of these items on dose reconstruction is site-specific and requires independent evaluation in each TBD.

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ATTACHMENT 1: CONFERENCE CALL WITH NIOSH AND SC&A

Teleconference of June 29, 2005
to Discuss SC&A Questions/Comments Regarding INL Site Profile[8]

Introduction

SC&A sent its initial list of questions concerning the INL Site Profile to NIOSH on June 16, 2005.[9] On June 29, 2005, the individuals listed below, from SC&A, NIOSH, ORAU, and the ORAU subcontractor, Intrepid, discussed the questions during a teleconference. SC&A summarized the responses to each question and invited all the participants to review and comment on the contents. Some comments were provided and have been incorporated into the summary. The questions (designated by "Q") and responses (designated by "R") are arranged by TBD number following a few general comments.

Teleconference Participants

SC&A
Nicole Briggs
John Hunt
John Mauro
Steve Ostrow (moderator)

NIOSH
Greg Macievic
Tom Tomes

ORAU
Ed Scalsky

Intrepid (sub. to ORAU)
Henry Peterson
Bryce Rich
Norman Rohrig

Questions and Responses

General

(1) Q: The content and organization of the INL Site Profile TBDs are quite uneven, where, often, useful default values and specific guidance for dose reconstructors are buried among general discussions about site activities and history and technical information about dosimetry, which may or may not have practical application. In addition, there are no INL site-specific TIBs to provide guidance, similar to those available for the Savannah River Site, for example. What guidance is given to the dose reconstructors to use the INL Site Profile TBDs? Are workbooks or other summary guidance documents provided to the reconstructors that extract the useful information from the TBDs and present it in a concise, accessible form?

[8] *The lab has changed names and acronyms several times over the years; INEEL (old) and INL (new) both refer to the same national laboratory.*

[9] *Letter from John Mauro (SC&A) to Dr. Lewis Wade (U.S. Dept. of Health and Human Services), June 16, 2005.*

R: The dose reconstructors are not provided with any special instruction per se in the use of the TBDs, but they have workbooks available. NIOSH[10] thought it had provided the INL notebook to SC&A at a meeting a few weeks ago. [note – subsequent to the teleconference, SC&A checked and determined that it had received the INL notebooks, which are in Excel spreadsheet format.]

(2) Q: Section 2.1 (pg. 13) of the Site Description TBD notes that the Naval Reactors Facility (NRF) is exempted under the EEOICPA. However, it should be recognized that workers not connected with the NRF had the potential of receiving exposures from the NRF through various pathways (e.g., airborne, skyshine, ground-shine), especially since the NRF is centrally located on the site. In addition, apparently, some INL personnel also worked at NRF, where they could have received an exposure. For example, Section 5.1.3 (pg. 9) of the Occupational Internal Dose TBD states: "It is possible that some workers' internal dose could have resulted from their support work at the NRF." No information on missed internal, environmental, or external doses from NRF is provided in the TBDs. Nor is information of operational and episodic releases from NRF provided. How should a dose reconstructor deal with INL individuals exposed from NRF activities whether located outside or inside of the NRF boundaries?

R: Some exchange of personnel between NRF and the rest of the site took place in the early days of operation, but the badging system was effective and recorded exposures appropriately. NIOSH considered exposure contributions from NRF to personnel outside the NRF area and concluded that it was not a significant factor. For example, of the 114 site-wide releases listed for 1955, only one, of 310 Ci, was attributable to NRF. The Historical Dose Evaluation database lists the NRF contribution to overall dose in the "other" category, with less than a 0.4% contribution.

(3) Q: The INL Health and Safety Laboratory published annual reports on environmental surveillance, external dosimetry, radiation detection, internal bioassay, quality assurance, personnel dosimetry recordkeeping, and research and development. It is not clear why: only the 1960 Annual Report is used in the Medical Dose TBD; only the 1958 and 1962 Annual Reports are used for the Environmental Dose TBD; and only the 1958, 1959, 1960, 1961, 1962, 1963, 1968, 1970, and 1971 Annual Reports are used for the Internal Dose TBD. No justification is given for including some years and excluding others. Are the chosen years supposed to be representative? If so, why?

R: NIOSH looked at all the Annual Reports that were available (they were not issued every year) and cited only the ones that provided information cited in the TBDs.

[10] *"NIOSH" is used to denote a response from NIOSH, ORAU, or Intrepid.*

Introduction (ORAUT-TKBS-0007-1, Rev. 0, 5/7/04)

No Questions

Site Description (ORAUT-TKBS-0007-2, Rev. 1, 7/28/04)

(1) Q: TBD Section 2.3.1 (pg. 27) on the ICPP Criticality Accident of October 17, 1978 states that: "The atmospheric Protection System (APS) at INTEC … significantly reduced particulate emissions, and filtered all releases associated with the criticality event." Noble gases, for example, would not have been filtered out; how were exposures from such radionuclides determined?

R: NIOSH looked at the incident report and considered the resulting exposure in the Environmental TBD. The evaluation included exposure from noble gases.

Occupational Medical Dose (ORAUT-TKBS-0007-3, Rev. 0, 5/28/05)

(1) Q: TBD Section 3.3 (pg. 5) and Attachment 3A (pg. 10) recommend 200 mrad (Kathren 2003) as the default value for entrance air kerma for pre-1954.

(a) What is the uncertainty associated with this default value?

(b) For the pre-1954 period, why is the assumed lateral view air kerma the same as the PA view air kerma while the former are more than 40% greater than the latter for periods after 1954 (Attachment 3A)?

(c) Kathren 2003 (Table 3.3-1) recommends 500 mrad as the default lateral view entrance air kerma value for the pre-1970 period. Why is a lower value of 200 mrad recommended in the TBD?

(d) In addition, the default values for the other periods in Kathren 2003 are significantly higher than the default values recommended in this TBD. For example, Kathren recommends 100 mrad for PA view and 250 mrad lateral view between 1970 and 1985 while the TBD recommends 52 mrad for PA view and 74 mrad for lateral view between 1954 and 1990. What is the basis for the lower default values? Which values should a dose reconstructor use to obtain claimant favorable results?

R: (a) As stated in the last line on page 7 of Section 3.5 of the TBD, the uncertainty is 30% at one sigma, which is a typical uncertainty value for medical x-ray equipment

(b) This is a "slip-up." No lateral views were taken in the pre-1954 time period. The entry should be replaced by "N/A"

(c) See the previous answer for the pre-1954 period of the table. For later periods, NIOSH reported posterior-anterior and lateral exposures (i.e., 52 and 74 mrad) based on actual equipment settings and practices and,

therefore, did not use Kathren's default values; (d) See the previous answer.

Occupational Environmental Dose (ORAUT-TKBS-0007-4, Rev. 0, 3/30/04)

(1) Q: The TBD focuses primarily on inhalation dose from airborne releases; no consideration is given to inhalation doses from resuspension, oro-nasal doses, ingestion doses, and external doses due to cumulative deposition of these airborne releases. How should a dose reconstructor deal with these missed doses? What about skyshine from high level gamma sources in adjacent facilities?

R: NIOSH considered dose from resuspension of radioactive material and determined that, in the worst case, the contribution through this pathway is not significant; death from asphyxiation would occur before deleterious effects from radiation. Oro-nasal and ingestion (transferred from the lungs into the GI tract, not encountered by eating contaminated material) pathways are considered in determining total exposure. Skyshine contributions to external doses are recorded by TLDs. In general, the individual facilities within INL are relatively isolated from one another and no site is downwind of another so that activities within one facility have little effect on other facilities. For example, the SL-1 accident disposal area produces some wind-swept activity, but it is not transported outside the facility fence.

(2) Q: TBD Section 4.1 (pg. 6) states:

> *This TBD also addresses direct gamma doses resulting from facility operations. In general, these doses, if not controlled by management, increase with time and create a facility background dose. At INEEL, these facility background doses were recorded by film badges infrequently and inconsistently before 1970 and by thermoluminescent dosimeters (TLDs) on a routine basis since 1972. These facility background doses, or facility fence-line doses, as they are sometimes called, are a nebulous indication of a dose that workers could receive if they inhabited the facility. INEEL facility fence-line doses (minus background) are presented for 11 locations.*

(a) Does "facility background dose" result only from general facility operations, or should the facility background dose be the sum of doses resulting from facility operations and environmental deposition from neighboring facilities?

(b) Can the fence-line doses represent the facility background doses for workers occupying the facility inside the fence-line?

(c) When the background is subtracted from the fence-line doses, is it the "natural background" dose that would be present in the absence of INL? If so, how and where is it measured?

R: (a) A TLD cannot distinguish between radiation from the facility and from neighboring facilities

(b) Yes. All operational releases are from 250 ft stacks, so environmental doses are relatively uniform throughout the site; (c) Background measurements are taken in Idaho Falls, 50 miles from the site.

(3) Q: TBD Section 4.1 (pg. 6) states:

> *ICPP airborne effluents have been attributed to creating the maximum INEEL boundary dose. Considering this fact, it should be suspected that ICPP airborne effluent would also be responsible for the maximum INEEL worker doses. Calculations performed for the INEEL TBD show that although ICPP airborne effluent is the most radiologically significant release at INEEL, the impact to workers is significantly below the allowable and acceptable limit.*

Since this TBD is concerned primarily with doses due to airborne effluents, it is logical to assume that if "ICPP airborne effluents have been attributed to creating the maximum INL boundary dose," then those effluents would also be responsible for the maximum offsite environmental doses to the surrounding population.

(a) How could the doses resulting from ICPP airborne effluents be accounted for as the maximum INL worker doses?

(b) Is there a possibility that a worker might be working in a facility subject to higher airborne effluents from a neighboring facility other than the ICPP?

(c) Is there any consideration given to episodic releases in a facility other than ICPP?

(d) Shouldn't the maximum worker doses be the summation of occupational environmental doses from airborne effluents, environmental doses from facility background (cumulative deposition), direct beta-gamma doses during various operational and episodic releases, and internal doses from ingestion, inhalation, and oro-nasal breathing?

R: (a) Evaluations have shown that the ICPP airborne effluents, which contained a significant amount of long-lived isotopes, were the greatest contributors to the environmental dose

(b) The facility sites are quite isolated from each other and ICPP was the most important contributor to the environmental dose; therefore,

it is unlikely that a worker might be exposed to greater airborne effluents than from ICPP

(c) Yes. All identified episodic releases from all facilities were considered and actual meteorological data were used; (d) Yes, they are determined this way.

(4) Q: TBD Section 4.1 (pg. 8) states:

> *All of the airborne releases at INEEL that have occurred since the beginning of the Site were reviewed and analyzed ... This request … was to evaluate the radiological impact to INEEL boundary individuals from airborne releases that had occurred since the beginning of operations at the Site. With the help of NOAA, which had hourly meteorological data from 1956 to that time, analyses were completed for all airborne releases that occurred at INEEL. The radiological consequences for an adult, a child, and an infant were calculated with Version 4 of the Radiological Safety Analysis Computer program RSAC-4 (Wenzel 1990). The results of the study were published in the Idaho National Engineering Laboratory Historical Dose Evaluation (DOE 1991*[a]*); this TBD refers to that report as the INELHDE. All releases considered for that report are the basis for the releases considered in this TBD. In addition, all the releases documented in the INELHDE, operational and episodic, have been independently reviewed and found, with minor modifications, to be substantially appropriate.*

(a) What are the "minor modifications" to the releases used in this TBD?

(b) Why are these releases, which were used to determine doses to offsite populations outside the site boundary, "substantially appropriate" for onsite workers, who are largely inside the site boundary and inside the fence-line of a facility? In reality, source terms considered for offsite population dose evaluation tend to eliminate short-lived radionuclides. These short-lived radionuclides could be significant dose contributors to onsite workers.

R: (a) NIOSH modified releases following examination of SC&A's evaluation of the INELHDE. In addition, following analyses to determine the isotopes making the greatest contribution to exposure (releases x ICRP68 dose conversion factors), the original set of 56 isotopes was reduced to nine. These nine account for over 95% of the total dose

(b) Some short-lived isotopes were eliminated from the original set of 56 isotopes since decay reduced their contributions by the time they reached ground level following release from high stacks.

Table A3: Comparison of Default Assumptions for Internal Exposure at INL, Savannah River Site, and Hanford

Description of Assumption	Idaho National Laboratory	SRS	Hanford
Internal Dose for radionuclides other than tritium	See Table 5.7-1: defaults table for missed dose. This table provides the default assumptions for calculating missed dose of personnel working at a specific INEEL facility and during a specified time period (TBD, pp. 38–39).	Based on either actual bioassay values or detection levels for bioassay techniques. For non-metabolic cancers, the maximizing approach is used (Scalsky 2003, pg. 85).	Based on either actual bioassay values for positive values. Based on a chronic intake over the entire exposure period with the last sample assumed to be at the MDA (Bihl 2004, pg. 47).
Basis for pre-bioassay program doses	Not included in the TBD.	Not included in the TBD.	Air concentration tolerance or limits, (Bihl 2004, pg, 7)
Ingestion	Not included in the TBD.	Not included in the TBD.	Assigned during periods were air sampling was used to determine internal dose. The quantity is based on the air concentration level or on the guidance provided in *Estimation of Ingestion Intakes* (NIOSH 2004). (Bihl 2004, pg. 8)
Surrogate Radionuclide in IMBA for $^{65}Zn/^{95}Zr$	Not included in the TBD.	^{137}Cs used as a surrogate. Surrogate Adjustment factor = 2.43. (Brackett 2003, pg. 9)	Not included in the TBD.
Surrogate Radionuclide in IMBA for $^{106}Ru/^{144}Ce/^{95}Nb$	Not included in the TBD.	Radionuclides not available in IMBA. ^{90}Sr used as a surrogate. Surrogate Adjustment factor = 7.25 (Brackett 2003, pg. 9).	Not included in the TBD.
Surrogate Radionuclide in IMBA for $^{242}Cm/^{252}Cf$	Not included in the TBD.	Radionuclides not available in IMBA. ^{244}Cm used as a surrogate. Surrogate Adjustment factor = 1.09 (Brackett 2003, pg. 9).	Not included in the TBD.
IREP Radiation Types for Hypothetical Intake	Not included in the TBD.	Alpha Beta: >15 keV Tritium: < 15 keV (Bracket 2003, pp. 8 and 12)	Alpha[1] Beta: >15 keV[1] Photon: > 250 keV[1] Tritium: < 15 keV[1]
IREP Dose Distribution Type	Not included in the TBD.	Constant (Brackett 2003, pg. 12)	Constant[1]
Internal Dose Uncertainty	Not included in the TBD.	For the missed dose assignments, the value entered includes the uncertainty. [1] No direction is provided to the dose reconstructor for dose assignments based on monitoring data.	For the missed dose assignments, the value entered includes the uncertainty. For dose assignments based on monitoring data, the following values can be applied as a standard deviation: (1) 0.3 times the MDA or reporting level, or (2) 0.5 times the MDA for chest counting.

Table A4: Comparison of Default Assumptions for Environmental Exposure at INL, Savannah River Site, and Hanford

Description of Assumption	Idaho National Laboratory	SRS	Hanford
IREP Radiation Type	Not included in the TBD.	Photon, 30–250 keV ^{41}Ar , 100% photon, > 250 keV (Scalsky 2004, pp. 60 and 61)	Photon, 30–250 keV[1]
IREP Dose Distribution Type	|Not included in the TBD.	Constant. Doses and intake quantities provided with a 50th percentile and a geometric standard deviation. A 95th percentile for the source term is estimated as 25% greater than the 50th percentile (Scalsky 2004, pg. 60).	Constant. Doses and intake quantities provided with a geometric mean and standard deviation. There is no direction on how these values should be entered into IREP.
Special Considerations for Uranium and Plutonium	No special considerations for uranium and plutonium in the TBD.	The isotope yielding the maximum organ dose was assumed at 100% rather than applying a mixture (Scalsky 2004, pg. 59).	Not applicable.
Other	Dose reconstruction for individual whose location is unknown should use intakes provided by Table 4-3 (CFA) and exposures for ICPP as provided in Table 4-13. The values suggested will maximize the resultant individual dose.	1955 values are assigned to 1952, 1953, and 1954 (Scalsky 2004, pg 54)	The four chemical separations plants, T Plant, B Plant, REDOX Plant and the PUREX plant, along with the plutonium handling Z-plant are shown in Figure 4.1.1 to be the most important release points at Hanford (Savignac 2003).

[1] These parameters were obtained from review of several Hanford dose reconstruction IREP input sheets