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August 28, 2006

Mr. David Staudt
Centers for Disease Control and Prevention
Acquisition and Assistance Field Branch
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Subject: Contract No. 200-2004-03805, Task Order 1: *Los Alamos National Laboratory Site Profile Review*, SCA-TR-TASK1-0011

Dear Mr. Staudt:

SC&A is pleased to submit to NIOSH and the Advisory Board our draft *Los Alamos National Laboratory Site Profile Review.*

If you have any questions or comments on this report, please contact John Mauro at 732-530-0104. We look forward to discussing this draft report with NIOSH and the Advisory Board.

Sincerely,

John Mauro, PhD, CHP
Project Manager

cc: P. Ziemer, PhD, Board Chairperson
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Draft

ADVISORY BOARD ON

RADIATION AND WORKER HEALTH

National Institute of Occupational Safety and Health

Los Alamos National Laboratory Site Profile Review

Contract No. 200-2004-03805
Task Order No. 1
SCA-TR-TASK1-0011

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August 2006

S. Cohen & Associates: **Technical Support for the Advisory Board on Radiation and Worker Health Review of NIOSH Dose Reconstruction Program**	Document No. SCA-TR-TASK1-0011 Effective Date: Draft — August 28, 2006 Revision No. 0 – DRAFT
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Task Manager: __________________________ Date: ____________ Joseph Fitzgerald	Supersedes: N/A
Project Manager: __________________________ Date: ____________ John Mauro, Ph.D, CHP	

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ACRONYMS AND ABBREVIATIONS

AA-2	Audits and Assessment Group
Advisory Board	Advisory Board on Radiation and Worker Health
AP	Anterior-Posterior
AEC	Atomic Energy Commission
AWE	Atomic Weapons Employer
Bq	Becquerel
CAM	Continuous Air Monitor
CDC	Centers for Disease Control and Prevention
CEDE	Committed Effective Dose Equivalent
CFR	*Code of Federal Regulations*
Ci	Curie
CMR	Chemistry and Metallurgy Research
Cpm	Counts per Minute
DAC	Derived Air Concentration
DARHT	Dual Axis Radiographic Hydrodynamics Test
DCF	Dose Conversion Factor
D&D	Decontamination and Decommissioning
DNAA	Delayed Neutron Activation Analysis
DOD	Department of Defense
DOELAP	DOE Laboratory Accreditation Program
DOL	Department of Labor
DOT	Department of Transportation
DP	Defense Programs
DR	Dose Reconstruction/Dose Reconstructor
DOE	Department of Energy
dpm	Disintegrations per Minute
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
ESE	Entrance Skin Exposure
FDA	Food and Drug Administration
FMPC	Feed Materials Production Center (Fernald)
FMU	Facility Manager Unit

FOIA	Freedom of Information Act
GM	Geometric Means
GSD	Geometric Standard Deviation
HEPA	High Efficiency Particulate Air
HP	Health Physics
HPTL	High Pressure Tritium Laboratory
HRL	Health Research Laboratory
HT	Tritium gas
HTO	Tritiated Water
HVL	Half value layer
IAAP	Iowa Army Ammunition Plant
IBF	Ion Beam Facility
ICRP	International Commission on Radiological Protection
IMBA	Integrated Modules for Bioassay Analysis
INEEL	Idaho National Engineering and Environmental Laboratory
IREP	Interactive RadioEpidemiological Program
keV	Kilo electron Volt
kVp	Kilovolt Peak
LAHDRA	Los Alamos Historical Document Retrieval and Assessment Project
LAMC	Los Alamos Medical Center
LAMPF	Los Alamos Meson Physics Facility
LANL	Los Alamos National Laboratory
LANSCE	Los Alamos Neutron Science Center
LAPRE	Los Alamos Power Reactor Experiment
LASL	Los Alamos Scientific Laboratory
LAT	Lateral
LLNL	Lawrence Livermore National Laboratory
µCi	Microcurie
MAC	Maximum Allowable Concentration
MCW	Mallinckrodt Chemical Works
MDA	Minimum Detectable Activity
MDL	Minimum Detectable Level

MED	Manhattan Engineering District
MeV	Mega-electron Volt
MFP	Mixed Fission Products
MPBB	Maximum Permissible Body Burden
MPC	Maximum Permissible Concentration
mR	Milliroentgen
mrem	Millirem
MT	Metal Tritides
NCRP	National Council on Radiation Protection and Measurements
n/g	Neutron-to-gamma
n-p	Neutron-to-photon
NIOSH	National Institute for Occupational Safety and Health
NOO	Nevada Operations Office
NTA	Eastman Kodak Nuclear Track Film Type A
NTP	Nuclear Track Plate
NTS	Nevada Test Site
OBT	Organically Bound Tritium
OCAS	Office of Compensation Analysis and Support
OCR	Occurrence Reports Collection
ORNL	Oak Ridge National Laboratory
ORAU	Oak Ridge Associated Universities
ORISE	Oak Ridge Institute for Science and Education
OTIB	ORAU Technical Information Bulletin
OW	Open Window
OWR	Omega West Reactor
PA	Posterior-Anterior
PAS	Personal Air Sampling
PFG	Photofluorography
PHERMEX	Pulsed High-Energy Radiographic Machine Emitting X-rays
PIC	Pocket Ionization Chamber
PNAD	Personal Neutron Accident Dosimeter
POC	Probability of Causation

PPE	Personnel Protective Equipment
PPG	Pacific Proving Grounds
ppm	Parts Per Million
PTLA	Protection Technology Los Alamos
P/VAP	Particulate and Vapor Activation Products
R&D	Research and Development
RAM	Radiation/Remote Area Monitor
RCRA	Resource Conservation and Recovery Act
RCT	Radiological Control Technician
REECo	Reynolds Electrical Engineering Company
rem	Roentgen Equivalent Man
RFP	Rocky Flats Plant
RIR	Radiation Incident Report
RWP	Radiation Work Permit
SC&A	S. Cohen and Associates
SCBA	Self-contained Breathing Apparatus
SMT	Special Metal Tritides
SNL	Sandia National Laboratory
SNM	Special Nuclear Material
SOP	Standard Operating Procedure
SRDB	Site Research Database
SRS	Savannah River Site
SSD	Source to Surface Distance
STC	Stable tritiated compounds
TA	Technical Area
TBD	Technical Basis Document
TIB	NIOSH Technical Information Bulletin
TIMS	Thermal Ionization Mass Spectrometry
TLD	Thermoluminescent Dosimeter
TSFF	Tritium Science and Fabrication Facility
TSTA	Tritium System Test Assembly
UPPU	Original plutonium workers of the Manhattan Project, the UPPU Club

UTA	Urine Tracking System
WETF	Weapons Engineering Tritium Facility
Y-12 Plant	Y-12 National Security Complex

1.0 EXECUTIVE SUMMARY

This report provides the results of an independent audit conducted by S. Cohen and Associates (SC&A, Inc.) of the technical basis documents (TBDs) that make up the site profile for the Los Alamos National Laboratory (LANL) developed by the National Institute of Occupational Safety and Health (NIOSH). This audit was conducted during the period October 18, 2005–July 18, 2006, in support of the Advisory Board on Radiation and Worker Health (Advisory Board) in the latter's statutory responsibility under the Energy Employees Occupational Illness Compensation Program Act of 2000 (EEOICPA) to conduct such reviews and advise the Secretary of Health and Human Services on the "completeness and adequacy" of the EEOICPA program.

Los Alamos National Laboratory (LANL) is owned by the U. S. Department of Energy (DOE) and has been managed by the University of California since its establishment in 1943 as part of the Manhattan Project's early efforts to create the first atomic weapons. Management of LANL, as of June 1, 2006, has transitioned to Los Alamos National Security, LLC, a new consortium of four contractors with the University of California, still managing scientific research. After World War II, LANL's primary mission has been to serve as an experimental facility for defense-related programs, and for basic scientific research and development (R&D). The facility was Los Alamos Scientific Laboratory (LASL) until 1981. LANL's responsibilities have expanded since the early days to include thermonuclear weapons design, high explosives and ordnance development and testing, weapons reactor research, waste disposal, waste incineration, chemistry, criticality experimentation, tritium handling, biophysics, and radiobiology.

LANL has performed special functions in its longstanding backup role to Hanford and Rocky Flats Plant (RFP). When an accident occurred at the Hanford Plutonium Finishing Plant in 1984, plutonium was sent in oxide form to LANL for conversion to metal. In addition, LANL served in a backup role for limited periods after major fires in plutonium production facilities at RFP in 1957 and 1969. Today, LANL operates the only remaining U.S. plutonium pit production facility.

The Introduction TBD, ORAUT-TKBS-0010-1 (Buddenbaum 2005), provides the following history on some of LANL's key operational roles over the years:

> *The original main technical area (TA-1) processed plutonium and uranium for the World War II devices. TA-1 continued to build and test nuclear weapon critical assemblies on a limited scale until the late 1950s. Other radionuclides handled on a smaller scale compared with plutonium and uranium included americium, polonium, lanthanum, and barium. Starting in 1946, TA-21 (aka DP West and DP East) which was built over several years became the primary plutonium and uranium processing facilities. In 1978, plutonium and uranium operations were moved to TA-55 and the DP sites during the next several years underwent decontamination and decommissioning. The Chemistry and Metallurgy Research (CMR) at TA-3 processed primarily plutonium, uranium, and americium.*

Omega Site (TA-2) was used for critical assembly experiments and was the site of the water boilers, Pu Fast Reactor, a.k.a. Clementine (1946–1950), Omega West Reactor (1956–1992), and other reactors for critical experiments that were later moved to TA-18 in 1947. Early reactors, built to confirm critical masses for fissionable materials and to study properties of fission and the behavior of the resultant neutrons, were the forerunners of a variety of reactors designed, and in some cases built and operated, at Los Alamos. While some of these reactors served as sources of neutrons for various nuclear research or for materials testing, other designs related to potential applications in power generation and propulsion of nuclear rockets into deep space. Some of the first significant steps towards controlled nuclear fusion as a power source were taken at Los Alamos, and the plasma thermocouple program explored methods for direct conversion of fission energy to electricity for potential application in spacecraft.

The Los Alamos Neutron Source Center (LANSCE), formerly known as LAMPF located at TA-53 is the largest accelerator at LANL. This unit became operational in 1972 and still operates today. It has been used for a variety of purposes including production of medical isotopes and weapons research. For some periods of time, radioactive airborne emissions have accounted for the largest boundary doses from all of LANL operations.

SC&A's review focused on the six TBDs that make up the LANL site profile. These address introduction, site description, internal dose, external dose, occupational medical occupational dose, and environmental occupational dose, as they pertain to historic occupational radiation exposure of LANL workers. These TBDs were variously issued in 2004–2005. As "living" documents, TBDs are constantly being revised as new information, experience, or issues arise. For the LANL site profile, in particular, interviews with NIOSH and ORAU staff underscored their ongoing and extensive efforts to upgrade the existing TBDs. In that context, SC&A discussed with NIOSH (and ORAU) the latter's dose estimation guidance for LANL that may figure in their next TBD revision and would supersede earlier site profile direction. That discussion is reflected in several of the SC&A findings in order to add an updated perspective of how NIOSH plans to address these issues (notwithstanding that the SC&A review remains based on the current TBD editions).

SC&A's review process included a review of the TBDs, two onsite visits to conduct interviews with site experts and identify documents for data retrieval, reviews of retrieved LANL and other historic records, and an exchange of questions and answers, in addition to TBD-specific conference calls, between SC&A and its NIOSH and ORAU counterparts. The TBDs were evaluated for their completeness, technical accuracy, adequacy of data, compliance with stated objectives, and consistency with other site profiles, as stipulated in the *SC&A Standard Operating Procedure for Performing Site Profile Reviews* (SC&A 2004). A complete list of the LANL TBDs, as well as supporting documents, that were reviewed by SC&A is provided in Attachment 1.

This review was prolonged by the ongoing LANL contract competition that delayed site data retrieval during November 2005 to January 2006. It was also necessary to have all interview notes and retrieved documents screened by LANL classification reviewers to assure that no sensitive material was inadvertently included.

SC&A found that the site profile made a reasoned effort to cover the broad historic scope, and diverse and extensive radiological source terms of LANL's operational history, but fell considerably short, nonetheless; this was particularly so in characterizing and providing appropriate dose estimation guidance for the early years (1943 through the 1960s). As observed in the Site Description TBD, ORAU-TKBS-0010-2 (Buddenbaum 2004):

> *The diversity of lab operations may be second-to-none when compared to other sites within the DOE complex. With a few exceptions, most man-made or natural radionuclides known to exist have, at one time or another, been present and/or processed at LANL.*

SC&A concurs with this conclusion, but is concerned with the TBD's position that

> *This document attempts to highlight those radioactive materials or radiation sources that can be tied to particular operations and have been well documented over time. As new information becomes available or as claimant information requirements change or expand over time, descriptions of other sources of radiation at LANL will be added to this document in future revisions.* (Buddenbaum 2004, pg. 6)

This admission that the site profile does not address occupational radiation sources beyond the more established and well documented ones is problematic given this tremendous diversity, the radiological significance of many of these "other" radionuclides, and the steadily evolving nature of radiological controls, dosimetry practices, and recordkeeping at the site through the late 1940s, 1950s, 1960s, and into the 1970s, that may have contributed to information gaps critical to dose estimation.

In this regard, SC&A found that the site profile does not adequately address the central question of data insufficiency for its 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 SC&A review finds that inadequate consideration was given to potential exposure and missed dose from radionuclides other than the "well documented" ones cited by the TBD (e.g., plutonium polonium, tritium etc.). These "other" radionuclides include P-32, Na-24, C-14, N-15, O-18, Np-237, and various fission products that were used in research, and various isotopes of americium, curium, thorium, and uranium used in process and recovery operations. The internal dosimetry TBD approach is to use data from a later era to assign dose, or to apply a hypothetical chronic intake for plutonium, polonium, and uranium when bioassay data is unavailable. In most cases at LANL, routine bioassay monitoring was limited to those workers programmatically identified as being potentially exposed to internal emitters, which were typically those individuals directly handling radionuclides.

With respect to unmonitored workers, SC&A finds that for a long period extending into the 1960s, the TBD does not provide a plausible approach for assigning missed internal dose to unmonitored LANL workers. Given the historic inadequacies in LANL's bioassay program even into the 1960s and 1970s, it is clear why NIOSH concluded in the TBD 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 and for many specific job locations; and second, it is not clear, as emphasized by the TBD itself, who may have been 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. Likewise, dose estimation for certain workers, who had site-wide access and were in close proximity to a broad range of radiation exposure sources (e.g., laboratory support workers from the Zia Company and LANL security guards), may be problematic. This would be true in such cases where workers were not monitored or were inadequately monitored for the exposure they received.

SC&A is similarly concerned about 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 minimum detectable level (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. Assignment of the median gamma and derived neutron doses from neutron-to-photon (n-p) ratio values, as recommended by the TBD, may lead to underestimating an unmonitored worker's dose where the potential existed for exposure to these sources of radiation.

From the information in the current Occupational External Dose TBD, it is not obvious that the dose reconstructor has sufficiently detailed correction factors and instructions available 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. Only a brief reference is made to neutron-gamma comparisons in the dose reconstruction guidelines in Appendix E on page 71 (Widner 2005), in reference to unmonitored neutron dose. NIOSH has recently commented on its intent to use n-p ratio values instead of the Eastman Kodak Nuclear Track Film Type A (NTA) film dose data for neutron dose estimation. If this method is used, then the photon doses and the n-p ratio values used will need to be verified.

SC&A's 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, indicates 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.

Likewise, it is not clear whether and how radiation dose data were collected and recorded for LANL employees participating in nuclear test activities at Trinity, the Pacific Proving Grounds (PPG), Nevada Test Site (NTS), and Amchitka. LANL was responsible for monitoring at the Trinity test and 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 have 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.

Issues presented in this report are sorted into the following categories, in accordance with SC&A's review procedures:

(1) Completeness of data sources
(2) Technical accuracy
(3) Adequacy of data
(4) Consistency among site profiles
(5) Regulatory compliance

Following the introduction and a description of the criteria and methods employed to perform the review, the report discusses the strengths of the TBD, followed by a description of the major issues identified during our review. The issues were carefully reviewed with respect to the five review criteria. Several of the issues were designated as primary findings because they represent key deficiencies in the TBDs that need to be corrected, and which have the potential to substantially impact at least some dose reconstructions. Others have been designated "secondary findings" to both connote their importance for the technical adequacy and completeness of the site profile, and to indicate that they have been judged by SC&A to have relatively less influence on dose reconstruction or the ultimate significance of worker doses so estimated.

1.1 SUMMARY OF STRENGTHS

The NIOSH/ORAU team is aware of gaps in the TBDs and has plans to update some of the TBDs based on new information gathered since the site profile's issuance. The NIOSH/ORAU team expects to get access to nine additional boxes of LANL documents (approximately 5,000 documents) and review these documents for their applicability to occupational dose reconstruction. The documents contained in these boxes are currently under review for the LAHDRA project and will be made available to the EEOICPA by the end of June 2006. There will be substantial updates to the Internal Dose TBD (Argall 2004) and the External TBD (Widner 2005).

1.2 SUMMARY OF FINDINGS

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 is 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 was 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.

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.

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.

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.

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 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.

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.

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 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.

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 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.

1.3 OPPORTUNITIES FOR IMPROVEMENT

(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.

(4) 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.

2.0 SCOPE AND INTRODUCTION

The review of the Los Alamos National Laboratory (LANL) Site Profile was conducted from October 18, 2005 – July 18, 2006, by a team of SC&A health physicists and technical personnel.

2.1 REVIEW SCOPE

Under the Energy Employees Occupational Illness Compensation Program Act of 2000 (EEOICPA) and Federal regulations defined in Title 42, Part 82, *Methods for Radiation Dose Reconstruction Under the Energy Employees Occupational Illness Compensation Program,* of the *Code of Federal Regulations* (42 CFR Part 82), the Advisory Board on Radiation and Worker Health (Advisory Board) is mandated to conduct an independent review of the methods and procedures used by the National Institute for Occupational Safety and Health (NIOSH) and its contractors for dose reconstruction. As a contractor to the Advisory Board, S. Cohen and Associates (SC&A, Inc.) has been charged under Task 1 to support the Advisory Board in this effort by independently evaluating a select number of site profiles that correspond to specific facilities at which energy employees worked and were exposed to ionizing radiation.

This report provides a review of the following six documents related to historical occupational exposures at Los Alamos National Laboratory:

- ORAUT-TKBS-0010-1, *Technical Basis Document for Los Alamos National Laboratory – Introduction, Rev. 00* (Buddenbaum 2005);
- ORAUT-TKBS-0010-2, *Technical Basis Document for Los Alamos National Laboratory – Site Description, Rev. 00* (Buddenbaum 2004);
- ORAUT-TKBS-0010-3, *Technical Basis Document for Los Alamos National Laboratory – Occupational Medical Dose, Rev. 00* (Johnson 2004);
- ORAUT-TKBS-0010-4, *Technical Basis Document for Los Alamos National Laboratory – Occupational Environmental Dose, Rev. 00* (Cehn and McDowell-Boyer 2004);
- ORAUT-TKBS-0010-5, *Technical Basis Document for Los Alamos National Laboratory – Occupational Internal Dose, Rev 00* (Argall 2004);
- ORAUT-TKBS-0010-6, *Technical Basis Document for Los Alamos National Laboratory – Occupational External Dose, Rev. 00* (Widner 2005).

These documents are supplemented by technical information bulletins (TIBs), which provide additional guidance to the dose reconstructor. A complete list of these documents is available in Attachment 1.

Implementation guidance is also provided by so-called "workbooks," which have been developed by NIOSH for selected sites to provide more definitive direction to the dose reconstructors on how to interpret and apply the technical basis documents (TBDs), as well as other available information.

Beyond the conduct of its independent interviews of site experts and former workers, the SC&A team is aware of and has requested access to a NIOSH database named "WISPR," which contains NIOSH/ORAU-conducted worker interviews. It was the team's understanding that use of the database requires training to be provided by ORAU. A formal request has been made for training and access to the database. In the meantime, SC&A has reviewed available worker input from worker outreach meetings, public comments from the Santa Fe Advisory Board meeting in 2002, and comments submitted by Dr. Ken Silver of East Tennessee State University. These references are sources of information for the WISPR databases. An addendum to this report will be provided based on the results of an evaluation of the information found in the WISPR database as necessary.

SC&A, in support of the Advisory Board, has critically evaluated the LANL Site TBDs in order to:

- Determine the completeness of the information gathered by NIOSH in behalf of the site profile with a view to assessing its adequacy and accuracy in supporting individual dose reconstructions
- Assess the technical merit of the data/information
- Assess NIOSH's use of the data in dose reconstructions

SC&A's review of the six TBDs focuses on the quality and completeness of the data that characterized the facility and its operations and the use of these data in dose reconstruction. The review was conducted in accordance with *Standard Operating Procedure for Performing Site Profile Reviews* (SC&A 2004), which was approved by the Advisory Board.

The review is directed at "sampling" the site profile analyses and data for validation purposes. The review does not provide a rigorous quality control process whereby actual analyses and calculations are duplicated or verified. The scope and depth of the review are focused on aspects or parameters of the site profile that would be particularly influential in deriving dose reconstructions, bridging uncertainties, or correcting technical inaccuracies. This review does not explicitly address the issue of radiation exposures to cleanup workers and decommissioning workers, as that is not addressed in the TBDs.

The six TBDs serve as site-specific guidance documents used in support of dose reconstructions. These site profiles provide the health physicists who conduct dose reconstructions on behalf of NIOSH with consistent general information and specifications to support their individual dose reconstructions. This report was prepared by SC&A to provide the Advisory Board with an evaluation of whether and how the TBDs can support dose reconstruction decisions. The criteria for evaluation include whether the TBDs provide a basis for scientifically supportable dose reconstruction in a manner that is adequate, complete, efficient, and claimant favorable. Specifically, these criteria were viewed from the lens of whether dose reconstructions based on the TBDs would provide for robust compensation decisions.

The basic principle of dose reconstruction is to characterize the radiation environments to which workers were exposed and determine the level of exposure the worker received in that environment through time. The hierarchy of data used for developing dose reconstruction methodologies is dosimeter readings and bioassay data, co-worker data and workplace monitoring data, and process description information or source term data.

2.2 REVIEW APPROACH

SC&A's review of the TBDs and supporting documentation concentrated on determining the completeness of data collected by NIOSH, the adequacy of existing LANL personnel and environmental monitoring data, and the evaluation of key dose reconstruction assumptions.

2.3 REPORT ORGANIZATION

In accordance with directions provided by the Advisory Board and with site profile review procedures prepared by SC&A and approved by the Advisory Board, this report is organized into the following sections:

(1) Executive Summary
(2) Scope and Introduction
(3) Assessment Criteria and Method
(4) Site Profile Strengths
(5) Vertical Issues and Secondary Issues
(6) Overall Adequacy of the LANL Site Profile as a Basis for Dose Reconstruction.

Based on the issues raised in each of these sections, SC&A prepared a list of findings, which are provided in the executive summary. Issues are designated as findings if SC&A believes that they represent deficiencies in the TBD that need to be corrected and which have the potential to have a substantial impact on at least some dose reconstructions. Issues can also be designated as Secondary Issues if they simply raise questions, which, if addressed, would further improve the TBDs and may possibly reveal deficiencies that will need to be addressed in future revisions of the TBDs.

Many of the issues that surfaced in the report correspond to more than one of the major objectives (i.e., strengths, completeness of data, technical accuracy, consistency among site profiles, and regulatory compliance). Section 6.0 provides in summary form a list of the issues, and to which objective the particular issue applies. Attachment 7 provides a more in-depth analysis of the consistency between site profiles.

The TBDs, in many ways, have done a successful job in addressing a series of technical challenges. In other areas, the TBDs exhibit shortcomings that may influence some dose reconstructions in a substantial manner. Major issue areas include the following:

- Insufficient data for early worker dose reconstructions.

- Inadequate consideration of missed dose to other radionuclides not as well characterized or monitored.
- Exposure to tritium compounds that are not fully addressed in the TBDs.
- Dose estimates not developed for unmonitored LANL personnel at the atmospheric and underground nuclear testing, particularly for potential internal intakes.
- Underestimation of neutron dose when using NTA file and in developing n-p ratios where the initial photon dose is not well characterized.
- Missed uptakes in period prior to the implementation of lung counting.
- Areas of completeness and gaps in the availability of dosimetry data, and the adequacy of the data that are available. This includes the lack of validation of the LANL database, radiation information lacking from the medical records, and exposure received by LANL workers during the human radiation experiments.
- Need to include in the dose reconstructions, the in-growth of Am-241 that may have been missed prior to the mid-1990s.
- Potential missed dose for workers involved in radiation experiments at LANL.
- Lack of data, particularly in the early days, of the type of x-ray equipment used, the beam quality, and the x-ray protocols that impact the dose conversion factors (DCFs).
- Lack of data to properly document the frequency of chest x-rays and other occupationally related x-rays.
- The lack of a site-wide atmospheric model for determination of environmental dose.
- Missed dose from episodic releases that often were not fully documented.

SC&A believes that these important issues need to be effectively dealt with in any upcoming revisions to the LANL site profile TBDs in order that more claimant-favorable dose reconstructions can be effectively conducted in areas where these data gaps exist.

3.0 ASSESSMENT CRITERIA AND METHODS

S. Cohen and Associates (SC&A, Inc.) is charged with evaluating the approach set forth in the site profiles that is used in the individual dose reconstruction process. These documents are reviewed for their completeness, technical accuracy, adequacy of data, consistency with other site profiles, and compliance with the stated objectives, as defined in *SC&A Standard Operating Procedure for Performing Site Profile Reviews* (SC&A 2004). This review is specific to the LANL Site Profile, supporting TIBs, and dose reconstruction worksheets; however, items identified in this report may be applied to other facilities, especially facilities with similar source terms and exposure conditions. The review identifies a number of issues and discusses the degree to which the site profile fulfills the review objectives delineated in SC&A's site profile review procedure.

3.1 OBJECTIVES

SC&A reviewed the site profile with respect to the degree to which technically sound judgments or assumptions are employed. In addition, the review identifies assumptions by NIOSH that give the benefit of the doubt to the claimant.

3.1.1 Objective 1: Completeness of Data Sources

SC&A reviewed the site profile with respect to Objective 1, which requires SC&A to identify principal sources of data and information that are applicable to the development of the site profile. The two elements examined under this objective include: (1) determining if the site profile made use of available data considered relevant and significant to the dose reconstruction, and (2) investigating whether other relevant/significant sources are available but were not used in the development of the site profile. For example, if data are available in site technical reports or other available site documents for particular processes, and if the TBDs have not taken into consideration these data where it should have, this would constitute a completeness of data issue. The ORAU site profile document database, including the referenced sources in the TBDs, was evaluated to determine the relevance of the data collected by NIOSH to the development of the site profile. Additionally, SC&A evaluated records publicly available relating to the LANL site and records provided by site experts.

3.1.2 Objective 2: Technical Accuracy

SC&A reviewed the site profile with respect to Objective 2, which requires SC&A to perform a critical assessment of the methods used in the site profile to develop technically defensible guidance or instruction, including evaluating field characterization data, source term data, technical reports, standards and guidance documents, and literature related to processes which occurred at LANL. The goal of this objective is to first analyze the data according to sound scientific principles, and then to evaluate this information in the context of compensation. If, for example, SC&A found that the technical approach used by NIOSH was not scientifically sound or claimant favorable, this would constitute a technical accuracy issue.

3.1.3 Objective 3: Adequacy of Data

SC&A reviewed the site profile with respect to Objective 3, which requires SC&A to determine whether the data and guidance presented in the site profile are sufficiently detailed and complete to conduct dose reconstruction, and whether a defensible approach has been developed in the absence of data. In addition, this objective requires SC&A to assess the credibility of the data used for dose reconstruction. The adequacy of the data identifies gaps in the facility data that may influence the outcome of the dose reconstruction process. For example, if a site did not monitor all workers exposed to neutrons who should have been monitored, this would be considered a gap and thus an inadequacy in the data.

3.1.4 Objective 4: Consistency Among Site Profiles

SC&A reviewed the site profile with respect to Objective 4, which requires SC&A to identify common elements within site profiles completed or reviewed to date, as appropriate. In order to accomplish this objective, the LANL TBD was compared to several of the sites already reviewed by SC&A. A detailed analysis of this review is provided in Attachment 7.

3.1.5 Objective 5: Regulatory Compliance

SC&A reviewed the site profile with respect to Objective 5, which requires SC&A to evaluate the degree to which the site profile complies with stated policy and directives contained in 42 CFR Part 82. In addition, SC&A evaluated the TBD for adherence to general quality assurance policies and procedures utilized for the performance of dose reconstructions.
In order to place the above objectives into the proper context as they pertain to the site profile, it is important to briefly review key elements of the dose reconstruction process, as specified in 42 CFR Part 82. Federal regulations specify that a dose reconstruction can be broadly placed into one of three discrete categories. These three categories differ greatly in terms of their dependence on and the completeness of available dose data, as well as on the accuracy/uncertainty of data.

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. Such partial/incomplete dose reconstructions with a POC greater than 50% may, in some cases, involve only a limited amount of external or internal data. In extreme cases, even a total absence of a positive measurement may suffice for an assigned organ dose that results in a POC greater than 50%. For this reason, dose reconstructions in behalf of this category may only be marginally affected by incomplete/missing data or uncertainty of the measurements. In fact, regulatory guidelines recommend the use of a partial/incomplete dose reconstruction, the minimization of dose, and the exclusion of uncertainty for reasons of process efficiency, as long as this limited effort produces a POC of greater than or equal to 50%.

Category 2: A second category of dose reconstruction is defined by Federal guidance, which recommends the use of "worst-case" assumptions. The purpose of worst-case assumptions in dose reconstruction is to derive maximal or highly improbable dose assignments. For example, a worst-case assumption may place a worker at a given work location 24 hours per day and 365 days per year. The use of such maximized (or upper bound) values, however, 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.

The obvious benefit of worst-case assumptions and the use of maximized doses in dose reconstruction is efficiency. Efficiency is achieved by the fact that maximized doses avoid the need for precise data and eliminates consideration for the uncertainty of the dose. Lastly, the use of bounding values in dose reconstruction minimizes any controversy regarding the decision not to compensate a claim.

Although simplistic in design, to satisfy this type of a dose reconstruction, the TBD must, at a minimum, provide information and data that clearly identify: (1) all potential radionuclides, (2) all potential modes of exposure, and (3) upper limits for each contaminant and mode of exposure. Thus, for external exposures, maximum dose rates must be identified in time and space that correspond to a worker's employment period, work locations, and job assignment; similarly, in order to maximize internal exposures, highest air concentrations and surface contaminations must be identified.

Category 3: The most complex and challenging dose reconstructions consist of claims where the case cannot be dealt with under one of the two categories above. For instance, when a minimum dose estimate does not result in compensation, a next step is required to make a more complete estimate. Or when a worst-case dose estimate that has assumptions that may be physically implausible results in a POC greater than 50%, a more refined analysis is required. A more refined estimate may be required either to deny or to compensate. In such dose reconstructions, which may be represented as "reasonable," NIOSH has committed to resolve uncertainties in favor of the claimant. According to 42 CFR Part 82, NIOSH interprets "reasonable estimates" of radiation dose to mean:

> *. . . estimates calculated using a substantial basis of fact and the application of science-based, logical assumptions to supplement or interpret the factual basis.* ***Claimants will in no case be harmed by any level of uncertainty involved in their claims, since assumptions applied by NIOSH will consistently give the benefit of the doubt to claimants.*** [Emphasis added.]

In order to achieve the five objectives described above, SC&A reviewed each of the six TBDs, their supplemental attachments, and TIBs, giving due consideration to the three categories of dose reconstructions that the site profile is intended to support. The six LANL TBDs provide well-organized and user-friendly information for the dose reconstructor when adequate data were available to do that comprehensively.

ORAUT-TKBS-0010-1, Rev. 00, *Technical Basis Document for Los Alamos National Laboratory – Introduction* (Buddenbaum 2005), explains the purpose and the scope of the site profile. SC&A was attentive to this section, because it explains the role of each TBD in support of the dose reconstruction process. During the course of its review, SC&A was cognizant of the fact that the site profile is not required by the EEOICPA or by 42 CFR Part 82, which implements the statute. Site profiles were developed by NIOSH as a resource to the dose reconstructors for identifying site-specific practices, parameter values, and factors that are relevant to dose reconstruction. Based on information provided by NIOSH personnel, SC&A understands that site profiles are living documents, which are revised, refined, and supplemented with TIBs as required to help dose reconstructors. Site profiles are not intended to be prescriptive nor necessarily complete in terms of addressing every possible issue that may be relevant to a given dose reconstruction. Hence, the introduction helps in framing the scope of the site profile. As will be discussed later in this report, NIOSH may want to include additional qualifying information in the introduction to this and other site profiles describing the dose reconstruction issues that are not explicitly addressed by a given site profile.

ORAUT-TKBS-0010-2, Rev. 00, *Technical Basis Document for Los Alamos National Laboratory – Site Description,* (Buddenbaum 2004), is an extremely important document, because it provides a description of the facilities, processes, and historical information that serve as the underpinning for subsequent LANL TBDs.

ORAUT-TKBS-0010-3, Rev. 00, *Technical Basis Document for Los Alamos National Laboratory – Occupational Medical Dose*, (Johnson 2004), provides an overview of the sources, types of exposure, and the frequency of exams that workers potentially received.

ORAUT-TKBS-0010-4, Rev. 00, *Technical Basis Document for Los Alamos National Laboratory – Occupational Environmental Dose*, (Cehn and McDowell-Boyer 2004), provides background information and guidance to dose reconstructors for reconstructing the doses to unmonitored workers outside of the facilities at the site who may have been exposed to routine and episodic airborne emissions from these facilities.

ORAUT-TKBS-0010-5, Rev. 00, *Technical Basis Document for Los Alamos National Laboratory – Occupational Internal Dose*, (Argall 2004), presents background information and guidance to dose reconstructors for deriving occupational internal doses to workers.

ORAUT-TKBS-0010-6, Rev. 00, *Technical Basis Document for Los Alamos National Laboratory – Occupational External Dose*, (Widner 2005), presents background information and guidance to dose reconstructors for deriving occupational external doses to workers.

In accordance with SC&A's site profile review procedures, SC&A performed an initial review of the six TBDs, their supporting documentation, and the three TIBs. Interviews with Site Experts are provided in Attachment 2. SC&A then submitted questions to NIOSH with regard to assumptions and methodologies used in the site profile. Prior to the conference calls with SC&A for the LANL Occupational External Dose TBD (Widner 2005), Introduction TBD (Buddenbaum 2005), Site Description TBD (Buddenbaum 2004), and Occupational Medical Dose TBD (Johnson 2004), NIOSH provided written responses to SC&A questions. The SC&A questions, along with the NIOSH responses, are provided in Attachment 3.

A series of conference calls were then conducted with NIOSH and ORAU, and the SC&A team to allow NIOSH to provide clarifications and to explain the approaches employed in the site profile TBDs. A summary of the series of individual conference calls with NIOSH, ORAU, and SC&A is provided in Attachment 4. NIOSH responded to action items identified in the conference calls and these supplemental NIOSH responses are provided in Attachment 5. Attachment 6 provides a listing of LANL-sponsored atmospheric and underwater tests.

An extensive comparison was done between the methodologies used in the LANL TBD and other TBDs reviewed to date to determine environmental, internal, and external doses. This comparison focused on the methodologies and assumptions associated with dose reconstruction and resultant values used to obtain a POC. A detailed analysis is provided in Attachment 7.

Individuals interviewed provided several comments that relate to the LANL Site Profile documents. These comments are provided and addressed in Attachment 8 and are separate from the site expert interview summaries found in Attachment 2. The information provided in Attachment 8 is from interviews and hardcopy documentation from Dr. Ken Silver (Silver 2005) of Eastern Tennessee State University and current employees at LANL.

Information provided in the conference call with NIOSH was evaluated against the preliminary findings to finalize the vertical issues[1] addressed in the audit report. There are three levels of review for this report. First, SC&A team members review the report internally. Second, SC&A engages an outside consultant who has not participated in the preparation of this document to review all aspects of this report. The third level, referred to as the expanded review cycle, will consist of a review of this draft by the Advisory Board and NIOSH. The first two of these have been completed.

After the Advisory Board and NIOSH have an opportunity to review this draft, SC&A plans to request a meeting with Advisory Board members and NIOSH representatives to discuss the report. Following this meeting, we will revise this report and deliver the final version to the Advisory Board and to NIOSH. We anticipate that, in accord with the procedures followed during previous site profile reviews, the report will then be published on the NIOSH Web site and discussed at the next Advisory Board meeting. This last step in the review cycle completes SC&A's role in the review process, unless the Advisory Board requests SC&A to participate in additional discussions regarding the closeout of issues, or if NIOSH issues revisions to the TBDs or additional TIBs, and the Advisory Board requests SC&A to review these documents.

Finally, it is important to note that SC&A's review of the six TBDs and their supporting TIBs is not exhaustive. These are large, complex documents and SC&A used its judgment in selecting those issues that we believe are important with respect to dose reconstruction.

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[1] The term "vertical issues" refers to specific issues identified during our review, which were identified as requiring more in-depth analysis due to their potential to have a significant impact on dose reconstruction.

4.0 SITE PROFILE STRENGTHS

In developing a TBD, the assumptions used must be fair, consistent, and scientifically robust, and uncertainties and inadequacies in source data must be explicitly addressed. The development of the TBD must also consider efficiency in the process of analyzing individual exposure histories so claims can be processed in a timely manner. With this perspective in mind, we identified a number of strengths in the LANL site TBDs. These strengths are described in the following sections.

4.1 COMPLETENESS OF DATA

In developing the Site Description TBD, ORAUT-TKBS-0010-2 (Buddenbaum 2004), NIOSH made extensive use of the LAHDRA report. Although this mainly focused on off-site environmental emissions, LAHDRA is the most comprehensive effort to retrieve documentation pertinent to radiation exposures at LANL. This has greatly enhanced the accuracy and completeness of the data provided in the Description TBD, ORAUT-TKBS-0010-2 (Buddenbaum 2004), as well as in the Occupational Environmental Dose TBD, ORAUT-TKBS-0010-4 (Cehn and McDowell-Boyer 2004).

NIOSH has agreed to search and add additional available references to help substantiate information depicted in Tables 3.2 and 3.3 of the Occupational Medical Dose TBD ORAUT-TKBS-0010-3 TBD (Johnson 2004).

The NIOSH/ORAU team is aware of gaps in the TBDs, and has plans to update some of them based on new information gathered since the site profile's issuance. The NIOSH/ORAU team has gained access to nine additional boxes of documents that previously had been held for classification screening. They intend to review these documents for relevance to each element of the site profile. There will be substantial updates to the Internal Dose TBD (Argall 2004) and the External TBD (Widner 2005).

The NIOSH/ORAU team is aware of gaps in the TBDs and has plans to update some of the documents. Most notably, there will be updates to the Occupational Internal Dose TBD (Argall 2004), the Occupational External Dose TBD (Widner 2005), and the Site Description TBD (Buddenbaum 2004). Proposed changes for the Internal Dose TBD include:

- Addition of a discussion on the format and contents of the LANL Bioassay Database. This will address interpretation of data in the new LANL Bioassay Database for U-238 and U-235, when both results are listed for a sample.
- Addition of descriptions of Delayed Neutron Activation Analysis (DNAA) and associated practices used by LANL for estimating uranium in bioassay samples.
- Clarification on minimum detectable activity (MDA) values used for the early years based on additional information obtained.
- Hypothetical estimates of missed intakes will be derived for workers with presumptive cancers potentially exposed during the RaLa project years.

- Clarification of the bioassay protocol for Zia workers, including a discussion of procedures used for restricting Zia workers' access to material handling areas.
- Clarification on the availability of bioassay data for radionuclides not currently in the LANL Bioassay Database.
- Development of internal co-worker doses to mitigate gaps in the data.
- Addition of a list of organs and the fission products that produce the highest potential dose to those organs. This is useful in assigning potential missed dose when whole-body count results are below MDA levels.
- Update information within the TBD, such as additional incidents based on documentation collected since the issuance of the TBD.

Proposed changes for the External Dose TBD (Widner 2005) include:

- Update the photon energy group percentages for Accelerator Operations.
- Clarification regarding the adjustment factors to be applied to reported photon doses and the time periods and conditions under which they should be applied.
- Change the recommended distributions for n-p ratio from uniform distributions to distributions characterized by median and 95th percentile values.
- Addition of a distribution for plutonium facilities that handled Pu-238.
- Pending further clarification concerning what information is desired, will add a discussion of external dose monitoring practices applied to workers involved in critical assembly experimentation and/or criticality incidents, and/or information regarding radiation fields that would have been expected from those activities.
- Update information currently within the TBD based on documentation collected since the issuance of the TBD, and eliminate discrepancies that exist within the document.
- Determine applicability of recent Savannah River Site (SRS) TBD revision to the LANL TBD.

In some cases, the changes have been communicated to the dose reconstructors, and are currently being implemented. SC&A is aware of the proposed changes; however, details of these changes were not available for this review.

4.2 ADEQUACY OF DATA

A good breakdown of the various site locations and activities as a function of time was provided. Dosimetry methods used for beta, photon, and neutron dose monitoring were described separately, and also as a function of time and technology changes. Some prescribed health physics monitoring procedures and record keeping methods were described, along with the logbooks containing this information. LANL has been fortunate to have noted scientists and

R&D facilities to address radiation and health physics problems throughout its years of operations.

4.3 TECHNICAL ACCURACY/CLAIMANT FAVORABILITY

The Occupational External Dose TBD, ORAUT-TKBS-0010-6 (Widner 2005) and the related Site Description TBD, ORAUT-TKBS-0010-2 (Buddenbaum 2004) were evaluated for relevance to external dose reconstruction (DR) for LANL workers, and to determine if the procedures recommended were technically sound and claimant favorable.

(1) SC&A's review of the Occupational External Dose TBD, ORAUT-TKBS-0010-6 (Widner 2005) found that these documents provided a very extensive overview, and numerous details, concerning various site descriptions, lab operations, radiation monitoring, dose analysis, and dose records for LANL workers.

(2) The Occupational Environmental Dose TBD applies a screening method to determine significance of radionuclides handled at LANL to environmental exposure. It is appropriate to eliminate radionuclides that contribute less than 1 mrem to the environmental dose over a select period of time. SC&A cautions NIOSH/ORAU to consider all radionuclides relative to the exposure from environmental media during their screening method.

4.4 CONSISTENCY AMONG SITE PROFILES

The implementation of ORAUT-OTIB-0006, *Dose Reconstruction for Occupationally Related Diagnostic X-Ray Procedures*, Revision 2 (Kathren 2003), has provided a great deal of consistency between different site profile assumptions. Incorporation of Revision 3 PC-1 (Kathren and Shockley 2005) of this document would provide further consistency among site profiles. The NIOSH/ORAU team is moving in the right direction to obtain consistency in most assumptions for occupational medical exposure.

4.5 REGULATORY COMPLIANCE

The TBD's use of personnel monitoring data and environmental monitoring data to determine dose is consistent with the requirements outlined in 42 CFR Part 82, as follows:

- Where in-vivo and in-vitro analyses are available, this information is provided for use in determination of internal dose.
- Where routine beta/gamma and neutron dosimeters are available and adequate, this information is provided for use in determination of external exposure.
- Where environmental measurements are available, these data are used as the basis for environmental dose.

5.0 VERTICAL ISSUES

SC&A has developed a list of key issues regarding the LANL Site Profile. These issues relate to each of the five objectives defined in SC&A's review procedures (SC&A 2004). Some issues are related to a particular objective, while others cover several objectives. Many of the issues raised below are applicable to other DOE and Atomic Weapons Employer (AWE) sites and should be considered in the preparation and revision of other site profiles.

5.1 ISSUE 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. Some gamma doses are available starting in the 1940s, but external radiation personnel monitoring did not include adequate methods to monitor beta, gamma, and neutrons until around 1951. Lack of complete photon dosimetry data in the early days brings into question the ability to compute neutron dose by using the n-p method. Early internal monitoring techniques were limited to urinalysis for plutonium and polonium, and nasal smears. Work with radionuclides, such as tritium, uranium, fission products, BaLa, radium, and other alpha and beta emitters, was diverse, extensive, and preceded many of the bioassay techniques for these sources developed in the late 1940s and 1950s. Overall, the goal in the early years was to keep individuals within laboratory defined tolerances; however, it was not uncommon to exceed the tolerances of the time for mission purposes.

In view of this early history, SC&A finds it problematic that the TBD methodology treats the historic dose record as if it is sufficiently complete for LANL workers of that period, particularly for 1943–1950. Each worker's actual dose will depend on the individual's radiological exposure circumstances in terms of type of work, work location, and time period, and cannot necessarily be extrapolated from co-workers or later dose data, or solely from MDL values. A lack of dose records in the early days does not warrant an assumption that workers did not receive any dose above the MDL during missed monitoring periods or that assigning the median dose is necessarily claimant favorable. This approach to dose reconstruction could lead to an underestimation of doses for workers who were not badged, or whose results were not recorded.

For example, the Occupational External Dose TBD, ORAUT-TKBS-0010-6 (Widner 2005, pg. 65), recommends assigning a median dose of 199 mrem/year for 1948 for an unbadged worker, and (Widner 2005, pg. 68) recommends assigning a missed dose of 240 mrem/year for 1948. This latter dose assignment would equate to only approximately 1 mrem/day (0.12 mrem/hr) for a worker who likely worked in close proximity to radiological facilities, was presumably exposed to some contamination, and was operating in an environment where he and his co-workers were learning and applying evolving radiation control measures. This was at a time when the radiation protection standards and guidelines were much less stringent than they are today. Given that the driving concern at the time was to keep the exposures below the guideline limits (i.e., 10% of 15 rem/year), radiation controls would have been considered satisfactory if exposure was maintained at or below these levels. However, the TBD approach would be non-conservative if one assumes that 10% of 15 rem/year equates to around 6 mrem/day, which is much greater than the proposed 1 mrem/day median dose that would be applied.

5.1.1 Background

While the site profile TBDs catalogue the radionuclides in use and outline the history of operations, they do not adequately characterize this history in terms of the often primitive radiological conditions under which work was performed and the inconsistent manner in which personnel monitoring was conducted and records maintained.

During the Manhattan Engineering District (MED) era at Los Alamos, much of the work was experimental in nature resulting in trial and error. Early experimental physics and weapons research resulted in immediate work with radiation producing devices, such as the cyclotron, electrostatic generators, neutron sources (e.g., RaBe, PoBe, etc.) Early activities included fast neutron research, slow neutron research, instrument development and testing (including radiological instrumentation), accelerator operations, and weapons component development and testing. During the early development period, experimentation with radiation generating sources led to work with Ra-Y-Be, yttrium, tantalum, Ra-D_2O, and YBe, and mesothorium (Ra-228) sources. Fission measurements were made on thorium, ionium, protractinium, U-234, U-235, and Pu-239 (LAP 1944a, LAP, 1944b). Early work also included development of tampers, initiators, weapons housing, high explosives, and detonators. Los Alamos continued weapons development after World War II, and was the lead site for U.S. nuclear weapon component fabrication until 1949, when Hanford began making pits.

"Monitoring was scarce and rather primitive," observed the first director of LANL's Health Division, Dr. Robert Stone. "The whole clinical study of the personnel is one vast experiment" (Stone 1948). Stone's efforts to create an expanded safety margin through increased worker monitoring to reduce exposures below the 1934 limits then in place were met with opposition by his superiors.

Ted Lombard was an enlisted man in the U.S. Army assigned to work at the Los Alamos Laboratory during the war who recalled the less-than-ideal working conditions:

> *I'll tell you what the working conditions were at Los Alamos… We used to go to Fort Douglas, Utah in ambulances, pick up uranium and plutonium. We carried dosimeter badges in our pockets because you couldn't display them…Then [after the badges were turned over to an officer] we would proceed to unload uranium and plutonium barehanded…the fumes and dust were constantly in the air; there was no ventilation system. The dust was on the floor. Uranium chips would be in your shoes that you continued to wear. You went to eat with the same clothes on, you went to the barracks with the same clothes and sat on the beds... contamination was rampant and there was little or no protection, particularly for G.I.'s.* (NCRV 1980)

While these primitive radiological control circumstances are acknowledged in the site profile, a coherent dose reconstruction approach is not presented.

5.1.2 External Monitoring of Early Workers

The Occupational External Dose TBD, ORAUT-TKBS-0010-6 (Widner 2005, pg. 9), states the following:

> *LANL has used facility and individual worker monitoring methods to measure and control radiation exposures. Records of radiation doses to individual workers from personnel dosimeters worn by the worker and coworkers are available for LANL operations beginning in 1943. Doses from these dosimeters were recorded at the time of measurement and routinely reviewed by operations and radiation safety staff for compliance with radiation control limits.*

According to the Occupational External Dose TBD (Widner 2005), external radiation personnel monitoring did not include adequate methods to monitor beta, gamma, and neutrons until around 1951 (i.e., see Table 6-5 on pg. 21 and Table 6-7 on pg. 28). Some gamma doses were measured in the early days, but beta, gamma, and especially neutron doses were not adequately or routinely monitored. This includes n-p ratio values needed today for neutron dose reconstruction. Lack of complete dose data that may affect dose reconstruction is evident from other sections of the TBD (Widner 2005) and historic documents, as cited below:

- Relatively high unmonitored exposures were received by workers in early experiments at LANL's Omega Site as documented by Dan Mayers (Mayers 1946) in which he noted that:

  > *No accurate data on the amounts* [of radiation exposure] *is available although measurements were made but not recorded at the time. Mr. Feld estimated total personnel exposure to be roughly as follows for all three experiments: ...”*

  The article goes on to state that for the three experiments, the estimated total gamma plus neutron dose (in terms of Equivalent Gamma Dose using a conversion factor of 1 neutron r = 5 gamma r) was 3–15 r for worker #1, 2–10 r each for worker #2 and #3, and 1–5 r each for worker #4 and #5.

- According to several documents, the exposures that were measured for these three workers did not necessarily make it into the worker's records. (LANL 1956a and Hempelmann 1946)

- The Occupational External Dose TBD states in Section 6.2.1.5, page 19, that dosimetry measurements made prior to August 1950 apparently did not make it into long-term records for the GMX-1 group.

- Page 6 of the Introduction TBD, ORAUT-TKBS-0010-1 (Buddenbaum 2005), states "Many of the exposure histories and work records are not specific about the assigned work areas of individuals."
- According to recent worker interviews, the Radiation Control Technicians (RCTs) wore film badges during some jobs; however, the RCT was the least likely exposed individual in the group, because they were not involved in the hands-on tasks. Therefore, assignment of average co-worker doses to these workers on this basis would result in underestimated dose, because they would not be based on the most highly exposed workers.

These concerns with photon dosimetry are especially important because of NIOSH's intent to use n-p ratio values to calculate neutron doses.[2] An error in photon dosimetry is doubled when used as a basis for neutron dosimetry. Additionally, under such circumstances, the neutron dose cannot be used to check the gamma dose, nor can the gamma dose be used to check the neutron dose results.

5.1.3 Internal Monitoring of Early Workers

LANL was among the first facilities to handle major quantities of elements, such as plutonium and fission products. As such, the development of personnel monitoring, e.g., in-vivo and in-vitro, was in its infancy and was evolving as experience was gained at the laboratory. In retrospect, we know that standards were not as tight as they should have been and sensitivity of the bioassay and in-vivo measuring systems were not adequate to detect uptakes at levels considered to be safe by today's standards. These points are acknowledged in the Occupational Internal Dose TBD (ORAUT-TKBS-0010-5, Argall 2004); however, it is of concern to SC&A that significant and chronic exposures to these internal emitters may have occurred as a result of monitored personnel being exposed at levels below the sensitivity of the methods used for exposure detection or where unmonitored personnel were exposed.

The TBD, Section 5.1, page 9, points out that:

> *...the only method of monitoring intake was through loose contamination swipes… Nasal swipes, also called 'nose counts,' were used to indicate potential intakes.*

Section 5.2.1, page 21, of the TBD, notes that:

> *After the development of urine bioassay techniques, nasal swipes were used to indicate the need for follow-up bioassay, although bioassay was not always performed immediately following a positive nasal swipe. (McInroy et al. 1991)*

The use of nasal swipes can only be used as one of several available exposure indicators; however, the lack of a positive nasal swipe does not preclude the possibility that a very

[2] NIOSH and SC&A conference call, March 21, 2006.

significant uptake may have occurred. Extensive experience in the nuclear industry has shown that significant uptakes have occurred where nasal swipes did not exceed the 50 cpm action level. SC&A is concerned about the heavy dependency on nasal swipes, even into the 1980s, and the number of workers that may have had positive uptakes that may have been missed given the heavy reliance on nasal swipes.

The TBD notes in several places that only workers with a significant potential for exposure were monitored. Guidance in the *Chemistry and Metallurgy Health Handbook of Radioactive Materials* (Aebernald et al. 1945) states that only those people who worked directly with plutonium and polonium, or those in an accident involving these radionuclides, were monitored by urinalysis. In the case of uranium, only those individuals working with tuballoy or U-235 who showed albuminuria during routine weekly medical urinalysis testing were required to submit a urine sample to be tested for tuballoy (Aebernald et al. 1945). Thus, other workers with a potential for exposure and uptake, but not so identified, would not have been monitored. The TBD further notes that "many of the exposure histories and work records are not specific about the assigned work areas of individuals..." (Argall 2004, Section 5.1, pg. 11); this raises further doubts regarding the basis for applying co-worker internal dose distributions to unmonitored individuals.

The early LANL bioassay programs, up to the 1960s, missed many radionuclides before the health physics significance of them became obvious and bioassay measurement techniques were developed. Table 1 lists a portion of these radionuclides, the initial year of potential exposure, and the year when approved bioassay monitoring techniques first became available for these radionuclides. [This information was compiled from H-Division progress reports and other early H-Division technical documents. The first year of exposure reflects the year the radionuclide was first cited in these reports as being present in operations and monitored.]

Table 1: Radionuclides Handled in the Early Years of Operations at LANL

Radionuclide	First Year of Potential Exposure	Bioassay Start Year
Plutonium	1943?	1944
Uranium	1943	1949
Tritium	1945	1950
Americium	1947?	1954
Polonium	1944	1944
Fission Products	1944	1950
Strontium	1944	1952
Ra-226 + daughters	1944	1958
Iodine	1945?	1952
Thorium	?	1956?
Curium	?	?
Ba-La	1944	?
Other alpha emitters	1944?	?
Other beta emitters	1944	?

In summary, SC&A finds from the TBD, H Division progress reports, and other documentation from LANL's early operations that:

(1) Only workers with a significant potential for exposure were monitored and work histories are not specific about assigned work areas.

(2) Some individuals worked in laboratory areas with a potential for exposure and were never monitored nor were their job tasks recorded as having radiation exposure potential.

(3) Major emphasis was placed on monitoring surface contamination levels and using positive nasal swipes as primary indicators or "triggers" to initiate bioassay sampling for potential uptakes.

(4) Average chemical recoveries and matrix blanks were not reported prior to 1957, according to the TBD (Argall 2004, Section 5.2.1, pg.18).

Based on the foregoing, SC&A believes that the site profile does not provide an adequate and complete basis for dose reconstruction for unmonitored and even some monitored workers in the 1940s through possibly as late as the 1960s. The dose data is apparently unavailable for many radionuclides, the work location is not recorded, and the requisite measurement sensitivity for chronic or even, in some cases, acute exposures is not evident. Section 5.2.1 of the TBD does present a section on "Missed Intakes;" however, it does not adequately describe the approach that NIOSH will use to reconstruct a claimant-favorable dose for those that may have been missed entirely. In subsequent discussions with NIOSH, it was learned that they intend to apply a dose of 1/3 of the UPPU average dose for workers of early years. The NIOSH assignment of 1/3 of the UPPU average dose for workers of this period does not appear to be sufficiently claimant favorable in light of the fact that the sensitivity for uptakes exceeded a maximum permissible body burden (MPBB), and lung counting techniques and equipment were not yet developed.

Two papers—*The Los Alamos Scientific Laboratory's Experience with Plutonium in Man* (Langham et al. 1962) and *Studies on Persons Exposed to Plutonium* (Voelz et al. 1978)—provide insight and substantiation of this issue, describing the difficulties of detection and monitoring confronted in those early years at Los Alamos.

5.2 ISSUE 2: INADEQUATE CONSIDERATION HAS BEEN GIVEN TO POTENTIAL EXPOSURE AND MISSED DOSE FROM OTHER RADIONUCLIDES

Numerous radionuclides were handled at LANL ranging in quantities from fractions of a gram to kilograms. The amounts of particular radionuclides handled changed over time as LANL shifted from research and development (R&D) to production. Radionuclides other than plutonium, uranium, tritium, and polonium, handled at LANL included radium, thorium, actinium, protactinium, americium, neptunium, curium, lanthanum, barium, yttrium, and other fission products, alpha emitters, and beta emitters associated with accelerator production and weapons development. Inadequate or no consideration in the Occupational Internal Dose TBD, ORAUT-

TKBS-0010-5 (Argall 2004), has been given to the potential exposure and missed dose from radionuclides other than the aforementioned plutonium, tritium, polonium, and uranium. Some of these radionuclides are listed in Table 5A-10 as a nuclide handled in particular technical areas. In several instances, the TBD directs the dose reconstructor to rely on the claimant interviews for identification of potential exposure to non-traditional radionuclides. Inadequate dosimetry characterization and 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 basis is provided for dose assignment for radium, actinium, neptunium, curium, yttrium, tantalum, radon, and radionuclides created as a part of the medical isotope program. Adequate guidance is not provided for potential exposures from special tritium compounds, including organically bound tritium (OBTs) and special metal tritides (SMT) (see Issue 3, Section 5.3). In addition, as indicated in Attachment 4, *LANL Occupational Internal Dose TBD Conference Call Summary*, the NIOSH/ORAU team has decided not to pursue bioassay data for many radionuclides not currently in the LANL Bioassay Repository.

5.2.1 Missed Dose from Other Radionuclides

Both R&D and production operations have contributed to the extensive and diverse list of radionuclides historically present at LANL. The D-Building and Chemical Metallurgy Research (CMR) facility were both heavily involved in R&D to support the weapons program. Accelerator facilities have been used to produce both stable and radioactive elements for use by the DOE complex, and commercial vendors. Reactors have been used to irradiate elements. The Health Research Laboratory (HRL) has conducted studies on the metabolism of radionuclides in animals and humans. Tritium facilities have active in maintaining the U.S. nuclear warhead stockpile. The long-term operations and R&D activities at LANL provided constant opportunities for workers to come in contact with radionuclides spanning the periodic table. Some of the operations handling other than these “secondary” radionuclides are listed below.

- Biological research with P-32, Na-24, and C-14 labeled material
- Use of the Th-229 (d, pf) reaction to study the fission of Th-230
- Medical Radioisotope Research processing and shipping, including 13 different radionuclides
- Production of large quantities of N-15 and O-18 for scientific research
- Use of iodine in weapons diagnostics
- Determination of fission product yields of Np-237 relative to U-235
- Reduction of NpF4 to Np metal (Morgan et al. 1962)
- Processing of U-233 solution into metal
- Purification of americium from rare earths (Coleman 1956)

The Los Alamos Neutron Science Center (LANSCE) produces substantial quantities of a number of radioisotopes, including both short-lived and long-lived radionuclides (Peterson 2002).

Handling of radioactive waste itself involves potential exposures to over 50 different radionuclides. The primary mission of the CMR facility (TA-3 (South Mesa Site), Building 29) has been to provide a facility that supports engineering, chemistry, and research operations for groups working to ensure the safety and reliability of the U.S. nuclear warhead stockpile, improve the capability to handle nuclear materials and manufacture nuclear components, provide support to plutonium recovery and processing operations, and solve problems related to energy and the environment. As a result, CMR has worked with uranium, plutonium (Pu-238, Pu-239, Pu-242), americium (Am-241, Am-243), curium (Cm-244, Cm-248), neptunium (Np-237), Cf-249, and fission products either in a pure form or as a contaminant (Steele and O'Neil 1998). Finally, radionuclides such as fission products have been produced as a byproduct of operations.

These potential sources of exposure from secondary and so-called "exotic" radionuclides are based on a limited SC&A review of LANL operational history and available health physics files. Further research by NIOSH into these non-traditional radionuclides should be completed in any revision of the LANL site profile to assure their significance and dose contribution are fully addressed. Bioassay techniques should be evaluated for entire periods of potential exposure for the effectiveness in detecting other radionuclides. Appropriate methods for internal monitoring were not always available for all years of potential exposure. Although the TBD (Argall 2004) acknowledges the existence of non-traditional radionuclides, adequate direction is not provided on how and when to assess potential missed dose for many of them. The site profile is reliant on claimant interviews to ascertain potential exposure to any such nontraditional radioactive source, an approach that put former workers, and particularly their survivors, at a disadvantage because of the lack of hazard identification, lack of records, and considerable secrecy at the time. The TBD (Argall 2004) has also not considered the possibility that due to secrecy, the energy employee may not have known what radionuclides were in the workplace. NIOSH/ORAU should base missed dose assignments on available data, technical reports, and other sources of information to ascertain potential exposure to non-traditional radionuclides.

5.2.2 Radionuclides with Limited Bioassay Data

The Occupational Internal Dose TBD, ORAUT-TKBS-0010-5 (Argall 2004) points out in Section 5.2.7 (pg. 32) that:

> *LANL has always been a center for research. As such, small-scale use of various radionuclides not addressed above has occurred throughout the history of LANL. Little or no documentation has been found on bioassay for these nuclides.*

Furthermore, it is stated in the Occupational Internal Dose TBD, ORAUT-TKBS-0010-5 (Argall 2004), Section 5.2.5 (pg. 31), that:

> *Records of ^{90}Sr urinalysis, routine or special, are very sparse. The historical compilations of procedures do not list a specific ^{90}Sr urinalysis procedure. It appears that any record of ^{90}Sr analysis actually indicates that LANL performed a gross beta analysis or sent a sample to an outside laboratory. S**trontium-90 dose currently can be reconstructed only when ^{90}Sr results are actually listed for an***

> ***individual.**.. No information is available on MDA for ^{90}Sr analysis.* [Emphasis added.]

A review of monthly and annual H-Division progress reports clearly indicate that bioassay samples were collected and analyzed for Po-210, gross beta, Pm-147, radioiodine, Sr-90, Zn-65, Pb-210, curium, gross gamma, fission products, Th-230, Th-232, Ra-226, Ra-228 (mesothorium), radiolanthanum, and actinium. There is also indication of radon breath analysis (Schulte 1966). In addition, air sampling data is available for Ta-182, which appears to have been in use since the 1940s.

TBD guidance provided on the assignment of dose from polonium and other radionuclides, merely guides the dose reconstructor to assign a dose if there was a potential for exposure to the radionuclide, or when exposure is indicated in a claimant interview:

> *Therefore, missed dose for polonium should be assessed only if actual polonium bioassay has been performed for the individual or if there is indication, through claimant interview, that the employee was actually exposed to the polonium.* (Argall 2004, pg. 31)

And,

> *These nuclides [referring to ^{227}Ac, ^{32}P, ^{14}C, thorium and ^{231}Pa] should only be assessed when there is an indication that the worker had potential for interaction with that nuclide.* (Argall 2004, pg. 32)

Given the secrecy under which employees worked, they cannot be expected to know all of the radionuclides they were exposed to, especially those not directly involved in operations. Furthermore, it is highly unlikely that a claimant survivor will be able to provide details on exposures to any radionuclides, let alone such extraneous sources.

There is clear indication that bioassay data existed for radionuclides other than polonium, tritium, uranium, plutonium and americium, which are included in the LANL Bioassay Repository. In SC&A's conference call with NIOSH/ORAU (Attachment 4), it was stated that the data for unusual radionuclides is not easily accessible, although there is some data available in logbooks. Inadequate guidance on "other" radionuclides is particularly troubling since the site has not provided the original bioassay data files for these radionuclides and NIOSH/ORAU apparently does not plan to pursue them (see Attachment 2). SC&A recommends that NIOSH retrieve these original bioassay data files for use in dose reconstructions, where applicable. If bioassay records cannot be retrieved, a methodology for assignment of dose should be developed. Further information on where the radionuclides were handled and what time periods this covers needs to be collected, reviewed, and included in the TBD in the context of dose reconstruction.

In summary, SC&A recommends further evaluation of radionuclides handled at LANL to determine the extent of potential exposures and how it impacts dose reconstruction to the organs.

Attempts should be made to retrieve bioassay data where it is available, and include internal dose reconstruction methodologies for radionuclides without appropriate bioassay coverage.

5.3 ISSUE 3: SPECIAL TRITIUM COMPOUNDS NOT ADEQUATELY ADDRESSED

Adequate characterization and guidance for special tritium compounds is not provided in the Occupational Internal Dose TBD, ORAUT-TKBS-0010-5 (Argall 2004), including OBTs and SMTs. There is a complete reliance on OCAS-TIB-002, *Tritium Calculations with IMBA* (OCAS 2003), which only provides direction on how to enter urine measurements into the code. Although the dose consequences from special tritium compounds may not be significantly larger than those from tritiated water (HTO), NIOSH must be familiar with the special tritium compounds handled, the quantities of material, the locations and time periods of potential exposure, and the physical behaviors of tritium compounds in the environment (e.g., conversion to HTO, formation of rust) to correctly characterize tritium exposure. Bounding techniques, as proposed for SRS, cannot be effectively developed and applied without some basic understanding of the compounds handled and the extent to which individuals were exposed.

In order to develop a bounding exposure, NIOSH must make themselves familiar with the special tritium compounds handled, the quantities of material, and the locations and time periods of potential exposure. Some thought should be given to the chemical behavior of tritium, especially as it related to the decontamination and decommissioning (D&D) of aging tritium facilities and other facilities where tritium was a byproduct of operations.

LANL has been involved in work with tritium since the 1940s. Some of the major tritium facilities formerly or currently at LANL include:

- High Pressure Tritium Laboratory (HPTL)
- Tritium System Test Assembly (TSTA) Facility
- Tritium Science and Fabrication Facility (TSFF)
- Weapons Engineering Tritium Facility (WETF)

The HPTL (also called the Gas Handling Facility) was originally tasked with conducting research and development on tritium handling technology. This facility took over production work for a period of time, processing tritium gas (HT) and repackaging HT into small-volume high-pressure vessels. In 1992, WETF began receiving tritium and tritium-contaminated gases, repackaging these gases, and preparing them for shipment to other sites. TSFF provided a facility for R&D involving work with HT and metal tritides (MT). TSTA was involved in the use of tritium for development and demonstration of fusion fuel cycle technology. Other areas onsite which involved potential exposure to tritium include:

- Van de Graaff Accelerator (TA-3-16)
- Plutonium Facility Site (TA-55)
- F Area Vaults

- M Building
- Y Building
- HRL
- Ion Beam Facility (IBF)

The exact forms of tritium encountered in these facilities are not available; however, over the course of operations, LANL has handled tritium in the form of HTO, HT, organically bound tritium (OBT), and MT. A majority of the tritium handled was in the form of HTO or HT. HTO was also produced by exposure of HT and some special tritium compounds to air. Fires involving tritiated gas can also produce HTO. Tritium handling operations, research and development activities, and tritium facility D&D have exposed workers to other forms of tritium. The HRL and the IBF used labeled compounds, or OBTs, in the course of its research.

Worker exposure to MT included hydrides and dihydrides of metals associated with accelerator targets and weapons components (Inkret et al. 1999). More specifically, LANL has handled a broad variety of light and heavy MT, including hafnium tritide and uranium tritide. Other forms of tritium compounds, such as tritiated pump oil, rust, pump oil droplets, tritiated methane, and tritiated solvents, were formed during operations with HTO and HT.

The approach defined for tritium dose estimation provided in the TBD (Argall 2004, pp. 23–25) is not sufficient for many cases that involved significant exposures to stable tritiated compounds (STCs). The TBD refers the dose reconstructor to the guidance provided for exposure to tritium-labeled compounds and tritium particulates outlined in OCAS-TIB-002, *Tritium Calculations with IMBA* (OCAS 2003). This TIB merely provides directions on the use of IMBA to calculate tritium doses. There is no discussion on how to differentiate between intakes of HTO, HT, OBTs, or tritium particulates. There is no guidance on how to interpret bioassay data, what particle size to assume for particulates, or what solubility class to use.

The TBD recognizes the variability in distribution and absorption of OBT (Argall 2004, pg. 23):

> *The first approximation of the dose from OBT (labeled) compounds is the tritium in body water dose. However, the absorption, distribution, and excretion of tritium-labeled compounds are specific to the chemical and physiological behavior of the compound.*

The TBD identifies OBTs as the predominant form of tritium at the HRL and IBF Buildings. With respect to MT, the TBD recognizes their existence at LANL and the differences in potential dose to the lungs; however, it again refers the dose reconstructor to OCAS-TIB-002 (OCAS 2003). Information on when and where SMT exposures may have occurred is not provided (Argall 2004, pg. 24).

> *Information on building locations and years of operation when MT might have been encountered is not currently available. The claimant telephone interview can provide indications that a person was exposed to MT. If the dose*

reconstructor encounters a case involving exposure to MT, discussion among the task leadership might be needed to determine the appropriate biokinetic model.

Although the TBD has considered tritium-labeled compounds as a potential source of OBTs, it has not considered OBTs formed when tritium reacts with organic materials. The main types of OBTs found are tritiated solvents, tritiated oil, and solid particulates (e.g., organic dust, plastics, etc.) The absorbed dose from tritium in organic components is dependent on the specific chemical compound in which the material is bound. OBTs in the form of solid particulates reside in the lungs for a longer period of time resulting in higher dose to the lungs. More information on how prevalent OBTs are in the LANL work environments should be gathered, and consideration given to the potential difference in resulting dose.

Special metal tritides are solid substances containing tritium that do not readily react with air or in aqueous solutions, because tritium is tightly bound to the matrix. Because SMTs are relatively insoluble, and the retention of this type of tritium is longer than HTO in some organs, the internal dose delivered to the organ is higher. For particles of tritium, the lung is the primary organ of concern. Some of the tritium may leach out in the lung fluids and then be incorporated into the body water. These particles may also produce OBT from contact with lung tissue, which would further complicate the metabolic process (DOE 2004).

McConville and Woods (1995) discuss the challenges with determining internal dose from MT:

Tritium in the form of metal tritides particles presents a peculiar problem for the calculation of internal dose. Standard calculations indicate that just a few 3 to 5 micron sized particles appears to lead to a very large dose. There are very few data on which calculations can be based.

Inkret et al. (1999) found that hafnium tritide had a dissolution half-time of more than 10^5 days. Cheng et al. (1997) determined the dissolution time for fine and coarse titanium tritide particles to be 33 days and 361 days, respectively. International Commission on Radiological Protection (ICRP) publications have not provided a dosimetric model for the calculation of internal dose from MT.

Furthermore, STCs present unique challenges to radiological protection programs. Routine workplace monitoring techniques make it difficult to differentiate between STCs and more common forms of tritium, such as HTO. Due to the physical and chemical behavior of STCs, common bioassay and dose calculation models can be ineffective. For select STCs, air monitoring is preferable to bioassay (DOE 2004). *The ICRP Database of Dose Coefficients: Workers and Members of the Public* (ICRP 2001) provides information on tritium in particulate form (Types F, M, and S). In these cases, the default parameters of lung clearance and absorption are applied and the biokinetic model for HTO is used. Thus, the dose coefficients from the SMTs should be equal to the generic types F, M, and S, if the ICRP recommendations are followed.

Dose reconstructors should be made aware of the characteristics of STC excretion in urine to enable them to distinguish between STCs and tritium oxide or HT. For example, McConville and Woods (1995) demonstrated, with individual excretion data following tritide uptakes, that tritium excretion curves for particulate tritides do not follow a simple exponential curve, as is the case with HTO. In the case of these individuals, tritides built up for a few days followed by a more traditional elimination curve.

SC&A agrees with preliminary NIOSH proposals for derivation of a bounding estimate based on maximum potential exposures that a worker may have received over the years from an assumed very insoluble tritide form. In order to develop a bounding exposure, NIOSH would need to make themselves familiar with the special tritium compounds handled, the quantities of material, and the locations and time periods of potential exposure. Some thought should be given to the chemical behavior of tritium, especially as it related to the D&D of aging tritium facilities and other facilities where tritium was a byproduct of operations.

With the these concerns in mind, SC&A does not feel the Occupational Internal Dosimetry TBD, ORAUT-TKBS-0010-5 (Argall 2004) does an adequate job of addressing potential doses from uptakes of OBT and MT. Dose reconstruction guidelines need to be more specific and provide more backup materials to enable claimant-favorable estimates of high dose from STCs.

5.4 ISSUE 4: DOSE ESTIMATION NOT ADDRESSED FOR LANL PERSONNEL ASSIGNED TO WEAPONS TESTING

Exposure conditions and historic dosimetry practice related to LANL personnel participation in weapons and safety testing has not been considered in the site profile. LANL sponsored nuclear weapons testing of their weapons designs, supporting other laboratories conducting tests, and conducted safety experiments. Their involvement in weapons testing began at the Trinity site in Alamagordo, New Mexico on July 16, 1945, and continued until the end of testing in 1992. Included are LANL’s atmospheric and underwater tests at the NTS and PPG, all of which are listed in Attachment 6.

The site description TBD, ORAUT-TKBS-0010-2, recognizes LANL’s participation in testing:

> *They* [Los Alamos scientists and engineers] *were involved in many tests of nuclear devices in the continental United States, the Pacific, and Alaska, including some that were part of the Plowshare program for development of peaceful applications for nuclear explosives.* (Buddenbaum 2004, pg. 11)

Furthermore, the TBD recognizes LANL’s participation in the Rover Project:

> *LANL was also responsible for the design and manufacture of test reactors for the Rover Project. Once the reactors were assembled and verified within specifications, they were shipped to the Nevada Test Site for testing.* (Buddenbaum 2004)

Although LANL participation is mentioned in the site description, no characterization or evaluation of LANL worker dose from participation in weapons and safety testing has been included in the internal, external, and environment TBDs. While it is understood that NIOSH under EEOICPA protocols establishes work location, including work at other Atomic Energy Commission (AEC) or DOE sites, to enable dosimetry records to be obtained, it is not clear from either the LANL or NTS site profile how visiting LANL employees on testing missions were monitored and their doses recorded (i.e., who was monitored and how, how were the recorded doses integrated with their personnel dose record at LANL, and what status was accorded Reynolds Electrical Engineering Company (REECo) monitoring data?).

For example, the NTS site profile has not been referenced for determination of missed dose at the test site, itself. No site profiles currently exist to provide guidance on how to assess potential missed dose at Trinity, Amchitka, or the PPG. This facet of exposure to LANL employees requires treatment in the site profile or a TIB. The exposure conditions during these activities will differ from those received at the LANL site itself, and should be specifically addressed.

The test group from the laboratory responsible for the design of the weapon (e.g., LANL, Lawrence Livermore National Laboratory (LLNL), or Sandia National Laboratory (SNL)) sent a contingent of personnel to the test sites for testing preparation, detonations, recovery of data and materials post-detonation, and support functions (including radiological safety).

The J-Division was responsible for managing the testing program, and the H-Division provided considerable safety and health support for weapons testing.

> *Members of the staff of H-Division have held the full responsibility for radiological safety, first aid, and medical care, and safety for the test organization, with responsibility for radiation levels within a radius of 200 miles from the test site.* (LASL 1951)

Rotating crews of laboratory personnel were sent to the site for tests, with a typical test operation involving 50 or more personnel. These crews occupied the same areas as REECo employees, exposing them to the same hazards. Monthly H-Division Progress reports discuss the support provided at Operation Greenhouse, Operation Buster-Jangle, Operation Ranger, Operation Snapper, Operation Upshot-Knothole, and Operation Teapot by LANL radiation safety personnel.

Responsibilities of NTS and LANL radiological control staff were delineated by NTS and LANL in procedures and the Test Manager's Operational Plan. REECo served as a support contractor to the sponsoring laboratory providing dosimetry and records services, and instrumentation. These records are currently being retrieved by NIOSH from the Nevada repository, although it is uncertain how NIOSH determines for which individuals this data is to be requested. The responsibility for personnel monitoring for tests conducted in PPG appears to have been the responsibility of LANL, or the Nevada Operations Office (NOO). LANL personnel monitored individuals involved in the Trinity Test. Operations performed by LANL staff included test preparation, detonation, retrieval of equipment and material after detonation, follow-up monitoring after detonation, monitoring during analysis of weapons debris, and decontamination of test sites as necessary. These assignments could last up to several weeks. Radiological personnel were frequently deployed to test areas to assist with radiological safety problems at test sites.

> *In October, a monitor was sent to Eniwetok to take care of radiological safety problems in connection with current decontamination and construction work.* (LASL 1949)

Furthermore,

> *The unsuccessful attempt to launch a high-altitude detonation from Johnston Island resulted in the spread of a considerable quantity of plutonium in the launch area. The subsequent decontamination of this area was carried out under the supervision of three representatives of the Health Physics Group of H-1. Prior to decontamination, most of the pad was contaminated in excess of 2,000,000 cpm alpha per 55 cm^2 probe area.* (Shipman 1962)

In the cases where LLNL or SNL sponsored the weapons test, a smaller complement of LANL personnel was required to be present. Both LANL and LLNL personnel were also stationed at the NTS and the PPG for extended periods of time. In addition to site testing, laboratory personnel were stationed at the NTS and at the PPG for extended periods of time.

LANL had active participation in the assembly, testing, and disassembly of reactors for the Rover Project (LASL 1962, pg. 4).

> *Although Project 400, the Rover reactor test program of LASL at NTS, is under the administrative direction of J-Division, other divisions are involved in the test series of Kiwi reactors, especially N-Division and H-Division.*

The evaluation of dose from LANL personnel participation in weapons and safety testing has not been considered in the TBD. Internal and external monitoring programs for those involved in testing should be compared with the potential for exposures at the test sites to evaluate the adequacy of monitoring by LANL and Nevada, and determine the potential for missed dose. In particular, how bioassay monitoring was handled by REECo for LANL employees with regard to short-lived fission products from fallout and recovery operations needs to be clarified.

When individuals visited the NTS, they were asked to leave their LANL dosimeter at home. External dosimetry was supplied by REECo to individuals at the test site. Since the test site dosimeters were used in place of LANL dosimeters, the external dose obtained by REECo is subject to the same shortcomings as those documented in the *Review of the NIOSH Site Profile for the Nevada Test Site* (SCA-TR-TASK1-0006) (SC&A 2005a). In brief, these issues relate to lack of neutron dose data, potential neutron exposure during atmospheric testing, angular dependence of dosimeters, and uncertain status of bomb assembly workers. External monitoring for the PPG and for Trinity was provided by LANL, thus requiring a further evaluation of the LANL dosimeters under these exposure conditions.

Although there appears to be documented external exposure for those involved in testing at the NTS and the PPG through the NOO, there is no discussion of when this data is to be requested and how it is to be considered in dose reconstruction. The LANL TBD does not provide guidance on when to assume exposure as a result of test involvement, nor does it refer the dose reconstructor to the NTS TBD. In the case of Trinity, Amchitka, and the PPG, no TBD has been developed to characterize potential radiation exposure.

Site experts indicated that bioassay sampling was done at REECo under special conditions. For example, during underground testing, site experts indicated that when there was an unexpected venting, REECo personnel were monitored immediately. If the results for REECo personnel were positive, the laboratory staff was asked to submit a bioassay sample. The delay between sampling of REECo personnel and laboratory personnel was about 1–2 days. The data from bioassay monitoring conducted by REECo are available in records maintained by the NOO.

LANL has indicated that external dosimetry results from the test site have been integrated into their exposure database. There is uncertainty as to whether internal monitoring data collected at NTS, if any, have been incorporated into the LANL Bioassay Repository. SC&A was not able to evaluate whether this information was included, because they did not have access to the LANL Bioassay Repository database.

In summary, the presence of LANL personnel at weapons testing sites should be evaluated to ensure employees were adequately monitored for internal and external hazards at the test sites. A missed dose methodology should be included for unmonitored or inadequately monitored workers who participated in weapons testing, safety experiments, and reactor tests. Where available, references to other site profiles are appropriate.

5.5 ISSUE 5: NEUTRON DOSE RECONSTRUCTION APPROACH MAY RESULT IN UNDERESTIMATED DOSE

Recommended neutron dose reconstruction assumptions and approaches in the current external dose TBD (ORAUT-TKBS-0010-6 (Widner 2005) could result in missed neutron doses. In addition, the recent recommendation of using n-p ratio values for neutron dose reconstruction needs further development and may suffer from lack of reliable early photon dose data and valid n-p ratio values. Some areas of concern are as follows.

5.5.1 Neutron Doses Below 1 MeV and Above 3 MeV of Energy

As at other nuclear facilities, LANL became aware of the NTA film's under response to neutrons below 0.8–1.0 MeV around the late 1960s. The TBD, page 38, states that a study released in 1978 showed that the average neutron energy field at TA-55 was approximately 200 keV, and that explains why very little neutron dose was observed using NTA film at the facility. The TBD, page 41, states that a study showed that the average neutron energy field at Los Alamos

Meson Physics Facility (LAMPF) in 18 locations was <100 keV and that explains why very little neutron dose was observed using NTA film at the facility. Furthermore, the TBD, page 43, states that a fission neutron energy spectrum (0.1 to 1 MeV) is to be assumed at all LANL reactors for dose purposes. This entire spectrum is essentially below the practical 1-MeV detection limits of NTA film used in the workers' badges.

While facility-specific neutron energy bands are provided in the TBD (e.g., on pages 47 and 72), it is not obvious that the dose reconstructor has any detailed correction factor or instructions available 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. Table 6-22 on page 48 and Table 6E-9 on page 71 of the TBD only provide wide ranges of neutron-to-gamma ratios (n/g) for three areas at LANL (Pu facility, Criticality Experiments, and Other operations). These tables are not very specific, giving a range for n/g of 0.3 to 5.5. The only indirect mention of correcting for the under response of NTA film to lower energy neutrons is on page 47 of the TBD, where it states: "For years before 1980 at LANL, multiply annual photon dose (adjusted for any missed dose) times the neutron-to-photon dose factor from Section 6.4.4 and by the area-specific ICRP 60 correction factor shown above to estimate neutron dose." Only a brief reference is made to n/g as a means to address unmonitored neutron dose, e.g., in the dose reconstruction guidance in Appendix E on page 71 of the TBD.

If NTA neutron film data is to be used in DR, an area that needs to be investigated is the possibility of using overlapping NTA/thermoluminescent dosimeter (TLD) data to evaluate earlier missed neutron doses because of the 0.8–1.0 MeV neutron threshold of NTA film. This could provide some information on the amount of neutron dose missed at various work locations.

5.5.2 NIOSH's Recent Use of Neutron-to-Photon Ratio Values Instead of NTA Film Data

A significant amount of resources went into neutron dose analysis of nuclear track plates (NTPs) and the NTA film results cited in the Occupational External Dose TBD, ORAUT-TKBS-0010-6 (Widner 2005). However, in recent discussions,[3] NIOSH has indicated that the neutron dose reconstruction at LANL for 1943–1979 dose estimations should be based on the n-p method; relying on the n-p ratio values from 1980–2000 and photon measurements during 1943–1979. This method of using n-p ratio values to assign neutron doses can be used if direct neutron dose measurements are questionable or not available. However, to successfully do this, the photon dose measurements must be technically sound, and the n-p dose-equivalent values (implying knowledge of the neutron fields and energy spectra) for each given location and time period must be known with a reasonable degree of accuracy. The accuracy of the photon dose measurements is especially important when using the n-p method, because the total dose depends upon only one measurement (photon dose), rather than two independent methods (neutron and photon). The effects of an underestimation of the photon dose are doubled when using this method. In view of these facts, some issues of technical soundness need to be explored.

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[3] NIOSH and SC&A conference call, March 21, 2006.

5.5.2.1 Photon Dose Values Need Further Evaluation

(1) The possibility needs to be addressed that the photon doses and n-p ratio values derived from methods used during 1980–2000, and their response to such variables as radiation energy, dose, directional geometry, etc., may not sufficiently match those of the early years, especially the 1940s, to allow current n-p ratio value to be applied to these earlier measurements (performed by different methods) to arrive at reasonable neutron doses. For example, the Occupational External Dose TBD, ORAUT-TKBS-0010-6 (Widner 2005), page 36, states that a 1972 study showed that the film badge readings were about a factor of 3 higher than the TLDs. In addition, page 36 of the TBD states, "Hankins said that the method used to calibrate for plutonium did not consider the effect of the glovebox or buildup of ^{241}Am in the gloveboxes." Both of these statements are made in the TBD without stating what was done about the lower response of the TLDs to gamma dose or how Hankins' statement affects the reported dose. Issues such as different beta and photon filters, or lack thereof, as well as film versus TLD, which could impact the resulting doses recorded through the years, should be investigated in detail to reveal any problem in using photon values to calculate neutron doses. Different dose measurement methods, which are acceptable in their own timeframe, may not be compatible with each other when separated by 30–50 years. This is not addressed in the TBD.

(2) It could be difficult to obtain statistically valid photon dose values for 1943–1950, when relatively few workers were badged and a significant number of the results from those that were badged were not recorded and retained for future use. NIOSH needs to provide special procedures that cover this period. The photon dose values need to be based on realistic dose situations and not just on MDL values. This is especially important because not only will this dose affect the photon dose, it will determine the neutron dose using the n-p method.

(3) Page 17 of the Occupational External Dose TBD indicates that the individual values for beta, photon, and neutron doses were recorded separately in the records. However, the last paragraph on page 2 of an earlier document (LANL 1956a) indicates that the total dose was reported as one figure in terms of rem from January 1953 to February 1956. This could present a problem sorting out the doses caused by different radiation types during dose reconstruction for this period.

(4) Geometry factors were not addressed in the LANL TBDs, other than one statement in the Occupational External Dose TBD, ORAUT-TKBS-0010-6 (Wilder 2005), page 49, where it states that:

> *Unfortunately, there is no definitive process to determine the exposure geometry for each LANL worker. Through discussions with Task 5 personnel, a simple 100% AP geometry will be assumed for all workers, even likely compensable workers.*

This may not be claimant favorable considering that some technicians worked in unusual positions/situations, such as straddling accelerator components or working on tasks with their backs to the main radiation source.

5.5.2.2 Neutron Dose Spectra May Be Different from 1943 to 1979

LANL had many different operating areas with different neutron spectra and n-p ratio values over the period from 1943–1979. These values could be notably different from those of 1980–2000, because of changes in operations, regulatory standards, and instrumentation, as noted in the following observations:

(1) The n-p ratio values listed in Table 6E-9 of the Occupational External Dose TBD were derived from the 1980–2000 dose data. Determining n-p ratio values requires knowledge of the neutron energy spectra, because the neutron dose equivalent has to be determined by some measurement. The neutron energy spectrum must then remain relatively constant over time to allow the use of the same n-p ratio values for a given location. However, the TBD, page 43, states that "Because neutron spectra have not been obtained for the LANL reactors, an assumption of 100% fission spectrum neutrons (0.1 to 1 MeV) is used." NIOSH needs to illustrate how the n-p ratio values were derived, and why they should be considered sufficient to cover all types of situations at a given facility or facilities for which they are listed.

(2) Table 6E-9 of the Occupational External Dose TBD only lists three locations (Pu facility, Criticality experiments >50m, and Others) and the new Occupational External Dose TBD, ORAUT-TKBS-0010-6, when issued, would apparently list 4. NIOSH should demonstrate that this limited set of n-p ratio values cover all the varied activities at LANL over the intended period of use, 1943–1979.

(3) The need to have details concerning the workplace radiation environment is reiterated in the Occupational External Dose TBD, ORAUT-TKBS-0010-6 (Widner 2005), page 10, where it is mentioned that the calibration of the monitoring systems and similarity of the methods of calibration to sources of exposure in the workplace affects the accuracy and precision of the recorded dose. However, it appears that the "Other operations" n-p ratio values in Table 6E-9 of the TBD will cover everything from accelerators to moderated (i.e., alpha, n) neutrons to reactor neutrons with just one set of geometric means (GM) and 95th percentile values in the proposed new version of the LANL Occupational External Dose TBD. It does not appear reasonable to use only one n-p ratio value, considering that there was a wide range of neutron spectra present at LANL, ranging from high-energy neutrons around accelerators to thermal neutrons in the Omega Canyon. For example, an H-Division Progress report of 1952 observed that:

> *It has been estimated that ninety percent of the neutron exposures at Omega Canyon has been due to thermal and slow neutrons. It has been suggested that the nuclear track plate results be increased by a factor of 8 to 10 in order to compensate for the discrepancy.* (Shipman 1952)

The recommendation of the use of a single n-p ratio value needs additional investigation and support to be acceptable. Additionally, the maximum n-p ratio value of 2.4 as listed in the present Occupational External Dose TBD may not be sufficient for some situations in this wide variety of applications. It would be helpful to have Table 6E-9 expanded with a more detailed listing and guidance for its application, and illustrative examples in the TBD to establish its use of the present limited table entries.

(4) Only a brief mention is made of n-p ratios in the dose reconstruction guide section in the Occupational External Dose TBD, ORAUT-TKBS-0010-6 (Widner 2005), Attachment E, page 71, in reference to unmonitored neutron dose. Missed neutron dose is covered in TBD, ORAUT-TKBS-0010-6, Appendix 6E, Section 6E.7 on page 71. However, the entire neutron dose reconstruction process during 1943–1979 is now proposed to be treated as a case of unmonitored workers as far as neutrons are concerned. In view of this, Appendix 6E, Section 6E.6 and 6E.7, on page 7 of the TBD needs more work.

- For example, in the Occupational External Dose TBD, ORAUT-TKBS-0010-6 (Widner 2005), Appendix 6E, Section 6E.6 states that the unmonitored worker's neutron dose is equivalent to the median neutron dose for monitored workers. This may not be the case for all workers as brought out in Issues #7 and #8 above. Some earlier workers could have been exposed to neutron doses greater than the average badged workers before strict badging requirements were set in place and some radiation hazards were recognized.
- The Tiger Team report of 1991 (DOE 1991) found problems with neutron monitoring for extremity doses. On page 4-181, it states the following:

  > *The most likely type of radiation dose to extremities in nonaccident situations at TA-55 is from neutron and gamma radiation. Extremity neutron doses are determined from ratios of gamma-to-neutron doses for whole body dosimeters. This ratio includes shielding and albedo effects that may not be applicable to extremities, especially for neutron doses.*

- In Appendix 6E, Section 6E.7 of the TBD, it is stated that:

  > *To calculate the missed neutron dose, the reconstructor must first determine if the person worked near neutrons and the category of neutrons. This can best be determined by examining the work location records and whether a worker or others in the badge reporting group were assigned any neutron dose equivalent. If no neutron dose was assigned to the worker or coworker for several months, the dose reconstructor should assume that the person was not exposed to neutrons.*

> It is unclear if this statement is referring to each period of interest and if it would be evaluated for each missed neutron dose periods, or if it recommends using a very limited amount of data to make a decision concerning neutron exposures for a worker's career. A worker's individual working conditions, and the upper bounds to radiation exposures under these conditions, are more important than the co-worker data. It may be important to evaluate each period of missed dose during a worker's career at LANL and his work situation during each missed dose period in conjunction with assigning unmonitored or missed neutron doses.

All the above areas have an affect on neutron, and in some cases photon, dose reconstruction. Assuming radiation fields remain similar through time and were common to numerous facilities presents problems in performing technically sound and claimant-favorable dose reconstruction. In addition, assuming that any unmonitored worker received average doses, and any missed doses can be based on MDL values, as opposed to a specified radiation environment, could lead to an underestimate of individual doses. The present TBDs do not sufficiently demonstrate that the methods recommended and the data listed in the tables, such as n-p ratio values, are always applicable to the worker's radiation environment and claimant favorable to prevent underestimate of worker doses.

To apply n-p ratios to calculate missing neutron doses, the reliability and adequacy of the gamma monitoring program should first be evaluated. If the gamma doses of record are found to be flawed due to significant data integrity problems in the period in question, then it would appear that the derived neutron doses would also correspondingly lack integrity, with additional uncertainties introduced due to the use of an n-p ratio.

5.6 ISSUE 6: TBD DOES NOT ADEQUATELY ADDRESS MISSED PLUTONIUM INTERNAL UPTAKES PRIOR TO 1970 DUE TO ABSENCE OF LUNG COUNTERS

Section 5.2.1 of the Occupational Internal Dose TBD (Argall 2004) provides a section on "Missed Intakes;" however, it does not adequately describe the approach NIOSH intends to use to reconstruct a claimant-favorable dose for those individuals. In subsequent discussions with NIOSH,[4] it was learned that they intend to apply a dose of approximately 1/3 of the UPPU[5] average dose for workers of these early years. The use of one-third of the average value of the UPPU Club members is much less than the sensitivity of the monitoring capabilities in the early days. It is also known that inhalation of plutonium is not well quantified by urine analysis, and in some cases, transuranics are not detectable by this method for several years. Many of the early workers may not have had the opportunity for lung counting, which wasn't available until about 1970 and thus, may have had uptakes that were never detected or measured. Papers by

[4] NIOSH and SC&A conference call, March 21, 2006.

[5] One small, but significant, group of workers at LANL was the UPPU club. This group was established by Wright Langham in 1951 and consisted of individuals who had accumulated a significant plutonium body burden and who agreed to be monitored periodically and continue to be monitored even past the end of their employment at LANL.

Langham et al. (1962) and Voelz et al. (1978) provide insight and substantiation of this issue, describing the difficulties of detection and monitoring in those early years at Los Alamos.

The Occupational Internal Dose TBD supports the fact that, especially in the early years of LASL/LANL, many of the workers were not monitored and many were probably never monitored for uptakes. The plant was in its infancy and was on the leading edge of learning safe practices and inventing sensitive monitoring equipment for handling many of these radionuclides. As a result, the sensitivity for the first 10 to 20 years for measuring internal uptakes of these radionuclides was, in some cases, an order of magnitudes or more above the present day standards we consider acceptable. The TBD points out (Section 5.2.2, pg. 22) that "historically, emphasis was not on individuals being below the MDA, but rather being below the tolerance level." The early tolerance level was equal to about 8.3 times the MPBB for plutonium at the time (a standard later accepted and used). The TBD recognizes and discusses examples of missed intakes, detection sensitivities, reporting limits, tolerance limits, nasal swipes, and MDAs, all of which are a part of the issue. In later years, with the development of whole-body and lung-counting solid state systems, LANL was much more rigorous in their use of MDAs, decision levels, and better sensitivity in their in-vivo and in-vitro measurements.

Nonetheless, the Occupational Internal Dose TBD states in Section 5.1, page 11, that "only workers with a significant potential for exposure were monitored." The use of the term "significant potential" should be considered noteworthy, given the fact that sensitivity was based on tolerance levels in the early days before whole-body counting came into use in 1955 and chest counting in 1970. The urinalysis sensitivity for detecting plutonium could not even meet the tolerance level of 5 µg (0.33 µCi or 8.3 times the later accepted MPBB beginning in 1951). The TBD notes in Section 5.1, page10, that, "early Health Group reports indicate contamination inside many of the respirators indicating improper storage and handling and poor fit during use." The TBD further states the following in Section 5.2.1, page 16:

> *Detection sensitivity was not a primary concern in the early years of operation of LASL. The concern was whether a tolerance limit was exceeded. Results below MDA were originally reported as "less-than" values ("LX.XX") or 0 until the 1980s, when actual results, positive and negative, were listed in the database.*

This leads to the problem experienced at other sites where workers realized significant intakes from chronic low-level air concentrations that went undetected even at today's sensitive levels of detection. These types of exposures can lead to orders of magnitude greater potential exposure in workers exposed to such conditions.

The LANL is to be commended on its treatment and emphasis on measurement statistics, such as MDA, decision levels, and uncertainties, dating from the 1980s to present. However, prior to the 1980s there is concern by SC&A that the missed dose used for the dose reconstruction is not adequate or claimant favorable. Much of the discussion of MDA and chronic inhalation of Pu-239 in SC&A's review of the RFP site profile (SC&A 2005b) applies to these missed dose concerns.

5.7 ISSUE 7: COMPLETENESS AND ACCURACY OF DOSIMETRY RECORDS NOT SUBSTANTIATED

During site expert interviews with former workers, concerns were raised to SC&A regarding the completeness and accuracy of historic LANL radiation exposure records. The hierarchy of data used in the dose reconstruction process begins with the use of individual monitoring data as a priority. This is fundamental to the performance of dose reconstruction. The laboratory does not currently maintain a centralized, individual radiation exposure file similar to those maintained by other DOE sites. While such files at most DOE sites typically contain hardcopy internal and external monitoring results, incident or personal contamination records, secondary dosimetry results, whole-body count reports, etc., much of this data is not readily retrievable by LANL for a particular individual (See Attachment 2). The individual monitoring data provided to NIOSH, as cited by the site profile and applied in dose reconstruction, is pulled from a relational database compiled by Los Alamos. The absence of hardcopy records creates a heavy reliance on electronic data that has not undergone any independent validation regarding its completeness and accuracy.

5.7.1 Validation of the Database

The LANL and NIOSH, in a joint effort, compiled the LANL Bioassay Repository, which is a database inclusive of bioassay data, in-vivo measurements, and radiological incident reports, where applicable. The bioassay repository includes dose data for plutonium, americium, uranium, tritium, and polonium. Plutonium data extends back to 1944 (HSRPD 2005). Onsite expert interviews of radiological records personnel indicated that uranium and tritium were available for only some years (Attachment 2).

The LANL Bioassay Repository database as a whole has been provided to NIOSH for use in dose reconstruction. Printouts from both the external and internal database are provided upon request for specific claimant information. In the absence of hardcopy records, there is a total reliance on information contained in the electronic records.

In correspondence to SC&A, a former LANL subcontractor and site expert, Dr. Ken Silver, indicated that pre-1990 internal dosimetry data for plutonium and americium provided by LANL has not undergone verification and validation. This is confirmed by statements made in the LANL Bioassay Repository Report provided with claimant bioassay data that indicates that an effort was expended to verify and validate the electronic bioassay file, but the pre-1990 data may have been only partially reviewed:

> *Although many hundreds of hours of effort have been expended, not all the V & V* [verification and validation] *could be accomplished where data was traced back to the original laboratory notebooks. The V & V that was accomplished focused on larger values or other records that might have dosimetric significance. From 2000 to the present, virtually all the data is V & V'd; from 1990 to 2000 approximately 85% is V & V'd; from 1944 to 1990 the V&V varies by nuclide, ranging from 90% to 25%. Virtually all records of dosimetric significance have*

been V & V'd. LANL management and the NIOSH project manager have determined that the level of V & V is acceptable given the financial constraints of the Bioassay Data Repository Project. (HSRPD 2005)

Dr. Silver also alleges in his letter that this data may have been modified in some fashion by LANL prior to transmittal to NIOSH (Silver 2006). Considering the importance of this data, further verification of data completeness and accuracy, especially for those results that were determined to have no "dosimetric significance" or were not included because of "financial reasons," may be prudent. Likewise, it would be helpful to have the verification and validation process used and identified in the revised site profile.

Furthermore, the Department of Energy's 1991 "Tiger Team" Assessment of Los Alamos (DOE 1991) found several deficiencies regarding accuracy and completeness of personnel radiation dosimetry. For instance:

- *Historical radiation dose data, radiation dose data while working other than at ANL, and life-time radiation dose data on Radiation workers is not available at the Health Physics Operations Group.*
- *Accelerator personnel who work with depleted uranium components or with activated targets in the IBML have not been evaluated to determine whether they must wear extremity dosimeters.*
- *External radiation personnel dosimeters are exchanged monthly, site-wide, without regard to a worker's potential for exposure.*
- *The existing LANL dosimeter cannot be used for determining low-energy beta or positron doses, such as thallium-204.*
- *Approximately 200 to 500 personnel dosimeters out of a total of 7500 are not returned at each exchange period for processing.*
- *The personnel dosimeter has a lower limit of detection of 10 mrem, resulting in dose of 9 mrem or less being recorded as zero. This practice results in a potential missed dose of 108 mrem per year.*
- *Extremity dosimetry is not worn when handling cast depleted uranium. Extremity doses from handling newly cast depleted uranium and its oxide can be significant.*
- *All the firing sites, including TA-36 and TA 17, LANL personnel are not evaluated for inclusion in the bioassay program.*
- *Not all personnel at the plutonium and depleted uranium facilities are evaluated for participation in the bioassay program to comply with DOE 5480.11.*
- *Procedures for collecting processing and analyzing some bioassay samples do not ensure the accuracy, timeliness and quality of internal dose assessment as required by DOE 5480.11 (DOE 1991 – pg. 4-784).* [For example: *It is*

common industry practice to pick up tritium bioassay samples the same day they are submitted and process them within 48 hours...at LANL, tritium bioassay samples are picked up from field locations once a week (on Tuesdays). Normally, these samples are processed on the following Friday.]

- *At the Los Alamos National Laboratory, there is no Health and Safety Division assurance that accurate monitoring of either external or internal exposures is accomplished.*

SC&A has determined that a second database containing Po-210 bioassay information exists; however, this database still requires verification and validation. The Po-210 bioassay information is linkable only to a name and not a Z-number. It is uncertain whether these data have been fully incorporated into the LANL Bioassay Repository.

In summary, SC&A is concerned that 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. As a compensatory process, SC&A is not aware of any effort to collect bioassay data known to be absent from this database, or to independently validate its reliability by comparing the electronic bioassay results with available logbooks, air sampling data, or other sources.

5.7.2 Radiation Exposure Information in Medical Files

NIOSH is provided with a printout of cycle-by-cycle external dosimetry information and bioassay data from exposure databases to conduct dose reconstructions. Additional data exist which is pertinent to the reconstruction of dose at LANL. In a report on the LANL radiological records program, reference is made to radiation data in "medical records:"

> *Prior to January 1953, all exposures to beta and gamma radiation were reported to Medical Records for transposing into each individual Personnel Medical File.* (LANL, 1956b)

SC&A reviewed selected individual medical and radiological files during site visits to LANL. Records found in medical files included hazard reports, whole body and extremity dose information, nasal count data, personnel exposure record – airborne contamination reports, and incident reports. The hazard reports provide information on radiological hazards to which an individual was exposed during the course of their work (i.e., uranium, plutonium, polonium, beta, neutron x-ray, gamma or other sources of radiation). Routine and special nasal counts from the 1940s reside in the medical file. Reports on personnel exposure records and airborne contamination provide airborne concentration data for areas where an individual was assigned. Currently, NIOSH has requested that occupational x-ray and incident reports be provided from the medical record. The additional radiological information is not provided in the claimant package, which emphasizes the importance of verifying the completeness of information received for dose reconstruction.

The issue is further complicated by the existence of decaying medical records in the basement of the Los Alamos Medical Center (LAMC). Medical records in question may include historical patient files for not only the local community and families of workers, but for Los Alamos employees themselves. These records are stored at LAMC and in a nearby warehouse, and are under the control of the hospital. At the present time, these records are not readily retrievable due to the biological hazards associated with them. A preliminary review indicates that information pertinent to dose reconstruction is contained in these records. Considering the frequent inclusion of radiological files in onsite records, there is a potential that the medical records stored at the hospital also contain radiological information. Further evaluation on the pertinence of these records to energy employee dose reconstruction is warranted. Radiological data found in these files should be evaluated to ensure this data is reflected in the exposure databases compiled by Los Alamos.

5.7.3 Human Radiation Experiments

Human Radiation Experiments were conducted at Los Alamos from the early 1950s through 1963. Radiation experiments included exposures to I-131, Na-24, tritium, Cr-51, Na-22, K-42, Rb-86, Cs-137, Cs-134, Fe-55, Fe-59, and Sr-85 (DOE 1995a). Some Los Alamos workers voluntarily participated in human radiation experiments. One former employee indicated that they had participated in a tritium ingestion study, as well as an ingestion study involving uranium carbide and Mn-54 in a capsule (DOE 1995b). Another LANL employee voluntarily took some Cr-51 and radioiodine labeled rose bengal (DOE 1995c). Ten LANL firemen orally ingested Fe-59 and were counted over a period of ten days (DOE 1995c).

Information on the exposures of LANL employees from participation in human radiation experiments is not currently provided to NIOSH. Los Alamos recently discovered a source of records referred to as "individual research files," which appear to contain information on radiation experimentation. These files are maintained separate from the medical and radiological records. The files are not limited to the experimentation, but include additional medical evaluations received by these personnel including supplemental x-rays. These individual research files, in addition to other information on worker participation in human radiation experiments, require further investigation to determine the number of claimants affected. Any files containing additional information on radiation exposures should be requested by NIOSH.

5.7.3.1 Incidents

Historic radiological exposure incidents were frequent at LANL, particularly in the early years. However, the site profile does not fully address the significance of such incidents, how they may have contributed to worker dose, and how they would be addressed by dose reconstruction (this issue has been addressed in other site profiles, albeit, inconsistently). It is not likely that NIOSH has specific information on who was monitored and who was not, how samples were collected during such incidents, and how these samples were handled and processed, especially in the early days. In the Site Description TBD, ORAUT-TKBS-0010-2 (Buddenbaum 2004), Table 2-4, pages 50–51, NIOSH has provided a list of 54 accidents and incidents. In addition, Table 5-22 in the Occupational Internal Dose TBD, ORAUT-TKBS-0010-5 (Argall 2004), pages 47–48, lists an additional 45 accidents and incidents. Dr. Ken Silver, a LANL site expert, in his LANL comment report points out that:

> *Two tables (2-4 and 5-22) in the site profile document list incidents that resulted in worker exposure to radiation. However, NIOSH and ORAU do not appear to have yet made comprehensive use of a voluminous Occurrence Reports Collection (ORC) located at TA-35 under the custodianship of John Voltin and William Inkret. Based on this author's first-hand experience in the ORC at TA-35, it is apparent that Tables 2-4 and 5-22 of the site profile document do not take account of numerous worker contamination episodes. A lower bound estimate of 64 net additional occurrences involving worker radiation contamination is derived for the years 1970–1980, 1985 and 1990 alone (Table 2), using this author's research notes taken when he had access to the ORC at TA-35 from 1996 to 1998. Extrapolation of this lower bound estimate to the entire period of 1944 to 1991 translates into more than 230 occurrences involving worker radiation contamination for which documentation would be available if NIOSH and ORAU were to thoroughly utilize the ORC at TA-35. Illustrative examples of incidents documented in this collection but not included in the site profile document are listed in Table 3. In addition, Table 4 presents a similar list for years other than the 13 years noted above, drawing upon multiple sources including the LAHDRA repository at UNM's Zimmerman Library and the files of the Joint Committee on Atomic Energy in Washington, D.C.* (Silver 2005)

While it is clear that judgment needs to be exercised regarding what accidents and incidents need to be reviewed and included in site profile characterization, it is important to identify available information regarding key accidents and incidents and assure their availability and use by dose reconstructors. As important, the site profile needs to evaluate this accident history for its implications to dosimetry adequacy and completeness of dose reconstruction.

5.8 ISSUE 8: TBD DOES NOT ADDRESS POTENTIALLY MISSED AM-241 INTAKES PRIOR TO THE MID-1990s

Section 5.2.2 of the Occupational Internal Dose TBD (Argall 2004, pg. 22), states the following regarding participation of LANL workers in the americium bioassay program prior to the mid-1990s:

> *…participated in the americium bioassay program only if there was a potential for exposure to pure americium*, and, *prior to the mid-1990s, very few individuals submitted urine samples that were analyzed for the presence of ^{241}Am. Samples were submitted in response to incidents involving exposures to sources of ^{241}Am not contained in the plutonium mixture.*

The TBD further states, "Historically, emphasis was not on individuals being below the MDA, but rather being below the tolerance level" (Section 5.2.1, pg. 20). (This topic is discussed further in a separate discussion under Section 5.3). The tolerance level and MPBB for plutonium started out at 5 μg or 0.33 μCi, which was 8.3 times the MPBB defined and used from 1951 through 1989.

It is noted in several places in the TBD that workers participated in the americium bioassay program only if there was a potential for exposure to pure americium. The explanation given for this in the TBD and in SC&A's discussions with NIOSH/ORAU was that the plutonium at LANL in the early days was "newly processed" plutonium, and thus, had little time for in-growth of Am-241 from the Pu-241. This still leaves a couple of issues. One, the newly separated plutonium still usually had 50 to 100 ppm of Am-241 in the product, and, with normal weapons-grade plutonium having approximately 0.5% by weight Pu-241, as noted in Table 5-6, page 19, of the TBD (Argall 2004), there is an in-growth of approximately 20 ppm of Am-241 per month. This leads to around 300 ppm Am-241 within a year, which is significant from a measurement standpoint. This becomes even more significant after 20 or 30 years of residence within the body after which the in-growth becomes 5,000 to 7,000 ppm Am. The dose from the Pu-241, Am-241, and U-237 alphas, x-rays, and 60 keV gamma rays become significant contributors to the lifetime dose to the individual. Second, LANL notes having received 6% and 12% Pu-240 mixtures from at least one other reactor facility. This significantly changes the activity ratios of the Pu-241 that, in turn, increases the build-up and in-growth rate for the Am-241. This presented serious problems at other DOE sites around the country back in the 1960s. It is the concern of SC&A that exposures and possibly intakes of Am-241 may have been missed over the years as a result of the practice of monitoring for americium **only** if the worker had potential for exposure to pure americium. This concern is corroborated by statements in the TBD, as follows.

The TBD (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 for exposure to pure americium.* (Argall 2004)

The TBD (Argall 2004) further states in Section 5.2.2, page 22, that:

> *…prior to the mid-1990s, very few individuals' submitted urine samples that were analyzed for the presence of 241Am. Samples were submitted in response to incidents involving exposures to sources of 241Am not contained in the plutonium mixture.* (Argall 2004)

The TBD (Argall 2004) also states that:

> *…if the selected plutonium mixture, based on plutonium bioassay results, indicates the presence of americium, the absence of americium bioassay should not preclude the calculation of the dose from the americium contribution to the mixture.* (Argall 2004)

This statement implies that some selected plutonium mixtures might indicate no presence of americium. The amount of americium may be small at initial intake; however, after years of in-growth within the body after uptake of the plutonium, this may no longer be true.

During the course of discussion between NIOSH, ORAU, and SC&A, there was the comment that americium and plutonium are linked inside the particle matrix and will remain bound and linked in the ratio of the initial material of intake. SC&A questions the technical validity of this statement based on the available scientific literature. The TBD (Argall 2004) in Section 5.2.1, page 21, notes a difference in plutonium-to-americium, particularly in the case of high-fired oxides, and this difference has been recognized and documented as far back as the 1960s (see *Americium and Plutonium Urine Excretion Following Acute Inhalation Exposures to High-Fired Oxides* (Hammond et al. 1968) and *Two-Year Follow-Up Study of Several Acute Inhalation Exposures to* PuO_2 (Mann 1968).

5.9 ISSUE 9: THE INTERNAL DOSE TBD LACKS A CLEAR MEANS TO ASSIGN DOSE TO UNMONITORED WORKERS

The Occupational Internal Dose TBD, ORAUT-TKBS-0010-5 (Argall 2004) includes a statement attributed to Hempelmann et al. that working conditions at LANL were "deplorable by present-day standards" and that "in June and July 1945, over 50% of the laboratories had areas that routinely exceeded the maximum removable contamination level" (Hempelmann et al. 1973 and Argall 2004). The TBD further states:

> *The potential for unmonitored intakes was significant in the early years (1944–1946) for any site worker. Bioassay was provided only for those workers who were most exposed. However, because excretion of plutonium is continuous following an intake, significant intakes might have been identified on later routine bioassay samples with improved sensitivity for workers who remained at LANL.* (Argall 2004)

The TBD observes that as "bioassay sensitivities and respiratory protection equipment improved, the potential for intakes decreased" (Argall 2004). It goes on further to state that while large intakes that were unmonitored and undetected became increasingly rare after 1946, the "probability of small intakes is larger." The TBD (Argall 2004) provides additional history that bolsters the case that such intakes would have been relatively common, given the significant number of "over tolerance" radiological occurrences even through the 1960s and the relatively loose programmatic requirements for who was required to receive routine or special bioassay, and loosely defined contamination control areas. Until 1970, the inclusion of workers in the bioassay program was at the complete discretion of the health physics monitor, leaving open the probability that workers were inappropriately not bioassayed even into the 1970s.

Based on this history, SC&A is concerned about the historic number of unmonitored workers with the potential for uptakes of radionuclides. The TBD (Argall 2004) notes in (Section 5.1, pg. 11) that:

> *Excreta bioassay methods for determining internal exposures were developed in late 1944 for plutonium (fully implemented in April 1945) and polonium, in 1949 for uranium, and in 1950 for tritium.* ***Only workers with a potential for exposure were monitored.*** *A survey taken in 1986 estimated that approximately 350 persons had known burdens of plutonium.* [Emphasis added] (Argall 2004)

In Section 5.1, page 10, the TBD states that, "the potential for monitored and unmonitored intakes has existed throughout the history of the site" (Argall 2004). The text in Section 5.1, page 10 of the TBD, also points out that in these early days that:

> *…research indicated that there was potential for work and casual encounters with plutonium and other radionuclides at various air concentrations or surface contamination levels, including levels that exceeded radiation exposure or control limits. Given that these operations were, in many cases, the first of their kind and that health physics practices were being developed and implemented at the same time plutonium processes were being brought online, some level of chronic or episodic intake during this period would be a reasonable assumption.*

A summary of some of the findings of the DOE Tiger Team Assessment conducted in November 1991 (DOE 1991) included the following comments regarding the LANL internal dosimetry program. (The page numbers shown are the pages in the Tiger Team assessment).

> *Not all personnel at the plutonium and depleted uranium facilities are evaluated for participation in the bioassay program.* (pg. 4-183)

> *A LANL employee was potentially exposed to substantial quantities of tritium contamination (i.e., oxide and organic bound) at the Ion Beam Facility. The facility does not provide proper controls and protection or require bioassay analyses for potentially exposed personnel.* (pg. 4-385)

In summary, at the time of the Tiger Team report in 1991, LANL did not have an adequate internal dosimetry program for four of the major categories of exposed workers; firing site workers, and workers potentially exposed to tritium, plutonium, and depleted uranium. An underlying reason may have been that three separate organizations were involved in staffing the bioassay program.

> *The LANL internal dosimetry program involves staff from three separate organizations. The program lacks clear organization, defined responsibilities, and authorities.* (pg. 4-783)

> *Studies have not been performed at LANL work locations having major potential for worker internal exposure to airborne uranium and plutonium compounds to characterize the in vivo solubility characteristics of specific chemical forms.* (pg. 4-785)

Interviews by SC&A have indicated that certain groups of individuals with access to radiological control areas, vaults, and special nuclear material (SNM) contaminated areas claim not to have been a part of the bioassay monitoring program. It was also claimed that certain groups of individuals were required to eat their lunches within these areas, and these individuals are among those that claim not to have been a part of the bioassay monitoring program (Attachment 2). It was further noted that during the dose reconstruction process for EEOICPA, records of security officers traveling to other DOE sites, such as NTS, were not included as a part of the LANL record and were not requested by LANL-DOE for submission to NIOSH. SC&A believes these issues and claims need to be addressed.

SC&A is also concerned over the TBD's speculative nature in addressing the provision of bioassay for students, postdoctoral researchers, and other temporary workers that may have had potential internal radionuclide intakes:

> *Short-term workers, such as summer students, persons participating in postdoctoral work, and teachers,* ***might*** *not have fully participated in routine bioassay programs. These workers were monitored for internal exposure only in unusual circumstances. Near the terminations date, the worker* ***might*** *have received an in vivo count. The worker* ***might*** *have been required to submit an initial urine sample or have an initial in vivo count.* [Emphasis added] (Argall 2004)

It is clear from these statements, that there is no substantiation on how short-term workers were provided bioassay.

Questions regarding data adequacy have largely focused on the adequacy of early occupational monitoring data. According to site experts, individuals who worked with 1 Ci of Am-241 or Pu-238/Pu-239 were placed on the urinalysis program (see Attachment 2). The potential for unmonitored intakes was significant from 1943–1946 for site workers. In the absence of early bioassay data, the TBD relies on maximum and average annual airborne concentrations to establish bounding conditions for chronic intakes. Airborne concentration data derived from LANL reports is not complete for all years of operations and radionuclides present, and in some cases is not specific to particular operations. For example, Table 5-20 of the TBD lists air sample values for DP (Defense Programs) West and DP East in 1949, which were involved in numerous operations. The air concentration values for I-131, fission products, and gross beta-gamma are limited for the 1940s and 1960s, and are not available for the 1950s. Maximum allowable concentrations (MACs) are used to bound doses in some cases; however, the TBD has not considered situations where airborne concentrations exceeded the MAC. During the early years, there were no consequences for exceeding these levels. At times, workers were exposed to airborne concentrations above the tolerance level for a radionuclide. MAC values may not represent a bounding condition in these cases.

The TBD indicates that air monitoring is not an accurate predictor of intake quantity. In spite of this, there is no discussion of uncertainty related to the use of air monitoring and tolerance levels. Several technical studies, including the recent 2003 Y-12 study, *Practical Use of Personal Air*

Sampling (PAS) Data in the Internal Dosimetry Program at the Y-12 National Security Complex (Snapp 2003), and Nuclear Regulatory Commission's NUREG 1400, *Air Sampling in the Workplace* (Hickey 1993), demonstrate that using air concentration data could lead to underestimating the worker intakes and subsequently the internal exposures. The Y-12 study shows as high as 10 times difference (underestimation) between intakes derived from bioassay data and intakes derived from air concentration data for uranium. In addition, the sensitivity of survey instruments, locations of the air sampling, and air flow studies of the buildings were not considered that could impact the accuracy of the air concentration data. The TBD instead applies a larger geometric standard deviation (GSD) (i.e., 5) to account for the uncertainties associated with estimating internal dose from air sampling. With the unknowns and shortcomings associated with the use of airborne concentration data for estimating missed dose, further evaluation should be provided to make sure this approach is bounding for unmonitored acute and chronic intakes.

Given the above historic perspectives by both the TBD (Argall 2004) and SC&A's references, it is clear why NIOSH concluded in the TBD that "the experiences of workers with monitored intakes cannot be used to develop a scenario [e.g., 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; see Section 5.1) and for many specific job locations; second, it is not clear, as emphasized by the TBD (Argall 2004), itself, who may have been 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. In short, 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.

5.10 ISSUE 10: THE TBD DOES NOT ADEQUATELY ADDRESS POTENTIAL DOSE CONTRIBUTION FROM EXTERNAL HIGH-RADIATION EXPOSURES TO UNBADGED WORKERS

SC&A is concerned regarding the Occupational External Dose TBD (Widner 2005) stated approach 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 as recommended on pages 49 and 65 of the TBD, when LANL's operational history is replete with instances where the potential existed for exposures in the **rem/hr** range. These sources or incidents of radiation exposures at LANL that had the potential for high exposures include:

- The early experimental accelerators and n-p sources at TA-1 (Original Main Technical Area) mentioned in the Site Description TBD (Buddenbaum 2004, pg. 29) presented neutron and gamma exposure hazards:

> *A betatron used to study implosions was housed in the Gamma Building at TA-1. The intensity of betatron's photon beam was reported to be* ***25 R/minute at one meter*** *and 0.16 R/minute at 12.5 meters (LASL 1946). The beam was* ***directed outside*** *and into a second building with* ***no access controls*** *in place."* [Emphasis added.] (Buddenbaum 2004, pg. 33)

- According to a LANL H-Division Progress Report of 1958 (Meyer 1958a), on January 3, 1948, a high radiation background of 17 mr/hr was detected in D-Wing of the Administration Building. Subsequent investigation revealed that a 200 curie Co-60 source was being used by J-10 on the third floor of A-wing. A reading of 120 mr/hr was detected on the sidewalk area and up to 18 mr/hr in adjacent rooms. It was found that a person had inadvertently walked in front of the beam and received 1.3R.
- The reactors and the Omega Stack at TA-2. The Site Description TBD (Buddenbaum 2004, pp. 58 and 59) states the following:

> *The exposure rate measurements made at head height at about 4 ft from the pit read* ***more than 14 R hr^{-1}*** *at the northeast corner and* ***2.2 R hr^{-1}*** *at the southeast corner...An accident at the Omega Water Boiler on August 3, 1953, caused a temporary rise in the background to* ***100 R hr^{-1}*** *in the Reactor Room. No details were provided in the report about what specifically occurred.* [Emphasis added.]

- The Site Description TBD (Buddenbaum 2004, pg. 59) also points out the following:

> *On July 24, 1957, 120 cm^3 of acid was added to the Water Boiler fuel solution. During this action, fission product material was inadvertently drawn into an evacuated line and deposited on the top of the reactor. Exposure rates as high as* ***20 R hr^{-1}*** *were measured on the floor surface.* [Emphasis added.]

- In an H-Division Progress Report of 1950 (Shipman 1950), it was stated that two experimenters walked through an unprotected fast [neutron] beam at the Water Boiler during a visit, resulting in a unusually high exposure on one of the worker's NTP. It was not stated if the other workers were exposed to this unprotected beam or how long it had existed.

- The radioactive lanthanum experiments contained large amounts of radioactivity. The Site Description TBD (Buddenbaum 2004, pg. 32) states the following:

> *The ^{140}La sources prepared at Ten Site were usually in the range of 2,000 to 4,000 Ci. Almost 2 million Ci of ^{140}Ba had been handled at Ten Site by 1963 when the RaLa program was terminated.*

The decay of Ba-140 to La-140 to Ce-140 has an effective half life of around 14 days and emits a hefty 1.6 MeV gamma 96% of the time. These RaLa shots also released an estimated 226 mCi of Sr-90.

- The pulsed high-energy x-ray machines and associated large radioisotope sources (i.e., Co-60 sources up to 500 Ci, Ir-192 sources up to 100 Ci, and Cs-137 sources up to 30 Ci) at TA-15 (R Site), and "In 1947, TA-11 (K Site) had a 20-MeV betatron and a 500-mCi radium–beryllium source," as stated in the Site Description TBD (Argall 2004, pg. 33).

- The operations of Los Alamos Power Reactor Experiments (LAPRE) I and II, with their associated leaks, created radiation fields upwards of several **thousand** roentgens per hour as cited by the Site Description TBD (Buddenbaum 2004), page 39.

- Neutron dose fields existed in, and surrounding, TA-18 during critical assembly operations as cited in the Site Description TBD (Buddenbaum 2004, pg. 46). The H-division Progress Report of 1955 states that on August 16, 1955 (Shipman 1955):

  > *Thirteen positions were checked, with five of the areas indicating almost prohibitive tolerance times of as low as 2 ½ hours per week. The five areas are manned with personnel 100% of the time during working hours. The controlling or limiting factor was found to be due to thermal and intermediate neutrons. For this reason, persons outdoors or in thin-walled buildings receive a high exposure rate under these conditions.*

- Neutron doses not monitored because significant neutron fields were not expected in that era of laboratory operations (e.g., accelerators, neutron generators, spontaneous-fission sources, critical assemblies, photo-neutron sources, alpha-neutron reactions, etc.).

- Waste handling and disposal activities, as noted in the Site Description TBD (Buddenbaum 2004, pp. 51–55), describe numerous waste treatment sites. However, much concern has been expressed in the past over workers who handled radioactive waste without proper monitoring because they were not considered radiation workers, or because the hazards were not recognized at the time. This was reiterated during recent worker interviews. This concern is with workers handling radioactive waste, not the environmental releases.

Reference to these areas of high-potential exposures was included in the LANL TBDs and other documents, such as in the 1957 Group H-1 Annual Report, where it states:

> *Certain types of work at the laboratory gave excessive difficulties in controlling external whole body radiation to personnel. These are: U-233 chemistry and fabrication, RaLa processing, experiments and water disposal, and the manipulation of critical assembly components.* (Chelius 1958)

Also, it was stated on page 2 of the September 1958 H-Division Progress Report the following:

> *A survey was made of the GMX-11 betatron. A report of the radiation levels was made to the operating group and the high radiation area was fenced. During the period August 14 through September 15 the calculated daytime dose to the Kappa Site area from activities at Pajarito Site was 0.297 rem.* (Meyer 1958a)

For example, the Occupational External Dose TBD, ORAUT-TKBS-0010-6 (Widner 2005, pg. 65) recommends assigning a median dose of 507 mrem for the year 1946 for unmonitored workers, and on page 68 (Widner 2005), it recommends assigning 240 mrem/year for missed doses for monitored workers who had missing data or zero entries on a monthly exchange basis. Compare this to the statement on page 33 of the Site Description TBD, ORAUT-TKBS-0010-2 (Buddenbaum 2004), as quoted above, concerning betatron fields of 25 R/minute (1500 R/hr) at one meter and 160 mR/minute (9.6 R/hr) at 12.5 meters and the beam was directed outside without access controls in place. A brief 2–4 minute one-time exposure at 12.5 meters (40 ft) would exceed either the recommended missed or unmonitored assigned dose for a year.

An example concerning high potential exposures from early reactors is provided on page 58 of ORAUT-TKBS-0010-2 (Buddenbaum 2004) where it states that, in 1950, exposure rates were 2.2 to 12 R/hr around the Water Boiler reactor and that radiation fields were detectable as far away as the Trailer Village, even after reactor shutdown. Compare this to the recommended assigned median dose of 140 mrem/year for 1950 from page 65 of Occupational External Dose TBD, ORAUT-TKBS-0010-6 (Widner 2005) for unmonitored workers and 240 mrem/year for missed doses for monitored workers who had missing data or zero entries on a monthly exchange basis. Again, several minutes of exposure would exceed the recommended yearly assigned unmonitored or missed dose.

Additional comparisons could be made for later periods; for example, the several thousand R/hr fields around the LAPRE I and II experimental reactors, which experienced leakage problems, ORAUT-TKBS-0010-2 (Buddenbaum 2004, pg. 39). A very brief exposure to these unexpected (at the time) high radiations fields would certainly overshadow the median or missed assigned doses as currently recommended.

NIOSH should evaluate each claimant's case to determine if the worker was involved in any of these high-exposure activities (not just accidents/incidents) before assigning the median unmonitored doses or missed doses based on MDL values. It has been contested that LANL over-badged its workers. This may have been true in some cases, but it would have been possible for unbadged workers to be exposed to high doses before the hazards were fully recognized; for example, when radiological controls were based on 10% of the radiation protection guidelines and badging was not as common.

The area of waste handling is of specific importance because it has been an area of controversy in the Los Alamos community for years and needs to be fully addressed in the Occupational External Dose TBD (Widner 2005). In the present TBDs, it has not been demonstrated that technically sound monitoring practices for waste handlers were implemented throughout the years, and that those workers who were not monitored should only be assigned doses based on median doses or MDL values as prescribed by the TBD approach.

In summary, the current recommended approach of the TBD (Widner 2005) in assigning median and missed doses could result in substantially underestimating worker's dose in a number of cases.

5.11 ISSUE 11: UNMONITORED EXPOSURES OF ZIA COMPANY MAINTENANCE, CONSTRUCTION, AND FACILITY SUPPORT WORKERS NOT SUFFICIENTLY ADDRESSED

Between 1946 and 1978, approximately 14,428 workers were employed by the Zia Company, the maintenance contractor at the LANL (Galke et al. 1992). Zia workers were involved in site-wide construction and maintenance of radiological facilities at LANL, as well as extensive radioactive waste management and disposal activities. 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. Examples of the potential radiological risks to Zia workers are found in a 1977 history of radioactive waste disposal at LANL (Rogers 1977).

- **1948 –** *The contamination on materials in these pits consists of all types of radioactive materials used at Los Alamos. Some of the known types of activity are: plutonium, polonium, uranium, americium, curium, RaLa [radioactive lanthanum], actinium, and waste products from the Water Boiler. No attempt has been made to keep the various materials separated.*
- **1948 –** *A fire broke out in Area B at approximately 10:20 a.m., May 3, 1948 …When the fire department arrived [they] found sixty percent of the open portion of the dump ablaze and flames shooting approximately fifty feet into the air. The firemen had little trouble in subduing the blaze, but persistent efforts to put it out were to little avail because of the loaded condition of the dump area in which the blaze was confined. Dense, low hanging smoke prevailed in large volume …Because of the dense smoke which scattered throughout the area, due to the condition of shifting winds, all areas east and west of the dump, from the food warehouses to the DP laundry were evacuated of personnel.* (Rogers 1977, pg. B-5)
- **1949 –** *The waste disposal program requires three men. Two of these work on the contaminated truck and are furnished by the Zia Company. The third man is a CMR-12 monitor. The monitor supervises the handling of material…The equipment used consists of a truck and a sedan. The material in the pits is*

covered once a week. This requires the use of a bulldozer and operator one day a week. (Rogers 1977, pg. B-4)

- **1956 –** *…collection of trash from laboratories was done in the following way. Zia janitors removed trash from host-waste cans and put trash into cardboard boxes. The boxes were then sealed and set outside the building for pickup by tru*ck. (Rogers 1977, pg. C-8).
- **1958 –** Workers are off loading radioactive sludge drums from the waste treatment plant in Pit C area by hand – "…a few shovels of dirt are shoveled on top of the container so as to reduce the gamma radiation to less than 1 mrem/hr." (Rogers 1977, pg. C-11).
- **1959 –** *The practice of backing a truck up to the edge of a disposal pit and throwing trash off the rear was abandoned in 1959 when Pit 1* [containing plutonium, uranium and tritium wastes] w*as in use, after a man fell into the pit when the edge crumbled beneath him.* (Rogers 1977, pg. G-16).
- **1973 –** Workers near Pit 1 were exposed to, "The tritium concentrations observed in the fill on Pit 1 are more than three orders of magnitude higher than this." [background concentrations] (Rogers 1977, pg. C-93)

Epidemiological research underscores the paucity of monitoring data to support dose estimation for Zia workers. Studies of the Zia workforce, which include many Hispanics and Native Americans, have been found to be much less complete than for the UC workforce. In one study, personnel records were found to be available for 97% of the UC workers, but only 20% of the Zia workers; and urinalysis records were found to be available for 39% of the UC workers, but only four percent of the Zia workers (Wing and Richardson 2004).

While the Zia monitoring program later had a computer program that locked out access to plutonium areas for workers not bioassayed within 425 days, it is not clear when this program was enacted. It is also unclear how this measure would have precluded workers from receiving uptakes and discontinuing employment, or moving to other radiological areas, and therefore not 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 workforce, given the spectrum of radiation sources involved and the varying site-wide work assignments to which they were assigned. For example, while Zia workers were bioassayed for Pu-238 and Pu-239, it is not clear when (or if) they were monitored for other internal emitters to which they were exposed. Furthermore, it is not clear whether external dosimetry was adjusted as maintenance and support workers moved from facility to facility and may have been exposed to varying neutron energy spectra.

It is also not clear from the TBD how the 1978 policy was carried out to reduce the number of Zia employee bioassays to no more than 500. The TBD notes that the reduction included supervisors who "only performed inspections." However, it is not clear what other job categories were included. SC&A wonders if this has an implication regarding potential unmonitored internal dose. Likewise, the reliability of the dosimetry data in this so-called "separate" monitoring program is not addressed.

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. Security performed patrols of the buildings and areas on foot, in vehicles, or on horse back. Building patrols required guards to check the outside of the building and perform internal walk-throughs of laboratory sites, including radiological areas. They had full access to all areas of the site, particularly in earlier years. Tours took them to various SNM storage areas as the machine shops, laboratories, assembly areas, firing sites, and near-critical assemblies. Many times officers were stationed in areas where nuclear weapons and components were out in the open.

Officers responded to security alarms throughout the LANL facility. When these units alarmed, Patrol was required to enter the area and determine why the alarm was sounding. In some cases, when responding to alarms at facilities in TA-2, TA-16 (S Site), TA-41 (W Site), TA-18, and DP-West, they actually had to pass through laboratories to get to the alarm or vault, or be stationed inside the vaults until the incident was resolved. As the eyes and ears of the laboratory on off-hours, they were often the individuals who identified spills or unusual conditions.

Other responsibilities included guarding SNM, escorting radioactive materials for scientists, and transporting of materials for testing. Security also inventoried material transported offsite, such as to the NTS, and participated in exercises involving detonation of nuclear weapons.

The security force had regular potential for exposure to numerous radionuclides as well as external exposure hazards. External monitoring was routinely provided as verified by former guard interviews. It will be difficult, however, to associate exposure to a particular facility. This brings into question the appropriate n-p ratios and correction factors to be applied to dosimetry results. The completeness of the bioassay sampling is also questionable, based on the number of radionuclides they may have been exposed to during their rotations throughout the site. Exposure conditions and potential for exposure will differ between areas. For example, exposure conditions from material contained in a glove box would differ from those in a machining area where material is more likely to go airborne.

Further consideration should be given to potential exposures and the adequacy of the internal and external monitoring data in relation to mobile workers, such as the Zia employees, security personnel, and other employees involved in site-wide activities. From interviews with NIOSH/ORAU staff, it was learned that additional bioassay information for Zia employees will be included in the next edition of the site profile.

5.12 SECONDARY ISSUES

5.12.1 Secondary Issue 1: Cumulative Effect of Numerous Source Terms Not Adequately Addressed

The Occupational Environmental Dose TBD, ORAUT-TKBS-0010-4 (Cehn and McDowell-Boyer 2004), as written, fails to test the adequacy of evaluating the cumulative (additive) effect of numerous source terms at differing locations, which are in different Technical Areas (TAs).

NIOSH has reported that recently released LANL documents that are associated with the Historical Document Retrieval and Assessment Project (LAHDRA) project are being used to review and determine whether additional information is available to fill gaps in the Occupational Environmental Dose TBD, ORAUT-TKBS-0010-4 (Cehn and McDowell-Boyer 2004) for sampling and effluent data. A revision to this TBD-4 is currently being developed and will utilize newly acquired information.

To further clarify the content of the current TBD, NIOSH has offered that monitoring data do not distinguish the source of emissions, and therefore, to some measure, do evaluate additive effects. Although the ratioing method, currently being applied by NIOSH, does not address cumulative effects, the use of site-wide maximum intakes lessens the importance of these potential effects.

SC&A believes that the lack of air monitoring stations, within a particular TA of known higher releases of a specified isotope, does not readily enable one to accurately estimate environmental dose. This is particularly true when using air monitoring data from an adjacent TA air monitoring station. It will be difficult for the dose assessor to accurately estimate environmental dose without accurate air monitoring data derived from a station proximal to the release point.

To this extent, NIOSH has recently agreed that using emissions data to estimate air concentrations in another TA would not be appropriate. Recently released data from the LAHDRA project will be used to fill the gaps for sampling and effluent data. Depending upon the outcome of this review, NIOSH plans to revise the Occupational Environmental Dose TBD, ORAUT-TKBS-0010-4 (Cehn and McDowell-Boyer 2004).

5.12.2 Secondary Issue 2: Validation of the LAHDRA Project Data Remains in Question

The Occupational Environmental Dose TBD, ORAUT-TKBS-0010-4 (Cehn and McDowell-Boyer 2004) has relied, to the extent possible, on data derived from the LAHDRA project, yet the validation of that data remains in question and is lacking sufficient effluent data for the years 1945–1971. NIOSH/ORAU intends to validate this data against the missing effluent reports for 1945–1971. Interviews of retired LANL personnel (see Attachment 2) suggest that essential data, as far back as 1958, does exist.

NIOSH has responded by indicating that its earlier evaluation of effluent data back to the 1940s and 1950s found it was not reliable or mature enough for dose assessment at the time this Occupational Environmental Dose TBD was written and approved for dose assessor use.

Recently released additional LANL documents that are associated with the LAHDRA project, are being further reviewed to determine whether enough additional information is available to fill gaps in the TBD for sampling and effluent data. Another source of ongoing work involves development of co-worker data that could possibly be used in some instances to address unaccounted doses from releases.

5.12.3 Secondary Issue 3: "Ratioing" Approach to Estimate Airborne Concentrations is Questionable

The Occupational Environmental Dose TBD, ORAUT-TKBS-0010-4 (Cehn and McDowell-Boyer 2004) fails to assure that the use of the "ratioing method" is adequate to estimate ambient air concentrations for Technical Areas (TAs) where limited ambient air monitoring data exists. The assumption that air concentrations are related to the ratio of effluents for nuclides in differing TAs has not been validated.

NIOSH has reported that recently released LANL documents that are associated with the Historical Document Retrieval and Assessment Project (LAHDRA) are being used in their review to determine whether additional ambient air data is available to fill in the gaps in the TBD for sampling and effluent data which necessitated the ratioing approach.

To further clarify the content of the current TBD, NIOSH has offered that since ambient monitoring data does not distinguish the actual source of emissions, then the application of a ratio approach based on actual effluent data may be appropriate. Also NIOSH feels the use of site-wide maximum intakes as a fallback would lessen the importance of the potential to underestimate dose.

SC&A believes that the lack of air monitoring stations, within a particular TA of known higher releases of a specified isotope, does not readily enable one to accurately estimate environmental dose, using air monitoring data, from an adjacent TA air monitoring station. Similarly, the use of a ratio of effluent data or the use of a site maximum is problematic. It will be difficult for the dose assessor to accurately estimate environmental dose without actual ambient air monitoring data.

To this extent, NIOSH has recently agreed that using emissions data to estimate air concentrations in another TA would not be appropriate. Recently released data from the LAHDRA project will be used to fill in the gaps for sampling and effluent data. Depending upon the outcome of this review, NIOSH plans to revise the TBD (Cehn and McDowell-Boyer 2004).

5.12.4 Secondary Issue 4: Additional Occupational Medical X-rays should be Included in Dose

The current guidelines, as presented in the reference OTIB-0006 (Kathren and Shockley 2005), go a long way in assuring that occupational medical exposures are included in determining the overall dose estimations for claimants. Unfortunately, the interpretation, to date, by the contractor, ORAU, has not been necessarily applied conservatively to be claimant favorable. The Occupational Medical Dose TBD, ORAUT-TKBS-0010-3 TBD (Johnson 2004) assumes an interpretation, which has been also considered and applied at other sites, such as Rocky Flats and Hanford Plants. To this extent, the assumption that medical procedures are limited to only one pre-employment and other potential annual chest x-rays, as part of routine physical exams, may substantially underestimate worker medical exposure, when evaluating the totality of occupational medical exposure.

In support documentation, OTIB-0006, Revision 3 (Kathren and Shockley 2005), it is concluded that other examinations may be included, such as special job exams (e.g., respiratory protection, beryllium workers, asbestos workers, etc.) and termination exams. The occupational medical TBD does not recognize this change from the previous Revision 2 of the OTIB-0006 (Kathren 2003), and also incorrectly assumes that special chest radiography for respirator certification, beryllium and asbestos workers, and food handlers are accomplished as part of the annual physical. This is not documented in past medical protocols, and often was performed separately, at the request of the Medical Department, until the mid-1980s. Another factor not discussed in the TBD is the potential and impact of x-ray procedures utilized by medical authorities to do special screenings, and to evaluate the result of injury and trauma.

The Occupational Medical Dose TBD makes the conclusion that one chest examination of a PA and LAT per year is probably limited to a small fraction of high-risk workers, especially after 1992, as documented in Table 3.1 of the TBD. To the contrary, there is ample evidence that chest x-rays were provided on a voluntary basis to nearly all workers, as part of routine physical examinations. The majority of workers had chest x-rays as a routine at DOE sites until the mid-1980s, when federal guidelines warning against routine screening were first being enforced.

After discussion with NIOSH personnel, it was their decision to limit occupational medical exposure to those chest exams described above, and to assume all other exposure as part of worker background. SC&A believes such an interpretation is not claimant favorable to those most at risk. Our concern is that specified high-risk workers will likely receive compensation based upon a probability of causation (POC) from exposure to radiation and beryllium principally. Second, all radiation provides some risk, and arguably, is somewhat cumulative. These are not normal workers and warrant consideration of all forms of work-related x-ray exposure, to be claimant favorable. SC&A believes NIOSH should review its interpretation of included exposure, and should reasonably adopt a broader interpretation of medical dose, as provided in the OTIB-0006, Revision 3 (Kathren and Shockley 2005).

Thus, it is not considered claimant favorable to limit occupational medical exams to one chest exam annually, unless medical records and protocols clearly limit the use of radiography to a small fraction of workers, which was not the case until the mid-1980s.

5.12.5 Secondary Issue 5: Beam Quality, Filtration, and X-ray Tube Output Not Well Known

The Occupational Medical Dose TBD, ORAUT-TKBS-0010-3 (Johnson 2004) in Sections 3.2 and 3.3 describes that little, if any, information exists upon which to establish beam quality for x-ray units in use from 1943 to 1984, when the site converted to Type III equipment. There is documentation to show that the General Electric KX810, in use from 1964 through 1984, did have initially 6.75 mm Al of added filtration, which was later reduced to 4.0 mm Al. In the absence of definitive tube output measurements, the TBD uses as default values, the DCFs derived from ICRP Report No. 34 (ICRP 1982). To calculate the dose from LAT chest x-rays, the TBD suggests using, as the LAT entrance skin exposure (ESE), a value that is 2.5 times the derived PA (ESE). These values are then applied to determine organ doses using Tables A.2 through A.8 of ICRP Report No. 34. An issue of concern is that the DCFs are derived using a default HVL of 2.5 mm Al for Type 1 units, in use from 1943–1963. Another issue is that the unit, in use from 1964–1976, had added filtration of 6.75 mm Al, which is significantly higher than the maximum 3.5 mm Al taken from NCRP Report 102 (NCRP 1989, Table B.2).

NIOSH believes that when no information is known about the energy spectrum, it is appropriate to use the Implementation Guide (NIOSH 2002a) as a basis document. However, SC&A is not able to verify that information provided in LASL 1972 and LASL 1976 are adequate to validate or support the assumption. NIOSH has agreed to search and add additional available references to help substantiate information depicted in Tables 3.2 and 3.3 of the Occupational Medical Dose TBD, ORAUT-TKBS-0010-3 (Johnson 2004).

5.12.6 Secondary Issue 6: Lack of Maintenance, Collimation, and X-ray Protocol Data Increase Uncertainty

The Occupational Medical Dose, ORAUT-TKBS-0010-3 (Johnson 2004) does not address the potential use of other forms of radiation exposure, other than x-ray units, to expose workers, to support medical injury diagnosis. This may involve use of isotopes, sealed sources, etc. The Occupational Medical Dose TBD, ORAUT-TKBS-0010-3 (Johnson 2004) is also deficient in that it does little to catalog the number, types of x-ray equipment, frequency of use, etc., discussed above.

The less than average performance at LANL to perform routine and preventative maintenance during the 1943–1985 timeframe, suggests that routine maintenance of x-ray units is not likely, unless performed by an outside contractor. Unfortunately, no records exist to evidence maintenance, calibrations, and other such safety-related procedures. The lack of defined protocols and basis for approval of radiography procedures suggests that the use of radiography was not closely controlled. The Occupational Medical Dose TBD does not discuss the use of portable radiography to perform screenings and the potential for exposure of medical personnel or other workers without dosimetry devices being utilized. Interviews with past medical staff do suggest that portable x-ray units were not used. This is potentially an issue for the PFG unit, which was often van-mounted at other sites. Additionally, the TBD fails to document that available x-ray units were not operated at greater than 80–90 kVp. To the contrary, Table 3-3 of the TBD indicates that the kVp after 1964 was set in a range from 96 to 102 kVp.

The conclusion is that the Occupational Medical Dose TBD does little to reasonably document the variety of medical occupational exposures, and the lack of documentation on the type of equipment and the maintenance records does little to assure that a conservative and claimant-favorable estimation of dose is possible. This circumstance would suggest the need to reconsider a worst-case approach to establishing dose.

5.12.7 Secondary Issue 7: Less than Optimal Collimation and Uncertain Substitute DCFs Impact Dose

The Occupational Medical Dose TBD, ORAUT-TKBS-0010-3 (Johnson 2004) does not consider dose impacts due to less than optimal use of technology, such as using screens, grids, or bucky systems. The TBD does not consider these elements as potential contributions to uncertainty.

The TBD does consider the potential contribution to dose that may have resulted in less than optimal use of collimation and offers substitute dose conversion factors (DCFs) for use by Dose Reconstructors (DRs) for selected exams, as presented in Table 3-8. The substitute DCFs are very limited in scope and can only be applied to exposure estimation for the gonads, eyes, and thyroid, as written. Unresolved is the concern that the DCFs are derived from ICRP (1982), and therefore, are not comparable, in terms of beam quality, which varies from unit to unit. These factors can contribute greatly to the dose to the chest and other organs, for units in operation prior to 1985, where little documentation exists.

Uncertainty is defined in the TBD as being due to measurement error. This uncertainty includes variations in kilovoltage, tube current, timers, and the source to surface distance (SSD). This approach is quite similar to the uncertainty analyses documented in other DOE site profiles. The conclusion in this TBD, and others, is that an uncertainty factor of +30% should be used by dose reconstructors.

SC&A agrees that the Occupational Medical Dose TBD conservatively estimates these essential aspects of an uncertainty review. Unresolved is the contribution to uncertainty in dose, due to other errors introduced by lack of quality controls in processing equipment and lack of adherence to established standard operating procedures (SOPs). A reasonable estimate of these contributions to uncertainty would be an evaluation of retake rates, per examination type. Interviews of LANL personnel suggest a 2.5% retake rate is appropriate for chest radiography. SC&A believes this estimate is very low, given that LANL used a higher kVp and shorter SSD protocols for many years, compared to other sites. NIOSH should revisit the potential for increased retake rates and evaluate its potential effect on dose, as part of its revision of this TBD.

The Occupational Medical Dose TBD does not show that LANL applied dose minimization principles to reduce medical exposures. The document also does not assess or consider the likely exposure to workers who are referred to off-site medical facilities for follow-up. The TBD states that review of selected medical records and files did not reasonably show or match expected x-ray exam frequency, and type of exam. Little evidence exists to document the number of x-ray exams provided to the average worker, or for special exposure needs.

5.12.8 Secondary Issue 8: Missed Noble Gases and Mixed Activation Product Environmental Dose

The most significant contributor to environmental dose is due to noble gases and mixed activation products. A review of estimates provided in Table 4-28 demonstrates that workers at, or near TA-53 (Los Alamos Neutron Science Center (LANSCE)) area might have received upwards of several hundred millirem unmonitored exposure during peak operation years after 1976. NIOSH agrees that elevated exposures from noble gases is likely, but disagrees to the magnitude, since most of these releases occurred through elevated exhaust stacks.

5.12.9 Secondary Issue 9: Lack of Equipment, Beam Quality, and X-ray Protocols Impact DCFs

The Occupational Medical Dose TBD, ORAUT-TKBS-0010-3 (Johnson 2004) in Sections 3.2 and 3.3 describes that little, if any, information exists upon which to establish beam quality for x-ray units in use from 1943 to 1984, when the site converted to Type III equipment. NIOSH believes that when no information is readily available about the energy spectrum, it is reasonable to use the assumptions for dose conversion factors (DCFs) which are presented in OTIB-0006 (Kathren and Shockley 2005). However, SC&A is not able to verify that information provided in LASL 1972 and LASL 1976 is adequate to validate or support the assumption. NIOSH has agreed to search and add additional available references to help substantiate information depicted in Tables 3.2 and 3.3 of the TBD. The TBD also provides little documentation to support the assumed techniques and protocols applied to calculate the dose, which is mainly derived from Cardarelli et al. 2002, are accurate. The TBD states that for chest x-rays given during the 1970s, SOPs required both a PA and LAT view. It further indicates this was consistent to protocol in use, prior to 1960. SC&A inquired whether definitive protocol existed to validate that chest exams included both a PA and LAT through 1985. NIOSH has acknowledged that the lack of verifiable protocols is a problem, and has planned to search all available records and include pertinent records and references in a planned revision of this section of the Occupational Medical Dose TBD.

The TBD is deficient in that little documentation exists to validate x-ray protocols, equipment maintenance and upkeep records prior to 1985. It uses information derived from the OTIB-0006, Revision 2 (Kathren 2003) to estimate dose impacts. Further dose estimations are derived from ICRP 34 and NCRP 102, and are not reflective of equipment and protocols used at LANL during 1943–1984.

The TBD further documents that photofluorography (PFG) units were routinely used at that site, from 1943 through 1957. PFG units were not considered when organ dose calculations were documented in ICRP 34 (ICRP 1982) and NCRP 102 (NCRP 1989), which forms the basis for organ dose calculations presented in the TBD, when documented use of an x-ray unit is available.

The TBD addresses the dose from PFGs as being conservatively estimated at 1.53 R, based upon a Hanford study by Rising and Soldat, 1959 (Rising and Soldat 1959). However, a recently revised version of OTIB-0006, Revision 03 (Kathren 2005) suggests that 3.0 rem per PFG exam is more appropriate. NIOSH agreed to provide further clarification of the dose applied to PFG exams from 1943–1956 in a pending revision to this section of the TBD.

5.12.10 Secondary Issue 10: A Site-wide Atmospheric Model is needed for Accurate Environmental Dose

There is no site-wide atmospheric model in use at LANL to assure an integrated environmental dose. The current Occupational Environmental Dose TBD, ORAUT-TKBS-0010-4 (Cehn and McDowell-Boyer 2004) recognizes this deficiency of lacking a site-wide model, which LANL has not put in place. SC&A questioned the need for such an atmospheric model and whether LANL could reasonably assess environmental dose, using only limited environmental data, as presented in the TBD.

NIOSH has relied upon the use of data derived from the pre-existing LANL AIRNET network to estimate dose to the environment. AIRNET has a number of known past and current deficiencies, including the lack of air monitoring in all areas, especially on the northern plateau. To offset this lack of data, the Occupational Environmental Dose TBD relies upon any available emissions data to estimate maximum and median intakes of workers in environmental areas outside of restricted areas. This is problematic, in that emissions data is not easily converted to environmental dose when several emission points have to be considered.

The TBD also evidences that effluent data before 1970 has not been identified and/or validated, and therefore, has relied on the incomplete air monitoring data as its basis. NIOSH has also indicated that recently released effluent data from the Los Alamos Historical Data Recovery and Assessment (LAHDRA) project will hopefully help to validate prior estimation. On the basis of that review, NIOSH expects to revise its TBD, as warranted.

5.12.11 Secondary Issue 11: Frequency and Types of X-ray Exposures are Uncertain

The Occupational Medical Dose TBD, ORAUT-TKBS-0010-3 (Johnson 2004) relies on frequency assumptions of other DOE sites. The assumption of two chest radiographs (PA and LAT) per year is not reasonably conservative, in that workers could essentially request an x-ray, or be subject to special screening exams. The frequency of screenings, and number and type of workers receiving x-rays varies from site to site, and within a site.

The TBD in Section 3.2 provides no documentation or references to support the assumption that only a limited group of workers received annual x-ray exams after 1990. To the contrary, up until about 1985, most DOE sites performed chest x-rays 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 annual physical is not well-documented.

The TBD in Sections 3.2 and 3.5 does document that photofluorography (PFG) units were available from 1943–1956. The presence of PFG units at LANL for nearly 15 years suggests their potential heavy utilization, more than most other DOE sites. The PFG unit also provides a dose to the worker greater by a factor of 5–6, more than that delivered by conventional radiography.

Also, the older version of the OTIB-0006, Revision 2 (Kathren 2003), upon which the TBD relies heavily, uses retake rates that average about 3%. The study referenced was based upon a large metropolitan hospital using highly trained technicians and well-maintained x-ray and processing units. A comparison review of federal facilities, such as by the Department of Defense (DOD) during the 1970s, using lesser-trained technicians (Federal regulations did not require technician certification.), showed that retakes sometimes ran up to 30% for abdominal exams, and often over 15% for chest radiography. Interviews of LANL staff indicated that retakes averaged 2.5% for chest x-rays until the Type V unit was installed. Although the PFG, by design, is less likely to require retakes, it is inherently much more dose-intensive.

SC&A believes that the reported retake rate of 2.5% is anecdotal, and no documentation is provided to substantiate that estimate.

5.12.12 Secondary Issue 12: Significant Estimates of Dose are Lacking for Some Episodic Releases

The Occupational Environmental Dose TBD, ORAUT-TKBS-0010-4 (Cehn and McDowell-Boyer 2004) details some of the known episodic releases, but fails to give significant estimates of dose.

NIOSH has responded that the 1957 fire, which released plutonium into the environment, is an example of the lack of these estimates. The TBD also notes that there is a paucity of information regarding episodic releases, resulting in potential environmental contamination of workers. NIOSH believes the purpose of the TBD is not to provide estimates of dose, but rather offers estimates of source term to be used by dose assessors to estimate dose to individuals. Effluent data used would often include quantities for both routine and episodic releases; however, NIOSH recognizes current gaps exist in this information. Recently released LANL documents that are associated with the LAHDRA project are being reviewed to determine whether additional information is available to fill in gaps in the Occupational Environmental Dose TBD for sampling and effluent data resulting from episodic events.

NIOSH has summarized that numerous references on the subject; Rogers (1977), LANL (1992), and DOE (1991) are all available. However, these documents do not provide sufficient quantitative information with which to estimate releases of radioactive materials. Rogers (1977) gives a good historical perspective on waste disposal activities, sites, and some incidents potentially causing releases to the environment at LASL/LANL, and provides many references pertinent to air monitoring activities. These references were previously consulted in developing the current approach in the TBD to estimate intakes. The LANL (1992) reference is a RCRA Facility Investigation Work Plan for TA-49 (Frijoles Site), and thus describes the extent and location of contamination, but does not provide quantitative information for estimating historic episodic releases. Air monitoring results are available for this location after 1970. The DOE (1991) reference is the Tiger Team Assessment of LANL, and as such, does not provide a historical perspective on releases.

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

The SC&A procedures call for both a "vertical" assessment of a site profile for purposes of evaluating specific issues of adequacy and completeness, as well as a "horizontal" assessment pertaining to how the profile satisfies its intended purpose and scope. This section addresses the latter objective in a summary manner by evaluation of (1) how, and to what extent, the site profile satisfies 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.

6.1 SATISFYING THE FIVE OBJECTIVES

The SC&A review procedures, as approved by the Advisory Board, require that each site profile be evaluated against five measures of adequacy—completeness of data sources, technical accuracy, adequacy of data, site profile consistency, and regulatory compliance. The SC&A review found that the NIOSH site profile (and its constituent TBDs) for LANL represents an adequate accounting of the primary internal issues related to plutonium, uranium, polonium, and tritium exposures, as well as main external hazards from the reactor and accelerator facilities. The LANL site profile falls short in fully characterizing a number of key underlying issues that are fundamental to guiding dose reconstruction. In some cases, these issues may impact other site profiles. Many of the issues involve lack of sufficient conservatism in key assumptions or estimation approaches or incomplete site data or incomplete analyses of these data. Section 6.0 summarizes the key issues. Detailed evaluation of these issues is provided elsewhere in the report.

6.1.1 Objective 1: Completeness of Data Source

The breadth of data sources used as a basis for the LANL site profile is evident in the 291 reports for Los Alamos National Laboratory in the Site Profile Research Database. Two hundred and seven reports were cited in the site profile references, while others served to provide confirmatory information. The NIOSH/ORAU team consulted health physics personnel with long histories at LANL who have extensive knowledge of key dosimetry historical processes and personnel monitoring data. Recently released LANL documents associated with the LAHDRA project are being reviewed by NIOSH/ORAU to determine whether information is available to fill gaps in the TBDs. A revision to the TBDs is under development and will utilize newly acquired information. Although SC&A was provided with a list of these documents, access to the particular documents was unavailable.

The current version of ORAUT-TKBS-0010-4 was published with known data gaps before 1971 in order to allow processing of selected LANL claims. NIOSH/ORAU realized at the issuance that a future planned revision would be necessary due to these existing data gaps. Revisions planned by NIOSH/ORAU will include additional information pertaining to environmental monitoring and effluent data collected since the publication of this TBD, as well as any recommendations from SC&A.

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, indicates a lack of verification on the part of NIOSH to ensure records provided by the site are complete. Interviews with LANL workers have uncovered some additional sources of personal radiation exposure that may not routinely be provided by Los Alamos to NIOSH for individual claimants. LANL has limited the information provided to NIOSH from the individual medical records to x-ray reports and, in some cases, incident information. Medical records were found to contain an exposure section, which included hazard reports, whole-body and extremity dose information, nasal count data, personnel exposure record – airborne contamination reports, and incident reports. 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. All this data is directly relevant and should be reflected in dose reconstruction. Finally, while accidents and incidents are listed in the site profile, the site profile does not fully address the significance of such incidents, how they may have contributed to worker dose, and how they would be addressed by dose reconstruction.

The hierarchy of data used in the dose reconstruction process begins with the use of individual monitoring data as a priority. This is fundamental to the performance of dose reconstruction. The laboratory does not currently maintain a centralized, individual radiation exposure file similar to those maintained by other DOE sites. While such files at most DOE sites typically contain hardcopy internal and external monitoring results, incident or personal contamination records, secondary dosimetry results, whole body count reports, etc., much of this data is not readily retrievable by LANL for a particular individual. The individual monitoring data provided to NIOSH, as cited by the site profile and applied in dose reconstruction, is pulled from a relational database compiled by Los Alamos. The absence of hardcopy records creates a heavy reliance on electronic data that has only undergone partial verification and validation regarding its completeness and accuracy. This is particularly of concern in the case of internal dose, as the source data is limited to information from the LANL Bioassay Repository database. This raises questions regarding the completeness and accuracy of internal dose estimates.

Although the internal dose TBD recognizes the potential exposures from the radioactive materials at some test shot locations (e.g., lanthanum test shots in Bayo Canyon, TA-27 (Gamma Site), TA-11 (K Site), TA-4 (alpha site), TA-3 (South Mesa Site), TA-8 (Nondestructive Testing), and TA-40 (Detonator Firing Site), there are a number of firing sites included in the site description TBD that are not included (Argall 2004, pp. 70–77). These test sites include TA-5 (Beta Site), TA-7 (Gomez Ranch Site), TA-9 (Anchor Site East), TA-12 (L Site), TA-13 (P Site), TA-14 (Q Site), TA-20 (Sandia Canyon Site), TA-67 (Pajarito Mesa Site), and TA-68 (Water Canyon Site) (Buddenbaum 2004, pp. 12–16). Hydroshots were considered as a potential for exposure at IAAP, yet many of the test shot sites have been overlooked by the LANL TBD.

6.1.2 Objective 2: Technical Accuracy

The 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 assign dose, or to use a hypothetical chronic intake for plutonium, polonium, and uranium where bioassay data is unavailable. The bioassay monitoring was limited to workers directly handling radionuclides, or had not 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, polonium, and uranium during the 1943–1946 timeframe. The questionable completeness of external dosimetry records and the lack of complete documentation make assignment of co-worker or average doses unfeasible. 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 method, which has been proposed by NIOSH.

A number of deficiencies were identified with the internal dose TBD (Argall 2004) related to inadequate consideration of exposure and missed dose. 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 completeness of results for uranium, tritium, and polonium is uncertain. Guidance provided on the assignment of dose from Sr-90, Cs-137, Ba/La-140, P-32, C-14, Pa-231, radioiodine, and tritides is incomplete or inadequate to determine internal dose. These radionuclides may result in significant organ doses that are neglected. Reliance on partially validated bioassay data and claimant interviews to identify intakes from secondary radionuclides does not provide a sound basis for determining which individuals received dose from secondary radionuclides. Further research into the potential exposures from these radionuclides is needed to determine which workers may have been exposed, the quantities they were exposed to, and the potential internal doses from intakes.

The Occupational Internal Dose TBD, ORAUT-TKBS-0010-5 (Argall 2004) 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; see Section 5.1 (Buddenbaum 2004, pg. 11) and for many specific job locations; second, it is not clear, as emphasized by the TBD, itself, who may have been 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. 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.

The current methodology outlined in ORAUT-TKBS-0010-6 (Widner 2005) may result in an underestimate of neutron dose. Neutron dose is determined from NTA film results and is modified with a correction factor. Some facility-specific neutron energy bands are provided; however, in some facilities, the entire spectrum is essentially below the practical 1-MeV detection limits of NTA film used in the workers' badges. From the information in the current Occupational External Dose TBD, ORAUT-TKBS-0010-6 (Widner 2005), it is not obvious that the DR has sufficient detailed correction factor/instructions available 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.

The Occupational Medical Dose TBD, ORAUT-TKBS-0010-3 TBD (Johnson 2004) provides little documentation to support the assumed techniques and protocols applied to calculate the dose, which is mainly derived from Cardarelli et al. 2002, are accurate. NIOSH believes that when no information is readily available about the energy spectrum, it is reasonable to use the assumptions for DCFs that are presented in the Implementation Guide.

The Occupational Medical Dose TBD, ORAUT-TKBS-0010-3 (Johnson 2004) does consider the potential contribution to dose that may have resulted in less than optimal use of collimation and offers substitute dose conversion factors (DCFs) for use by DRs for selected exams, as presented in Table 3-8. The substitute DCFs are very limited in scope and can only be applied to exposure estimation for the gonads, eyes, and thyroid, as written. Unresolved is the concern that the DCFs are derived from ICRP (1982), and therefore, are not comparable, in terms of beam quality, which varies from unit to unit. These factors can contribute greatly to the dose to the chest and other organs, for units in operation prior to 1985, where little documentation exists.

The Occupational Environmental Dose TBD, ORAUT-TKBS-0010-4 (Cehn and McDowell-Boyer 2004), as written, fails to test the adequacy of evaluating the cumulative (additive) effect of numerous source terms at differing locations, which are in different Technical Areas (TAs). It has relied, to the extent possible, on data derived from the LAHDRA project, yet the validation of that data remains in question and is lacking sufficient effluent data for the years 1945–1971. Interviews of retired LANL personnel (see Attachment 2) suggest that essential data, as far back as 1958, does exist. SC&A believes that the lack of air monitoring stations, within a particular TA of known higher releases of a specified isotope, does not readily enable one to accurately estimate environmental dose, using air monitoring data, from an adjacent TA air monitoring station. It will be difficult for the dose assessor to accurately estimate environmental dose without accurate air monitoring data derived from a station proximal to the release point.

6.1.3 Objective 3: Adequacy of Data

Questions regarding data adequacy have largely focused on the adequacy of early occupational monitoring data. According to site experts, individuals who worked with 1 Curie of Am-241 or Pu-238/Pu-239 were placed on the urinalysis program (See Attachment 2). The potential for unmonitored intakes was significant from 1943–1946 for site workers. In the absence of early bioassay data, the Occupational Internal Dose TBD (Argall 2004) relies on maximum and average airborne concentrations to establish boundary conditions for chronic intakes below the detectability of the time. Airborne concentration is not available for all years of operations and radionuclides present, especially fission products. There is a large amount of uncertainty in calculation of early internal doses resulting from inadequate or incomplete monitoring data, including air concentration data, which casts doubt on the feasibility to reconstruct internal dose prior to the establishment of routine, reliable bioassay methods.

According to the Occupational External Dose TBD (Widner 2005), external radiation personnel monitoring did not include adequate methods to monitor beta, gamma, and neutrons until around 1951 (i.e., see Table 6-5, pg. 21 and Table 6-7 on pg. 28). Some gamma doses were measured in the early days, but beta, gamma, and especially neutron doses were not adequately or routinely monitored. There are concerns related to the measurement of early exposures and the consistency in which they were documented. For example, the Occupational External Dose TBD states in Section 6.2.1.5, page 19, that dosimetry measurements made prior to August 1950 apparently did not make it into long-term records for the GMX-1 group.

NIOSH has indicated that its earlier evaluation of effluent data back to the 1940s and 1950s found it was not reliable or mature enough for dose assessment at the time this Occupational Environmental Dose TBD, ORAUT-TKBS-0010-4 (Cehn and McDowell-Boyer 2004) was written and approved for dose assessor use. Recently released additional LANL documents that are associated with the LAHDRA project, are being further reviewed to determine whether enough additional information is available to fill gaps in the Occupational Environmental Dose TBD, ORAUT-TKBS-0010-4 (Cehn and McDowell-Boyer 2004) for sampling and effluent data.

6.1.4 Objective 4: Consistency Among Site Profiles

An extensive comparison was performed by SC&A to compare and contrast the methodologies used in the LANL site profile and other site profiles reviewed to date. These comparisons focus on the methodologies and assumptions associated with dose assessments and the derivation of values used to obtain a probability of causation for individual claimants. A detailed analysis is provided in Attachment 7 to this report.

The site description provides a comprehensive evaluation of activities that occurred at the different technical areas, and some of the potential hazards associated with these operations. This valuable data is not carried through to the other TBDs, such as the environmental and internal dose TBDs. For example, many of the weapons firing sites mentioned in the site description are not mentioned in the environmental and internal dose TBDs. Some mention of these sites is warranted as they have been identified as handling radioactive material.

The basic default values assigned for determining medical exposure are relatively consistent among site profiles. The site profiles do not always apply the same revision of this ORAUT-OTIB-0006, as is the case with the LANL site profile, which can be corrected in subsequent revisions of TBDs. A more consistent approach to determining when dose from PFG is to be assigned is needed in cases where there is an absence of site-specific information. Other deviations from the standard assumptions are based on site-specific information.

Review of site profiles to date indicates that the NIOSH/ORAU team has not come to a consensus on what components should be considered in the environmental dose. The analysis considered internal dose from onsite atmospheric radionuclide concentrations, limited evaluation of internal dose from resuspended soil, and ambient external exposure. As acknowledged by NIOSH/ORAU, considerable investigation into dose from soil resuspension is needed with the numerous hydrotest locations at LANL and the heavy agitation of soils during D&D. As with many of the site profiles, there is no consideration of potential exposure from liquid effluents at LANL.

In the case of environmental dose, Am-241, H-3, I-131, Pu-239, Th-232, U-234, MFPs (i.e., Sr-90), and P/VAPs (i.e., Ge-68) were considered for the site-wide maximum exposures, which are applied when work location is unknown. Ambient external dose as well as dose external dose from Ar-41 was considered. External dose from Ar-41 was specific to TA-2. Be-7, P-32, As-72, Br-76, Rb-86, Cs-137, Cs-138, La-140, Ir-192, Hg-203, and Th-234 were considered; however, the dose contributions were <10E-5 Sv/year, so this dose was neglected. Other radionuclides, such as Po-210, I-131, Xe-131, Kr-85, Ra-226, Np-237, C-11, N-13, I-133, I-135, and U-233, were not considered even in the screening assessment, yet they were mentioned in the site description.

During the Y-12 Special Exposure Cohort (SEC) petition review, considerable attention was given to radionuclides generated by the Oak Ridge National Laboratory (ORNL) Isotopes Production Group and potential exposures to Y-12 workers from these activities. The LANL TBD has not included a discussion on the numerous radionuclides produced by the accelerators, such as medical radionuclide production. Depending on the quantities and types of radioactive material produced, this may affect internal dose.

The LANL Internal Dosimetry TBD simply refers to the specific guidance provided in OCAS-TIB-003 (OCAS 2003) when calculating internal dose from MT or OBTs. This is a general procedure on how to use IREP to calculate tritium dose from tritides and OBTs with no LANL specific guidance or general direction on solubility, particle size, or other pertinent internal dose calculation factors. With the Mound Internal Dosimetry TBD (Millard 2004), there was a more detailed discussion regarding MT including appropriate lung clearance classes. The SRS Internal Dosimetry TBD (Scalsky 2005) and associated TIBs fail to treat the topic of dose from exposure to OBT and MT at all. Given that tritium processes and the special tritium compounds handled at these sites were the same or similar, a consistent methodology is appropriate.

The LANL external dose TBD (Widner 2005) applies an area-specific neutron energy distribution for years after 1978. For years prior to 1980, the annual photon dose is multiplied by an n-p ratio to obtain the neutron dose. The TBD has derived three n-p ratios for the plutonium facilities, criticality experiments (> 50 m distant), and other operations. The SRS TBD distinguishes neutron energies and n-p ratios for reactors, fuel fabrication, plutonium production, and radionuclide production and calibration (Scalsky 2005). The INEEL TBD considers the reactors, the processing plant, waste handling operations, calibration sources, and uranium handling (Rohrig 2004). Neutron energy spectra and n-p ratios for Pu-238 and P-239 operations are segregated at SRS (Scalsky 2005). The categories used in the LANL TBD lack the detailed analyses seen in other TBDs. Further evaluation of n-p ratios should include more specific categories including neutron sources (RaBe, Cf, etc.), accelerators, early subcriticality experiments, initiator development, and neutron spectra from alternate fissile materials. The relative impact of further differentiation of n-p ratios will depend on the particular neutron source.

The Y-12, SRS, and Hanford TBDs base their default exposure geometry on the compensability or non-compensability of the claim. The Mallinckrodt Chemical Worker (MCW) and RFP TBDs based default exposure geometries on job titles. Both the LANL and the Idaho National Engineering and Environmental Laboratory (INEEL) TBDs choose to default to 100% Anterior-Posterior (AP) exposure. Further evaluation of exposure geometry for photon and neutron exposure should be evaluated for LANL workers to determine if 100% AP geometry is appropriate for all LANL workers. The NIOSH/ORAU team should consider development of a consistent default assumption for exposure geometry in all site profiles.

6.1.5 Objective 5: Regulatory Compliance

SC&A reviewed the site profile with respect to Objective 5, which requires SC&A to evaluate the degree to which the site profile complies with stated policy and directives contained in 42 CFR Part 82. In addition, SC&A evaluated the TBDs for adherence to general quality assurance policies and procedures utilized for the performance of dose reconstructions. NIOSH has complied with the hierarchy of data required under 42 CFR Part 82 and its implementation guides. As mentioned above, quality assurance with respect to claimant-specific information is lacking, and further consideration should be given to the evaluation of records provided by sites, and how the requests for these records are communicated to the sites. In essence, if something is not explicitly requested, it will not be provided.

6.2 USABILITY OF SITE PROFILE FOR INTENDED PURPOSE

SC&A has identified seven criteria that reflect the intent of the EEOICPA 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 LANL Site Profile TBDs 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 probability of causation 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.

6.2.1 Ambiguous Dose Reconstruction Direction

Direction provided in the site profile as a stand alone document can be confusing, and in some cases directions are inconsistent throughout a particular TBD. With the supplemental TIBs in the case of internal, external, and occupational medical dose, the approach is somewhat more clearly defined.

The conditions for application of environmental dose to LANL employees are not clearly defined in the introduction of the Environmental TBD, as is usually the case with other TBDs. There are recommendations for usage throughout the TBD, but concrete direction for which workers receive environmental dose is lacking.

Discussions on Sr-90, Cs-137, Ba/La-140, I-131, thorium, and I/Xe-135 are included in the internal TBD; however, a proposed method for identifying individuals potentially exposed to these radionuclides and assigning them a missed dose is absent from the TBD. The TBD recognizes that strontium dose reconstruction can only be done if strontium bioassay is available. There is limited guidance on how to assess intakes from tritides, P-32, C-14, and Pa-231. The TBD directs the DR to assess dose from Ac-227, P-32, C-14, thorium, and Pa-231 only when there is an indication that the worker had a potential for interaction with the radionuclide (pg. 32). There is mention of Ra-226 and radon in Table 5A-10 (pg. 70). Radon was specifically addressed in the Mallinckrodt Chemical Workers (MCW) and Fernald TBDs, where K-65 residues with high concentrations of Ra-226 were handled, yet the LANL TBD fails to consider radon exposure from the cooking off sources or leaking of radium sources in TA-1.

6.2.2 Inconsistencies and Editorial Errors in the Site Profiles

Errors were identified through Verification and Validation efforts in three tables of the Occupational Environmental Dose TBD (Cehn and McDowell-Boyer 2004). These errors are attributed to data transcription issues. Corrections have been made by the NIOSH/ORAU team to Tables 4-2, 4-10, and 4-15 and are available in Attachment 5 of this review. There were no cases of significant increases in intakes. In fact, the changes led to a lowering of estimated intakes, particularly for H-3 at TA-3.

6.3 UNRESOLVED POLICY OR GENERIC TECHNICAL ISSUES

A number of issues were identified that are common in the LANL and other site profiles reviewed to date and, in some cases, represent potential generic policy issues that transcend any individual site profile. These issues may involve the interpretation of existing standards (e.g., oro-nasal breathing), 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 these more generic issues. The following represents those issues identified in the LANL and previous Site Profile reviews that in SC&A's view represent transcendent issues that need to be considered by NIOSH as unresolved policy or generic technical issues.

Direction on the applicability of the TBD and/or TIBs to individual dose reconstructions is absent.

Mobility of work force between different areas of the site should be addressed. Site expert testimony that many workers moved from one plant to the next is a complicating factor. Establishment of an accurate worker history is crucial in such cases. This will be especially difficult for family-member claimants.

(1) Statistical techniques used in the application of the data to individual workers should be further considered and substantiated.

(2) Dose from impurities and/or daughter products in radioactive material received and processed at sites should be assessed as a contributory exposure source.

(3) The significance of various exposure pathways and the assumptions made that influence dose contributions need to be considered (most notably) for solubility, oro-nasal breathing, and ingestion.

(4) Analysis needs to be performed regarding how "frequent or routine incidents" should be addressed, given the possibility that such "spike" exposures may be often missed by routine monitoring as a function of how often and in what manner it was conducted.

(5) Availability of monitoring records for "transient or outside workers," e.g., subcontractors, construction workers, and visitors who may have potential exposure while working on or visiting a facility should be ascertained.

(6) Dose to D&D workers should be assessed. Many facilities have large-scale D&D operations, which extend back many years. Decontamination and decommissioning operations often requiring working in unknown situations, which may provide unique exposure situations.

(7) Dose reconstruction for occupational medical exposures remains incomplete. NIOSH needs to reconsider the definition to include all forms of radiation medical exposure, to ensure its considerations are claimant favorable.

(8) Dose reconstruction for workers involved in nuclear weapons testing who were employed by a site other than the test site.

(9) Quality Assurance on records provided by the site to the NIOSH/ORAU team is necessary to ascertain whether complete information is being provided.

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ATTACHMENT 1: NIOSH TECHNICAL DOCUMENTS CONSIDERED DURING THE REVIEW

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ATTACHMENT 2: SITE EXPERT INTERVIEW SUMMARY

Two sets of site expert interviews were conducted with 47 former and current Los Alamos National Laboratory (LANL) employees, Department of Energy (DOE) – Albuquerque oversight personnel, and individuals conducting historical research on LANL. Years represented by those interviewed range from 1945–2006. The interviews were conducted by Joseph Fitzgerald and Kathryn Robertson-DeMers, "Q"-cleared members of the SC&A LANL review team. The purpose of these interviews was to receive first-hand accounts of past radiological control and personnel monitoring practices at LANL, to better understand how operations were conducted, and to obtain further understanding of LANL employee participation in nuclear testing. The initial set of interviews was conducted from November 28–December 2, 2005. After review of the documents retrieved and the first set of site expert interviews, it was decided that a second visit was required. The second visit was conducted April 25–29, 2006, and included classified interviews, further document review, and an extensive tour of LANL from the Security Force. Security was chosen due to the extensive input they provided in the November 2005 interviews. Interviewees were selected to represent a reasonable cross-section of production areas and job categories. Interviewees were originally obtained through LANL, the National Institute for Occupational Safety and Health (NIOSH) worker outreach meeting minutes, union organizations, and other former health physics staff.

Workers were briefed on the purpose of the interviews and the LANL Site Profile. They were asked to provide their names in case there were follow-up questions. Participants were reminded that they would be provided the opportunity to review the interview summaries prior to inclusion into this report. Not all interview participants provided comments to SC&A. Interviewees from unclassified interviews were told that there were aspects of operations that were classified and that this information could not be divulged unless proper arrangements were made. To ensure classified information had not been included in the interview notes, the notes were reviewed by a classification officer prior to release.

Current and former LANL employees interviewed worked throughout the LANL site. Some of the primary buildings associated with their work included the following:

- Beryllium Technology Facility
- Chemical and Metallurgy Research (CMR) (TA-3-29 or SM-29)
- TA-3-28, Wing 9, TA-3-164, Bldg.46-200, TA-3-141
- Plutonium Chemistry and Metallurgy (TA-1, D-Building)
- DP East
- Dual Axis Radiographic Hydrodynamics Test (DARHT) Facility (firing site)
- Dynamic Experiment (DX)
- Plutonium Facility (DP West, TA-21)
- Health Research Laboratory (HRL, TA-43)
- Los Alamos Meson Physics Facility (LAMPF, TA-53)
- Los Alamos Neutron Science Center (LANSCE, TA-53)
- Mesa Facility
- Omega East Reactor
- Van de Graaff Accelerator (TA-3-16)

- Omega West Site (TA-2)
- TA-3
- TA-15 (firing site)
- TA-16-205 (WETF)
- Critical Test Facility (TA-18)
- Wet Chemistry (TA-21-3)
- High Pressure Tritium Laboratory (TA-33)
- Kappa Site (TA-36) (firing site)
- W-Site Tunnel (TA-41)
- WA Site (TA-46)
- Radiochemistry Site (TA-48)
- TA-48-RC1
- TA-48-5
- Waste Management Site (TA-50)
- Waste Storage Facility (TA-54)
- Plutonium Facility (TA-55) (PF3, PF4, etc.)
- TA-59-1
- Firing Sites
- GT Site

Support personnel (e.g., maintenance, security, etc.) had access to all areas of the laboratory. Some individuals interviewed participated in weapons testing at Amchitka, Nevada Test Site (NTS), Trinity, and in the Pacific.

The job categories represented included the following:

- Accelerator Scientist
- Accelerator Technician
- Chemist
- Chemical Technician
- Chemistry Team Lead
- Construction Pipefitter
- Construction Utility Worker
- Custodians
- DOE Radiological Control Auditor
- DOE Radiation Safety Officer
- Electrical Discharge Machinist
- Electrician
- Environmental Dose Assessment
- Group Leader, Health and Safety Division
- Health Physicist
- Machinist
- Mechanical Technician
- Medical X-ray Technician
- Meteorology and Air Quality
- Occupational Nurse

- Painter
- Radiological Control Technician/Radiation Monitor
- Radiological Control Technician Supervisors
- Reactor Operator
- Reactor Technician
- Section Leader
- Security Guard
- Security Captain

The information the workers provided to SC&A has been invaluable in providing a working knowledge of the various site operations, the safety program, and the LANL involvement in weapons and weapons component testing. All interviews have been compiled and summarized below. This is not a verbatim discussion, but is a summary of information from multiple interviews with many individuals. The information provided by the interviewees was based entirely on their personal experience. It is recognized that site expert and former LANL workers' recollections and statements may need to be further substantiated. However, they stand as critical operational feedback and reality reference checks. These interview summaries are provided in that context. LANL site expert input is similarly reflected in our evaluation. With the preceding qualifications in mind, this summary has contributed to our findings and observations.

Security

Starting in 1947, LANL security worked for the Department of Energy. In 1981, Mason and Hanger took control of security at the lab. Since April 1992, the Security subcontractor at LANL has been Protection Technology Los Alamos (PTLA).

Security existed at LANL to take care of Category 1 and Category 2 Special Nuclear Material (SNM), and provide safekeeping of other nuclear devices and explosives. Since LANL was handling plutonium, security in the plutonium areas was tight. Security checkpoints were established throughout the laboratory. Security officers provide a safe work environment for personnel entering and exiting LANL, and safety for personnel working on special projects.

When the Security Guards were under the jurisdiction of the Atomic Energy Commission (AEC) and its predecessors, they had full access to all areas onsite. Years ago, this included entry into storage vaults. Security performed patrols of the buildings and areas on foot, in vehicles, or on horseback. Building patrols required guards to check the outside of the building and perform internal walk through of areas including radiological areas. They verified that vaults were sealed, and in some cases were required to inventory seals, packages, and items in the vault. Rotations at a particular post were repeated periodically (i.e., every 30, 45, or 60 minutes). These types of walking tours were common in areas with plutonium, such as TA-21 and TA-55, as well as other facilities, such as Machine Shops and SNM storage areas. Guards had full access to all areas of these buildings. Many times officers were stationed in areas where nuclear weapons and/or components were out in the open. Security personnel were required to accompany fire inspectors into production areas for fire checks of glove boxes. They entered the explosives areas, the TA-41 tunnel where nuclear material was stored, the Omega Reactor Site, and other site locations where radioactive material was handled or stored. In more recent years, special access is required for some areas, such as vaults, so guards are stationed in corridors when guarding material.

Security officers responded to alarms throughout the LANL facility, which included roadblocks, incidents, and accidents, and were often the first to respond to these situations. Special Nuclear Material Monitors were used to pick up the gamma and neutron signatures of SNM. These monitors had an alarm capacity and would frequently alarm as material passed by. When these units alarmed, patrol was required to enter the area and determine why the alarm was sounding. For example, many times alarms took them into TA-3, Building 29, and the Wing 2 basement when the SNM monitor alarm was sounding. In some cases, when responding to alarms at facilities in TA-2, TA-16, TA-41, TA-18, and DP-West, they actually had to pass through laboratories to get to the alarm or vault, or be stationed inside the vaults until the incident was resolved. As the eyes and ears of the laboratory on off-hours, and they were often the individuals who identified spills or unusual conditions.

Environmental exposures were also a possibility. Security staff towers were next to the Kiva's, and they were occasionally not relocated when the Kiva's were running. Armored vehicles were used near the Kiva-3 critical assemblies. Security was not always alerted when the assembly approached criticality. This created a potential exposure. Security would drive around the PHERMEX area where they conducted explosion tests. There were security checks and patrolling of the area including entry of the building. Initially this area was not posted; however, later, guards found out that roads were being closed and roped off. There were then signs posted saying "Grave Danger." The guard post for TA-2 was adjacent to the fuel storage area and across a road from the reactor. Security exercises were conducted in the TA-2 area; however, they were later told not to do exercises there.

Another responsibility of Security was to guard SNM. For example, Security was required to guard TA-2 reactor fuel rods when handled in Chemical and Metallurgy Research, Wing 9. They were within hands-reach of the storage containers. Security officers usually worked 17–18 hour days when assigned to work in this area. Special Security was responsible for escorting radioactive material for scientists. Scientists work with SNM 6–8 hours per day, but Security Officers provide security for this item 17–18 hours a day, plus they were there the following day. They were in the immediate work area throughout the week.

Safe Security vehicles were used to transport material onsite. Transport to TA-8 for quality assurance x-ray checks was common. The nuclear material is placed in a container with a seal. All personnel exited the room while the x-ray was shot. Security had to return to the room, verify that the material was replaced, and replace the security seal on the container.

Security was responsible for inventorying material transported offsite, such as to the Nevada Test Site. This activity resulted in higher dosimeter readings than usual. They also worked and participated in the exercises involving detonation of nuclear weapons, with a potential for exposure.

Security staff were not allowed to leave their post during some assignments (e.g., the tunnel post), and meals were eaten at the post, which may have been in areas with chemical and/or radiological material. Security was also not allowed to co-mingle with LANL personnel, such as in their cafeterias. Guards were not allowed to leave their post. Often times, LANL employees were made to evacuate a certain area because an alarm went off. However, the security officer was required to stay with the item. Protective suits and/or respirators were not provided officers during these situations. Even after an area was cleared and workers returned to work, guards were not told of the potential exposure. According to interviewees, guards were also not told about the chemical hazards they encountered unless they had a “need-to-know.” This had been an ongoing hazard to PTLA employees.

Despite touring radiological areas, the typical measured dose by the dosimeter was zero. This did not make sense to those who spent considerable time in these areas. Despite obvious exposures, and guards sometimes setting off alarms on the SNM monitors when exiting a work area, dosimeters still gave a zero reading. Security officers were not routinely monitored through bioassay testing.

On specific tours, guards had to punch into Detex clocks. Security logs were maintained; however, there are likely classification issues with accessing these. Some, but not all, facilities maintained hardcopy or electronic entry logs to keep track of individuals entering a particular facility. Zone Activity Reports also tied an individual to an area at a particular time. This information, coupled with survey data, could serve as a method for tracking entries into radiological areas.

According to current and former security personnel, Mason and Hanger apparently implemented a point system and placed everyone on a minus 35 points. According to one interviewee, in order to earn points, employees were encouraged to “snitch” on one another. Mason and Hanger apparently maintained a secretive atmosphere. As noted by one former guard, individuals didn’t complain or they were “in trouble.” Employees of Mason and Hanger worked long hours as the contractor tried to minimize the total number of employees. During this time period, former security personnel indicated they worked 40–80 hours per week; sometimes 16–18 hours at the same post. In 1993, there were contract changes that restricted security personnel to 72 hours per week. Overtime typically was directed or involuntary. The current Collective Bargaining Agreement allows Security personnel to work up to 96 hours per week. Roughly 75% of the workday was spent in radiological areas. In March 1989, there was a strike that lasted 69 days; during that timeframe, the contractor (Mason and Hanger) was reportedly involved in fourteen unfair labor practices, many of which implicated forced overtime as an issue.

Accelerators

LANL began accelerator operations in the 1940s with a long tank Van de Graaff Accelerator, a short tank Van de Graaff Accelerator, a Cyclotron, and a Cockcroft-Walton Accelerator. Accelerators at LANL were used for atomic and nuclear research, and to produce a wide variety of radionuclides. There were likely activation products in the work environment. Some radionuclides were produced for sale while others remained onsite. There has not been a good effort to characterize the type and quantities of radionuclides produced at the accelerators.

The Van De Graaff accelerator had peak energy of 18 Mev. Hydrogen, deuterium, tritium, and helium were the primary particles being accelerated toward the target. It had a sputter source so it was capable of accelerating heavier (higher-Z) elements. The facility had multiple interlock systems. The particular interlocks activated are dependent on the energy used and the target. Tritium was a significant source of radiation at this facility. Flow-through ionization chambers (e.g., Johnston 110, Johnston 111, Operhoff 394) were used to monitor airborne levels. More recently, bubble suits were used for entry into areas with high levels of tritium. It could produce neutron energies that even the Los Alamos Meson Physics Facility (LAMPF) facility was not able to produce.

The Isotope Production Facility used "naked" (H+) beams from LAMPF and had hot cells for handling target change-out. The beamline maintenance and target areas were the source of most exposure at LAMPF. There was some neutron exposure at the LAMPF, but only during operation. Areas A and B had airborne environmental emission problems due to releases of short-lived radioactive gases, e.g., tritium and iodine. Penetrating radiation was much less of a problem.

The Los Alamos Neutron Science Center (LANSCE) is a proton accelerator with energies up to 800 MeV. LANSCE accelerated H+, H-, and polarized domes. There was some concern related to exposure from C-11, O-16, N-15, and Ar-41 when entry was not adequately delayed for decay. The LANSCE facility produced a neutron hazard with a wide energy range of neutrons. The accelerator produced a number of short-lived radionuclides during its various operations. Most doses came from tritium, iodine, and noble gases. In the modern era, workers wear "bubble suits" in potentially high tritium atmospheres, and use gloves otherwise. Thorium-230 and Th-232 were used as targets at LANSCE.

Ground Test Accelerator at TA-53 involved "neutral beam" experiments in support of the strategic defense initiative ("Star Wars"). The Low Energy Demonstration Accelerator used proton beam at the 70–90 MeV range in late 1990s (not particularly high energy). The Ground Test Accelerator and the Low Energy Demonstration Accelerator have been decommissioned.

The New "Lujan Center" (aka LANSCE) limits operator exposure with heavily shielded experimental halls; typical annual radiation in 5–15 mrem range. However, resident researchers in this facility may have as much as 300–400 mrem in neutron dose due to proximity to beam operation. This is probably the most potentially significant exposure issue because of the higher residence time of experimenters at LANSCE (>18 hours/days, sometimes) and the presence of a thermal neutron field. Changing the accelerator target boxes, often kilocurie targets, would give a typical maintenance worker doing this task 300–400 mrem a year, with some as a high range of 600–900 mrem/year. To minimize such exposures, remote handling of sources was used. High gamma exposures are also seen in TA-48 where the targets are handled and radionuclides separated.

Mechanical Technicians were responsible for performing maintenance on the accelerator (maintenance days) from one end to the other. Maintenance days would be set up to work on parts of the accelerator. Each section had its own maintenance group which performed duties on maintenance days. Activities included maintenance on ion pumps, isolation valves, diagnostic equipment, etc. In order to change isolation valves, repair or replace diagnostic equipment, and repair or replace ion pumps, the technicians would have to straddle the magnets. They also did vacuum work and welded beam pipes. Electricians were responsible for the electrical components at the accelerator. A lot of the maintenance work was done in the 201 Area/ 203 Area in the tank sections. While evacuating the tank sections, working in experimental areas, or performing vacuum leak checking at the vacuum lab, the mechanical pumps and blower packages emitted oil vapor/mists and exhausted smoke into the areas. Other responsibilities included rebuilding of vacuum ion pumps, cryogenic pumps, mechanical pumps, isolation valves, turbomolecular pumps, and repairing of diagnostic equipment. They were also involved with fabrication of beam piping, silver soldering of let-up valves, etc. During the down time of any one of the domes, technicians would evacuate the dome system (bring it to atmosphere) for replacement of ion pumps and instrumentation. Periodically the maintenance personnel would have to enter the domes to remove the source, which generates the beam. Radioactive material would leak on top of the turbomolecular pumps.

Special entries were made to repair accelerator functional critical equipment. For corrective maintenance, entry into the accelerator area occurred shortly after shutdown, not allowing sufficient time for short-lived radionuclides to decay completely. The scientists were not tolerant of having maintenance hold up their experiments, so there was pressure to get the accelerator back online as soon as possible.

Chemistry

The Chemistry Division, also referred to as the C Division, is composed of several departments. Analytical Chemistry is located at the Chemical and Metallurgical Research (CMR) facility. Chemists and Metallurgists at CMR worked with plutonium, uranium (including U-233), neptunium, americium, radioactive gases, thorium isotopes and their daughters, and curium. The Chemistry Division worked with pure transuranics and performed analysis (e.g., inorganic trace analysis) on waste forms. Work was done in an open front hood or glove box. The Chemical Division provided analytical support to operations from all over the laboratory. There is currently a research group evaluating the behavior of plutonium in aqueous system in the environment. The Isotope and Nuclear Chemistry group is responsible for analytical support to the Medical Radioisotopes Group. TA-48 provided chemical separations support to the weapons testing group. Chemists unexpectedly identified Cm-244 during a contamination spill in CMR about 6–8 years ago. The material was particularly “flighty.”

There are multiple operations in CMR that produce an external exposure hazard. Industrial x-ray units were scattered throughout the laboratory and included x-ray diffraction units, x-ray photoelectron spectroscopy units, and x-ray fluorescence units. Control on radiation generating units was not as stringent until about the 1980s. Units could be bought without the knowledge of Radiological Control. A majority of the x-ray diffraction units were closed beam; however, there were some open beam units. The level of exposure to chemists and technicians was dependent on where they were assigned at LANL and their particular responsibilities.

Chemists at the CMR lab were involved in a number of operations. More senior level chemists were responsible for all activities in the lab(s) under their jurisdiction. They had to respond to any incidents or unusual events that occurred in their laboratories. The Chemistry staff performed manual as well as remote work. There were hot cells available for high potential exposure work.

Other Operations

The Low Power, High Power, and Super Power "water boiler" reactors were built in 1943 at the Omega Site to conduct critical mass calculations, measure fission cross-sections, and conduct Neutron Radiography. A collimated beam was brought out of the water boiler to the object being radiographed. As a result of the radiation hazard, the area was roped off. Other reactors were built for reactor testing and experimentation. The Omega West Reactor had various neutron beam ports for experimentation. Ultra-High Temperature Reactor Experiment was a small high-temperature, graphite-moderated, gas-cooled reactor (8 mW) built as a pilot reactor in the early 1970s that was dismantled once design objectives were achieved. Los Alamos Molten Plutonium Reactor Experiment was a molten plutonium reactor. The Omega West area posed a major radiation exposure hazard compared to other areas onsite. The highest doses occurred near the deionizer where dose rates could be several Roentgen per hour above the lead shield.

The first critical assemblies were manipulated by hand until 1946. The Dragon Machine was the predecessor to the Super Prompt Critical or Burst Reactors (Godiva). The Masheba Device used low enriched uranyl fluoride as fuel. There was no shielding, so it had to be operated at night. Its operation required that roads be closed down. The Pajarito Site (TA-18) was developed to remotely complete critical and subcritical experiments. There were upwards of 40 machines used to study the effect of nuclear chain reactors. Some of the machines were operated outdoors which required that operations be conducted at night when most of the laboratory staff was gone. The road was closed due to the potential for exceeding offsite limits. Offsite exposures were monitored by placing dosimeters at the highway during operation of the experiments. Both pulsed and steady-state exposure was possible with more exposure occurring in the steady state capacity. The experiments were run from a control room with the critical assembly buildings located a distance away. This facility utilized real-time neutron field monitoring. Entry into the Criticality Assembly buildings occurred periodically for maintenance.

TA-54 housed the solid waste facilities while TA-50 housed liquid waste facilities. The radiological conditions in TA-50 were better than that in TA-54. Various maintenance personnel have supported these areas (e.g., exhaust duct work, D&D, etc.) Waste drums were stored in many areas at the site. Under some conditions the waste drums were leaking. Approximately 35 truckloads of waste were being accumulated and stored in drums in the basement of the CMR Building for a period of time. This waste was relocated to another location about the time the Tiger Team came to LANL. There is no record of how waste was disposed of in 1945. Through time, the methods have continually improved.

The TA-21 Area (also known as the Old DP Site) was decommissioned in the late 1990s. During D&D, significant contamination was found at DP West. The area was painted over to try to control the contamination; however, they eventually had to pour concrete to control contamination. Initially, construction crafts were involved in disconnected pipes and utilities. After this, there was a dedicated crew responsible for the actual decommissioning work.

Hydrodynamic testing or Explosives Testing occurred in a number of the technical areas at LANL (e.g., S-site, TA-8, TA-9, TA-15, TA-16, and TA-33).

Maintenance

The Maintenance Division was segregated into facility-specific maintenance crews, Construction Maintenance, and a general maintenance pool. Facilities such as TA-55 and LANSCE had its own set of maintenance personnel. The Construction Maintenance population was generally stable at LANL. They were responsible for new construction, remodeling, and some general maintenance. They were deployed to any location onsite, and were considered as a separate group from the standard maintenance crews. Construction Maintenance was typically provided by a subcontractor. The Hill was segregated into a number of zones that included multiple facilities. The general maintenance pool was assigned to a particular zone on the Hill. TA-3-38 and TA-3-39 house the Central Crafts and Central Shops, respectively.

Each craft had specific responsibilities:

- Pipefitters were involved in activities such as working on piping in glove boxes, cutting and replacing piping, and installing new piping. This work may or may not be done in a radiological area.

- Sheetmetal workers were responsible for stack filter change outs among other things.

- Utility workers maintained, replaced, or installed plumbing, water lines, gas lines or any other utilities.

- Electricians maintained, installed, disconnected, or removed electrical materials including during demolition.

- Painters were responsible for painting fixed contamination areas, offices, roads, building structures, or objects. Painters could be assigned to a "hot area" or a "cold area." Those not exclusively assigned to a hot area entered radiological areas about 3–4 times per year.

- Laborers were responsible for doing cleanup after hydrodynamic testing among other duties.

- Some custodians were responsible for sweeping, mopping, cleaning bathrooms, trash removal, and vacuuming administrative offices. Other custodians were required to clean up machine shops by sweeping up metal chips and scrubbing floors. Specially trained janitors, under the direction of Radiation Monitors, were responsible for decontamination activities.

High-risk maintenance jobs included equipment and filter changes, duct work, cutting or tying into lines and drains, and other similar activities. There was a potential for unexpected contamination and radiation hazards during these operations, although personnel got better at anticipating these hazards with experience. Maintenance crews were sometimes involved in demolition work, such as drilling walls, concreted, floors, etc.

Machine shops were located throughout the site (e.g., TA-2, TA-3, TA-21, TA-41), although not every shop onsite handled radioactive material. There were machine shops dedicated to the handling and machining of sensitive materials. Special Metal Machining included machining of lead, Tuballoy, Oralloy, plutonium, beryllium, etc. The Central Shop contained numerous machines including lathes, presses, grinders, milling machines, open boring mills, and a number of other machines. Machinists were typically responsible for more than one machine. The Central Shop was responsible for Electrical Discharge Machining that involved machining hard metals submerged in oil to form material into patterns. This was referred to as machining by sparking. Machines were historically open to the air versus the contained machines of today. There were not ventilation hoods over the machines. The machine shops were very dusty while operations were ongoing, and it was not uncommon to find material shavings on the floor. Operations created smoke and vapors from the metals being machined. The engineering controls such as ventilation and containment of material have improved over time. The upkeep to the Central Shop has improved significantly over time to the point where the shop is clean and organized today.

Maintenance jobs were documented on a ticket and/or in a work package. Prior to the implementation of RWPs, Crafts Work Permits were required for authorization to work in an area. The permit was filled out by the Crafts Supervisor and reviewed by a Radiation Monitor. It did not document radiological requirements for a particular job. Names were documented for particular jobs on “Special Air Test” forms and/or “Accident/Incident” report forms if an incident occurred. Those mobile workers were required to sign in on “visitor logs” when reporting for work at a particular facility. Currently, maintenance staff works under Integrated Work Documents that include the Radiation Work Permits (RWPs) and other safety requirements. These are used to communicate the hazards associated with the job and the controls to be put in place to minimize exposure. They have been used at LANL for at least 15–20 years. All activities in TA-55 and CMR require RWPs.

Weapons Testing Participation

LANL supported weapons testing at the Trinity, Nevada Test Site, and the Pacific Proving Grounds (PPG). Site experts participated in the Trinity test (1945), Operation Plumbbob (1957), Operation Hardtack Phase II (Fall 1958), 56 Project at NTS (1955–1956), the San Clemente Island Test, Long Shot in Amchitka (1965), and other tests at the Nevada Test Site and in the Pacific. A contingent of employees, including individuals from all over the LANL site, was sent to the test site for weapons testing. W-Division was responsible for weapons assembly and actually placing the unit in the ground. H-Division provided Radiological Control and Medical Support during testing. During the time when security was overseen by DOE, some employees would travel to the Nevada Test Site for testing of LANL devices. Security officers accompanied weapons to the NTS. They provided security at the site, by “cleaning the area” which included securing the perimeter. Officers secured the nuclear weapons in vaults, in vehicles, and in tunnels. Each individual from LANL who participated in NTS testing operations received a Certificate of Participation.

For Pacific tests, at any one time there were greater than 50 laboratory employees on the island and at detonation about 25 laboratory employees were on ships and/or involved in recovery. At the Mike Event (1952), there were six laboratory employees on the island in a bunker. During the heavy underground testing period, approximately 100 individuals were at the test site for an event. Individuals were rotated so the same 100 individuals were not at each test.

The lab was also involved in the evaluation of radiation as a result of testing. RCTs were sent to perform surveys and monitor personnel readings following the blast. Surveys were conducted prior to allowing LANL staff in to recover the equipment. For this operation they wore coveralls, booties, and sometimes respirators. There were about 10 surveyors who participated in offsite testing.

The Long Shot (1965) test on Amchitka Island was sponsored by the Department of Defense (Defense Atomic Support Agency) using a Los Alamos device and Los Alamos scientists and technical personnel. The LANL sponsored the Milrow shot (1969) at Amchitka. The Cannikan shot was sponsored by LLNL. Amchitka was selected as the high-yield test site. For Long Shot, support staff included both military and civilian personnel. There was no radioactive material on the island except calibration sources prior to the weapon arrival. The military provided the health physics and security support for the tests. Two weeks prior to the arrival of weapons at the site, there was pre-detonation sampling. A Remote Area Monitoring System was put in place to monitor the environment during and after the shots. Air sampling equipment was set up to monitor gamma radiation. Long Shot was an 80-kiloton shot approximately 2,300 ft underground. Long Shot was completed to provide seismic information from the detonation of weapons underground. Tritium was identified in the surface water about one year after the test. Milrow was a one-megaton shot approximately 4,000 ft underground. There was no drill-back attempted for Milrow, nor was there an atmospheric release to the environment.

Test reactors were designed at LANL for application in the Nuclear Rocket Program and tested at NTS. There was a permanent party of 20–25 LANL employees supporting the Nuclear Rocket Development Station at NTS. Tested under this program were Kiwi and Phoebus reactor designs. The fuel was fabricated and the initial critical experiments were completed at LANL. The ROVER reactors were constructed and underwent initial verification at LANL, they were taken apart and transported to NTS, and they were reassembled at the Nevada Test Site (NTS). The Nuclear Rockets involved had power levels of 300, 1,500 and 4,000 megawatts. The “super kukla” reactor was operated in Test Cell C at NTS in 1965. When the reactor tests occurred, individuals were positioned upwind from ground zero. With these types of tests, iodine releases were expected so measurements were made.

LANL and the military participated in the Enewetak Radiation Support Project. Laboratory employees were sent to Enewetak for six weeks at a time for a period of two years. There was measurable plutonium on the island. Plutonium bioassay was performed by the laboratory before and after deployment.

Upon completion of the underground tests, a portion of what was left of the device was removed and monitored as it was brought to the surface. The laboratory was interested in retrieving the refractory material (e.g., glass at the bottom of the hole) for analysis back at the laboratory. “2R” Department of Transportation containers were used to transport samples from the core extraction to TA-48 to the Radiochemistry Group. TA-48 handled and evaluated core samples returned from the test sites after weapons testing was completed. After the test was completed, the drill ridge and area at the test site were decontaminated and decommissioned. The hole created during the explosion was plugged with concrete.

NTS provided dosimetry for LANL personnel participating in weapons testing and test shots at the NTS. Their LANL dosimeters were not to be worn at NTS. Those participating in testing were diligent about wearing their dosimeter. REECo was responsible for processing the dosimeter and providing the results back to LANL. LANL provided the dosimetry for the Pacific tests (i.e., Enewetak and Bikini). While retrieving radioactive samples during post-shot drilling, both REECo and LANL workers, who were handling tools or containers of radioactive material, wore assigned extremity dosimetry. The laboratory Health Physicist at the drill-back location determined who were issued these dosimeters. They were supplied and processed by REECo onsite, and the results were sent to LANL. NTS dosimetry results were added to the individual's LANL occupational exposure record as they are reported to LANL.

RCT were present on the drill rigs to check for elevated exposure rates. A series of air samples (filter/charcoal canisters) were taken and analyzed at the Nevada Test Site. Continuous Air Monitors (CAMs) with the capability of discriminating between xenon and iodine were operated during the drill backs. If there were elevated airborne levels, the CAM would alert personnel. Certain REECo employees were selected to submit a bioassay sample. This information was passed back to LANL individuals with a quick turnaround time so decisions could be made to sample or not sample LANL employees. The REECo lab would process initial bioassays and ship the data back to the laboratory. Iodine was the principal radionuclide potentially causing internal exposure. LANL personnel were periodically monitored for iodine uptake using gamma spectroscopy. Data was considered qualitative and was not used for dose assessment. During this period of time the laboratory used bioassay (urine) samples to calculate the dose of record.

The primary bioassay for LANL employees was the responsibility of the laboratory. Bioassay samples were taken after testing upon return to the laboratory. The type of sampling was based on the particular routine monitoring program (e.g., urinalysis once per year, in vivo count every three years after its implementation). Special bioassay sampling was conducted if there were problems with the drill-back. During Project 56 and Project 57, there was a considerable amount of plutonium bioassay sampling.

Tritium Operations

LANL has been involved in work with tritium since the 1940s. Some of the major tritium facilities formerly or currently at LANL include:

- High Pressure Tritium Laboratory (HPTL)
- Tritium System Test Assembly (TSTA) Facility
- Tritium Science and Fabrication Facility (TSFF)
- Weapons Engineering Tritium Facility (WETF).

The HPTL (also called the Gas Handling Facility) was originally tasked with conducting research and development on tritium handling technology. This facility took over production work for a period of time, processing tritium gas and repackaging tritium gas into small-volume high-pressure vessels. In 1992, WETF began receiving tritium and tritium contaminated gases, repackaging these gases, and preparing them for shipment to other sites. TSFF provided a facility for Research and Development involving work with tritium gas and metal tritides. TSTA was involved in the use of tritium for development and demonstration of fusion fuel cycle technology. Other areas onsite which involved potential exposure to tritium include the following:

- Van de Graaff Accelerators (TA-3-16)
- Anchor Site East (TA-9)
- LANSCE (TA-53)
- TA-55
- F Area Vaults
- M Building
- Y Building
- Health Research Laboratory
- Ion Beam Facility
- Firing Experiments
- Waste Handling

Tritium handling operations, research and development activities, disassembly and retrofit of weapons, and tritium facility decontamination and decommissioning (D&D) activities have exposed workers to various forms of tritium. The primary forms of tritium at the laboratory include tritiated water (HTO) and tritium gas (T_2, HT). This constituted a majority of what was handled onsite. Special Metal Tritides (SMTs) and organically bound tritium (OBT) were found in specific areas onsite. Metal tritides included hafnium tritide, lithium-tritium compounds, tritiated uranium, zirconium tritide, and palladium tritide. The lighter metal tritides (e.g., lithium tritide) degrade to tritiated water which can be detected through bioassay. Heavier metal tritides behave similar to particulates. Tritides can be found in legacy materials. Fire or exposure of tritium gas will produce HTO. Other forms of tritium compounds, such as tritiated pump oil, rust, pump oil droplets, tritiated methane, and tritiated solvents, are formed during operations with HTO and HT and pose exposure hazards. For example, one worker came in contact with tritiated oil and received about one rem from the incident.

Special Metal Tritides are difficult to detect with the traditional urine monitoring program. The insolubility of SMTs leads to a long residence time in the lung. It is easy to mistake intakes of special tritium compounds for chronic HTO exposures. As a result, LANL did routine tritium air monitoring and implemented enhanced engineering controls to keep particulates under control. A special monitoring program had to be established for this type of material. Tritium was handled in contained systems. Real-time tritium monitors are used in the tritium glove box areas and during recovery. The Bubble Suit is used when airborne tritium concentration cannot be controlled by other means. There are also integrated stack monitors to measure tritium exhausted out the stack.

Tritium exposures in the accelerator areas were associated with tritium targets, as well as tritium contaminated liquids and surfaces (e.g., oils). Tritium bioassay was conducted on a routine basis, after incidents, or as a post-job bioassay sample. The comprehensiveness of the tritium bioassay program for all workers is uncertain. Some site experts potentially exposed to tritium indicate they were monitored for tritium and others indicated they were not. There was generally no measurable dose from tritium for those monitored; although there were exceptions.

Radiological Characterization

The most radioactive areas at LANL include CMR, Wing-9, TA-21, and TA-55. External dose is particularly elevated with TA-55 vault and glove box work. LANL has worked with most elements on the periodic table from hydrogen up to curium. Some of the radionuclides encountered included plutonium, polonium, neptunium, curium, tritium, thorium (i.e., pellets and thorium powder), americium, fission products in the form of sources, radium and its daughters, medical isotopes (e.g., Mo-99, Ga), and noble gases. There are fission and activation products found in some areas of the site.

Sigma Building processed natural and enriched uranium. Plutonium research at TA-1 started in 1944. Prior to the closure of TA-1 plutonium operations were transferred to TA-21. TA-55 replaced TA-21 and continues operations today. There were trace amounts of Am-241 found in TA-55. In TA-55-PF4 200-Wing, there is a Pu-238 Laboratory. The laboratory used to generate Pu-238 thermal generators for the space program, such as the "Cassini" project. Pu-238 produces more neutrons and a "more active" gamma flux resulting in increased operator dose as compared to Pu-239. The Pu-238 is more flighty, making it more difficult to control. Chemical analysis for this operation was completed at CMR.

Plutonium can be present as a powder oxide, metal oxide, and plutonium fluoride (from Plutonium Fluoride Reduction). The raw powder oxide can spread easily. After the oxide is cooked and formed into a capsule, a small amount of plutonium behaves like "fleas on a dog." There were furnace operations at TA-55 to press and form Pu-238 and Pu-239 capsules at temperatures in excess of 600°C, creating the potential for high-fired oxides.

The concentration of Pu-240 in plutonium is typically 6%. There are also trace amounts of Pu-238, Pu-241, and Pu-242. This material would be found in TA-55-PF4 and TA-21 in the past. With milligram quantities of plutonium, there is approximately 0.01% Am-241 on a mass basis. Ion Exchange was used to remove americium. The americium extracted from plutonium under normal operations is sent to the waste stream. Americium-241 will build up in the waste.

Industrial x-ray units were used for quality control (e.g., weapons components, welds, etc.) and to record explosions. Both the PHERMEX Facility and the DARHT Facility used high energy flash x-ray machines to record explosions. The industrial x-ray units at PHERMEX emitted x-rays up to 25 MeV. Prior to shooting x-rays, the immediate area is roped off to prevent inadvertent entry. When the critical assemblies were pulsed, skyshine could be detected. As a result, if the dose rate at the public roadway exceeded 5 mrem for a typical operation, the road was closed to public access.

Radiological Controls

The HSR-Division is divided into eight groups presently. These include Health Physics Operations (HSR-1), Occupational Medicine (HSR-2), Health Physics Measurements (HSR-4), Institutional Industrial Hygiene and Safety Group (HSR-5), Nuclear Criticality Safety (HSR-6), Information Management (HSR-7), Operation and Facility Support Group (HSR-8), and Radiation Protection Services (HSR-12). HSR-12 includes the Radiological Engineering Team, the Radiation Dosimetry Records and Reports Team, the Dose Assessment Team, the Policy and Integration Team, and the NTS Support Team. The Dose Assessment team is a part of Radiation Protection Services (HSR-12). Their primary function is to group workers referred to them in order to perform internal dose assessments based on bioassay data and other pertinent field information. They are responsible for calculating internal dose for plutonium and americium for workers past and present. For other nuclides, doses are calculated for current workers for the current year.

LANL currently uses the Facility Manager Unit (FMU) Concept. There is a single Radiation Protection Program plan for the site. The various facilities onsite may implement the requirements in different ways. The Facility Manager is responsible for ensuring all requirements for the particular facility are met. They negotiate with HSR-1 to obtain appropriate RadCon support.

Workplace Radiation Monitoring

The early Radiological Control Organization was spread throughout the plant. The Radiological Control Technicians (RCTs; formerly known as radiation monitors) and their supervisor were a part of Radiological Fields Operations (HSR-1). At one point in time, the site maintained a central pool of radiation monitors who were cross-trained to work throughout LANL. Prior to the mid-1990s, radiation monitors gained their knowledge through experience rather than formal training. This experience taught them what to expect from situations they encounter. In the 1990s, there was a gradual improvement in the Radiation Protection Program based on revised Radiation Protection regulations. RCTs were provided with improved instrumentation and formal training.

Radiological Control Technicians (RCTs) had responsibilities for more than one area at a time prior to the Tiger Team assessment. They were responsible for maintaining shift logbooks of daily activities. Any task related to radiological control (e.g., surveys, air sampling, incidents, etc.) was documented in these logbooks. The historic logbooks were sent to the TA-35 archives. RadCon Operations documents incidents or unusual events in the logbooks, on surveys, and on what is referred to as a Radiation Incident Report (RIR). Historical field records are not well organized.

Prior to the requirement of Radiation Work Permits (RWPs), usage varied by facility. For example, LANSCE had a permit of some type back in the 1970s; whereas, there was only limited use of permits in the early years of TA-55. A majority of the employees in the radiological zones follow work in accordance with the rules set forth by the Radiation Work Permit. Requirements were determined from field conditions.

Radiation monitors were responsible for performing radiation and contamination surveys. Surveys included routine, pre-job, post-job, and special measurement of alpha, beta, gamma, and neutron radiation. Another responsibility included job coverage for glove changeouts, High Efficiency Particulate Air (HEPA) filter changes on glove boxes and hoods, and other high-risk jobs. Survey frequencies varied. For example, at TA-21 there were daily alpha surveys, biweekly beta/gamma surveys, and monthly neutron surveys. Survey results are posted at the entrance to an area or on the hoods (usually written on the posting) to alert workers to the radiological conditions.

The portable radiation instruments used for contamination surveys include the Ludlum 139 and the Eberline 530. Sources used for instrument calibration include a Cs-137 source, a Co-60 source, and a Cf-252 source. The neutron source is portable. Calibrations are the responsibility of the HSR-4 group. In the early days "the Cow" was the neutron instrument of choice and was developed at Los Alamos by Dale Hankins. This unit was designed to measure a dose equivalent in rem for fast neutrons up to about 8 MeV.

Original air samplers were the old Filter Queen air samplers with 4" x 9" filters. The hazard in the area determined whether the filter was analyzed for beta, photon or alpha, or all types of radiation. For this particular area, the filters were analyzed for only alpha. Air samplers eventually changed from the Filter Queens with the 4" x 9" filters to 2" fixed air head samplers operated by vacuum pumps. This meant there was an increase in the number of filters to be counted. Job-specific air sampling was done using Giraffe Air Samplers. These were placed on carts so they could be moved to the job site. Giraffe samplers consisted of a filter holder mounted at the end of an extendable tube connected to a vacuum pump. Site experts indicated that if a fixed-air head filter read over 5,000 dpm, the RCTs were told not to send it to the counting lab and to dispose of it in the radioactive trash. Howard Eberline later developed a Continuous Air Monitor for high-risk jobs. Air sample results were documented on a Special Air Test form that described the area and job, and included monitoring and airborne test results.

Protection measures including Personal Protective Equipment (PPE), engineering controls, and administrative controls have changed over time. Individuals are more involved in work planning. Historically, the workers were not told what material they were working with; however, the workers are now more cognizant of the hazards and materials with which they work. PPE has ranged from laboratory coats or coveralls to Bubble Suits. When an individual exited contamination or potential contamination areas, they were required to self monitor their hands and booties. If either of these were contaminated, a Radiation Monitor was called.

The current contamination control procedures at CMR are extensive. Individuals who work in labs don PPE, including booties, lab coats, and taped gloves. In some situations, more substantial PPE is required, including the use of respirators. There is a survey meter mounted on hoods to monitor hands and arms each time they are removed from the hood. Lab coats are surveyed and stored in the lab. Personnel leaving the lab doff their PPE and check for contamination on a Ludlum 214 hand and foot monitor. A final survey of personnel and personal effects were completed with personnel contamination monitoring. With other areas of the laboratory, there may be an RCT covering the job that provides contamination monitoring support.

Respiratory protection is often used for invasive work in operating areas. There are jobs for which respiratory protection has been changed over time. In some situations, PPE and respiratory protection were initially not required, but later were determined to be necessary. For example, historically, the DP tunnels were considered uncontaminated; however, later it was determined they were contaminated. Initially, no PPE was required. Later PPE and a respirator were required. Although radiological tape and ropes are established around an area, there is not always an air space between those in PPE and those not.

Lead aprons are worn during transportation of material or in the bagout rooms. Dosimeters were worn under the apron. The aprons were effective in reducing gamma exposure, but had little effect on neutron exposure.

Currently, items coming out of radiological areas are surveyed or property bagged to contain contamination. Any conduit or wiring in the controlled area stayed in the controlled area until it was properly bagged out.

No eating, drinking, smoking, or gum chewing have been allowed in radiological areas at least since the early 1980s; however, this was prevalent prior to that time. Eating, drinking and smoking were allowed in the Main Shops. Security Guards spend 11 hours per day at the TA-21 Orange Room, which had visible dust and chipping paint. They were not allowed to leave this post. This meant meals and beverages were consumed in this area, surrounded by dust from various metals and radiological contaminants.

Radiological areas are maintained under negative pressure with HEPA-filtered exhaust systems. Operations in CMR used acids in the glove boxes and hoods. As a result, the exhaust system was corroded by the acid. When this occurred, the area was patched or replaced. Prior to the repair, leakage of material from the system would occur. Starting in the 1940s, shielding was utilized throughout the site to control external exposure. For example, accelerators such as LANCSE are well shielded to reduce exposure. In cases where engineering controls are available, such as during a line cut, the laboratory employees use glove bags.

Although much of the work was performed in hot cells, by distant remote control, reactor fuel testing required some hands-on operations. Glove box leakage was not a routine problem except in the case where holes formed in gloves. At times, holes would form in the gloves when working with metal. There were quite a few of these occurrences over the years. These would be documented in incident and accident reports. There were also cases where product was dropped either in the glove box or when it was handled outside, creating spills.

Employees working overtime had the potential for extended exposure to radiological materials and toxic chemicals. Overtime varied by job responsibility and time period, but ranged from zero to 40 hours per week. If fact, security personnel went on strike in March 1969 alleging unfair labor practices on the part of Mason and Hanger which included overtime issues.

External Monitoring

The external dosimetry group has compiled a group of notebooks on the historical external dosimetry program. Included in this documentation is a description of formerly used dosimeters, external dosimetry procedures and practices, and comparisons between albedo dosimeters and film. This compilation of documents is sometimes referred to as the Dosimetry Bible. The current dosimeter is described in detail in the external dosimetry TBD.

The external exposure at LANL can be best characterized as chronic except in cases of incidents or non-routine jobs. There was a change in the number monitored for external exposure over time. Initially, 1 in 10 were monitored, then 1 in 5, then nearly everyone. Both hands-on and support workers have historically been assigned dosimeters. For jobs where there was a high potential for exposure, pencil dosimeters were assigned in addition to the whole-body dosimeter.

Currently, the lab implements a Health Physics (HP) Checklist used by the employee and employee supervisor to determine whether external monitoring is required. External monitoring is conservatively implemented with about 75% of the personnel being monitored at the present time. There are some individuals who do not enter radiological areas and who are not monitored. In the past, DOE has indicated to LANL that they were issuing more badges than necessary. About 90% of the dosimeter results are zero, currently. Collective dose at LANL compared to other DOE Facilities is larger because LANL is actively involved in production work.

The predominant sources of occupational external exposure have been DP West and TA-55. The highest current dose comes from the bagout process in TA-55 and other manual operations. The firing sites contribute around 150 mrem/year to worker dose. The Chemistry staff interviewed indicated their external dose peaked at 200 mrem/year based on operations performed since 1990. It is not uncommon to see Chemistry staff with external doses significantly below 100 mrem/year. The dose received is directly related to the time spent in the lab. Site experts indicated that about 50% of the time worked is spent in the laboratory.

Individuals were directed to wear their dosimeter between their neck and waist. In more recent years, the dosimeter was worn on a lanyard, with the exception of LANSCE, where it was reported that employees often wore the dosimeter on the collar. The dosimeter is not held flush with the body. Geometry may be an issue at LANSCE because PICs and badges were worn on the collar when working, although radiation sources often were at waist level (e.g., magnets and targets). Some individuals put their dosimeter in the pockets of their coveralls for hot jobs. Interviewees indicated that taking their dosimeters home was the norm. TA-55 does have a badge rack.

External dosimetry does not have an incident database, per se. There were no other major external dose incidents except the criticality accidents. Workers were occasionally put on radiation work restrictions and reassigned to non-radiation work due to excessive exposure. There was an investigation process for missing or damaged dosimetry, as well as for dosimeters with unusual results. There is also a process in place where a worker may have a particular dosimeter reading investigated if the worker questions the result. There have been various investigations related to leaving dosimeters in lockers or in the hallway. They can pick up thermal neutron exposure in some areas if badges are put in hallways.

Pocket Ionization Chambers (PICs) were used to monitor day-to-day exposures for dose-tracking purposes. If PICs were worn, they were collocated with the dosimeter. Sometimes, stay times in the area were very short. When workers got in, around, and over equipment at the accelerator, it was not uncommon for PICs to go off scale. The PIC used at the time had a 90 mR range. There were other times, where in similar situations, PICs were not used. When workers are assigned to TA-55, PICs are assigned in addition to the primary dosimeter. These PICs are turned in daily. There is no time-keeping data to the knowledge of current RadCon personnel. HSR-1 is responsible for maintaining these records.

There have been studies completed comparing pocket ionization chambers (PICs), electronic dosimeters, film badges and TLDs. PICs were usually assigned for short periods of time (i.e., a job) and could over-respond by as much as 50%. There was a correction factor that was used to compensate for this over-response; however, it is not clear that the RCTs always used it. The PIC responded to only photons and would under-respond in areas where there was some level of neutron exposure. Primary dosimeters and electronic dosimeters typically agreed with one another. If there was a difference, the electronic dosimeter read slightly higher.

Neutron Dosimetry

There are neutron generators housed at various facilities around the site. Californium-252 is used as the current calibration source for neutron dosimeters and instruments. Source recovery has also collected sources no longer needed by groups. Historically, LANL had accelerators (e.g., LANSCE, Van de Graaff), reactors, critical and subcritical assemblies (i.e., TA-18), plutonium processing areas (e.g., TA-21, TA-55), initiator production areas, and research and development activities that potentially contributed to neutron exposure.

LANL conducted studies that included evaluation of the neutron flight path and neutron spectral measurements. In the 1950–1960 time period, beta, photon, and neutron measurements were made to determine correction factors by location. In the 1970–1980 timeframe, neutron-to-gamma dose rate measurements were made at various facilities. These measurements provided extremity and specific neutron correction ratios based on the location an employee worked. There were several types of neutron measurements that were associated with the reactor program. In one case, the radiation exposure to a plastic dummy was measured at Godiva at a peak power burst. A series of Bonner Sphere measurements were made in various areas.

There were conditions where neutron energies were high enough that the NTA film measured dose fairly accurately. The track in the film could indicate the energy of the particular neutrons encountered, especially high energy neutrons. There were other areas where thermal neutrons were predominate, and NTA film could underestimate neutron dose. There were significant neutron exposures at LANSCE from a wide range of neutron energies. The alpha-neutron reactions in areas of TA-55 produce thermal neutrons that would not be measured by the NTA film. The most common neutron energy at LAMPF was about 1 MeV based on spectral studies.

Neutron exposures at LANL were typically chronic exposures with personnel being exposed to low dose rates for long periods of time.

During the period when the lab was rebuilding Little Boy, several individuals from various facilities were invited to do neutron measurements. This served as information for the Hiroshima/Nagasaki dose assessment and helped determine the neutron quality factor. This data was presented at a symposium held at Hanford.

Neutron dosimetry was assigned intermittently for work in some facilities, such as TA-55, CMR, TA-21, and TA-3-31. For example, when one site expert was doing analyses for the Cassini Project (contains Pu-238) in TA-55-PF4, he received a neutron dosimeter for this period of time. There was an enhanced awareness of the higher specific activity with Pu-238.

In 1960–1970, Dale Hankins worked on the development of the albedo dosimeter. He later went to LLNL where he developed track etch dosimetry. There have been neutron dosimeters with and without cadmium shielding. It was determined that the dosimeters without cadmium shielding had the maximum sensitivity.

A significant neutron dose reconstruction project was conducted for RFP in which the nuclear track plates (NTPs) were retrieved and re-evaluated. Although the NTPs are available, the emulsion was falling off. LANL's historical doses have not been called into question like those for RFP. There was some experimentation with Track Etch dosimeters to determine whether they were effective with high energy interactions.

LANL has an Area Dosimetry Monitoring Program. These dosimeters are placed in the plutonium facility, x-ray surveillance areas, and where radiation generating devices are used. The need for area dosimetry is decided on a case-by-case basis.

Skin Dose

There were areas onsite where beta exposure was a concern. The primary beta exposure at LANL was associated with uranium operations, such as machining uranium parts. Phosphorus-32 was handled in small quantities in the bioscience area as a tracer. There was a major contamination incident in the past involving an intern who tracked P-32 throughout one of bioanalytic laboratories. Most of the skin contamination events that have occurred at LANL involved alpha emitters. The evaluation of skin dose from contamination incidents is performed on a case-by-case basis. This area of external dosimetry is continuing to be developed.

Extremity

The Radiation Operations group was responsible for identifying nonuniform fields and determining whether multi-badging was required. LANL did not use multiple dosimetry systems through at least 1982. The use of multiple dosimetry from 1982 forward was rare. The method of dose assignment was on a case-by-case basis.

Wrist dosimetry was assigned based on the quantity of radioactive material being handled. Machinists and those working hands on with material were assigned small thermoluminescent dosimeters (TLDs) worn on the fingers or fingertips. With smaller quantities of material, extremity dosimetry was found to be unnecessary. The maintenance staff interviewed indicated that they did not receive routine extremity dosimetry. Wrist dosimeters replaced finger rings for monitoring extremity dose beginning October 1998.

Internal Monitoring

The period of time covered by the Internal Dosimetry function at Los Alamos extends back to the earliest days of the laboratory. Historically, individuals who worked with 1 Curie of Am-241 or Pu-238 and Pu-239 were placed on the urinalysis program. The current internal dosimetry program operates at standards above and beyond the Department of Energy Laboratory Accreditation Program Standards. Health Physics Operations (HSR-1) does preliminary evaluations to determine if there is a possibility of an individual receiving 100 mrem CEDE or more. If this is the case, individuals are put on a urinalysis program. If they are expected to receive less than 100 mrem CEDE they are not put on a bioassay program. Virtually every current radiological worker at the site has some bioassay data.

The radionuclides of concern by area are based on the dose coefficients for the particular radioactive material and the amount present. When employees arrive at LANL, they are asked to submit a baseline urine bioassay sample. The monitoring program for the DP-West area included assignment of beta/gamma dosimeters, assignment of neutron dosimeters, submittal of bioassay samples for plutonium and uranium, and collection of routine air samples. Maintenance, Operations, and Radiological Control staff were on a routine bioassay program.

The internal monitoring among maintenance personnel varies. Some individuals submit annual or semi-annual urine samples for plutonium; others had no bioassay (in some cases, it had been discontinued years before). Those on plutonium bioassay also receive a whole-body count. Some individuals submitted bioassay samples up to monthly. They were unaware of the particular radionuclide of concern in this case. When individuals entered the tritium laboratory area, they were not always required to submit a tritium bioassay sample upon exit. In some cases, individuals received only a single whole-body count during their period of employment. Crafts personnel interviewed indicated that even among the same craft, there was a variation in bioassay requirements even though they performed the same type of work. Chemists received an annual whole-body count and participated in semi-annual urine bioassays. Four bottles are provided for the collection of bioassay samples. They are given 2 to 3 days to fill them and bring them back. In the case of incidents, special whole-body counts, lung counts, or bioassay samples are requested.

There were various chemical forms of plutonium used at LANL. Plutonium used at LANL includes aqueous solutions, such as plutonium nitrate and plutonium metals. During an incident in 1970 in Wing-9 of the Chemical and Metallurgical Research Building, the Dose Assessment Team observed a peculiar behavior in the plutonium excretion. The initial urine excretion was small, but then increased over time. In experiments with dogs it was found that the monodisperse aerosols deposited in the lungs were fragmenting due to the high specific activity of Pu-238. This is the reason for the increase in excretion rate over time. An additional biokinetic model discussed in the TBD is included for Pu-238 in order to describe this behavior. Tony James derived a similar model in a paper published in *Health Physics*. When an intake involved Pu-238, there was an assumption that this modified biokinetic model may apply. This has not been observed with Pu-239. LANL has not identified situations with high-fired uranium oxide.

Los Alamos has developed an ultrasensitive bioassay technique to identify intakes of Pu-239 and/or americium. This can lead to detection of small intakes not previously seen with other bioassay techniques. If high-sensitivity measurements suggest that an individual had an undetected intake while at LANL, the lab will collect follow-up bioassay samples for evaluation. There are some retirees with known intakes that the lab continues to monitor.

In-vivo counters are located in the Health Research Laboratory (HRL). In-vivo monitoring was primarily established for detection of fission and activation products. According to LANL health physics staff, all individuals on a plutonium urine and/or fecal monitoring program also receive lung counts. This was not always the case, historically. In the case of incidents, special whole-body or lung counts were requested.

Determining plutonium intakes with a lung count was dependent on the americium present in the mixture. There was no standard ratio between the americium and plutonium, as these ratios vary. LANL performed many chest counts for Am, but few bioassays unless workers were handling pure americium. Up until recently, in-vivo counts were recorded as being less than the detection limit ("no detectable activity"), and were not analyzed statistically to search for low-level intakes. They have used historical individual americium chest count data on a "case-by-case" basis, where individual dose analysis needs to be done.

Nasal smears were used to track potential intakes and were collected when a potential for intake existed. For example, within the DP West area nasal smears were taken at the end of the work shift. Everyone in the area had to submit them. If an individual exceeded an action limit, an investigation occurred and employees were asked to submit a special bioassay. These special bioassay samples could be requested by either field personnel or the Central RadCon group. The action level changed to 50 cpm in both nostrils in 1946, and remained at this level until 1982. This level would no longer be tolerated.

Although DAC-hour tracking may be used as a trigger, it is not used for dose assessment. The levels of triggers for DAC-hour tracking and other means of indicating potential intake are documented in the LANL Internal Dosimetry Technical Basis Document. If there is some question whether an individual may have had an intake, the Radiation Protection group err on the conservative side and collects bioassay samples.

LANL is responsible for monitoring all employees, subcontractor employees, and visitors to the site. Everyone who submits a bioassay sample is assigned a Z number and a PID number. There is a single database that includes information for all monitored individuals. Zia workers were treated the same as any other LANL employee. To track and manage the collection and analysis of bioassay samples, the site implemented the Urine Tracking System (UTS) database in the early 1990s, which was replaced in 2003. The current bioassay database is inclusive of both in-vivo and in-vitro results. There were measurement uncertainties associated with the original bioassay data. The plutonium bioassay data, with uncertainties, has been put into an electronic database and extends back to 1944. This database also includes Am-241 urine results. There are a few cases of large historical Po-210 doses at LANL.

When intakes of soluble uranium or tritium occurred, individuals working in this area were told to drink a lot of beer (or other liquid). This flushed the material out of the system.

Environmental Monitoring

The monitoring stations are numerous and change from year to year. The annual environmental reports list the monitoring station locations for a given year. Some stations are located close to the source and do not directly represent potential exposure to general workers. Some are also placed in restricted areas not accessible to general workers. There are 40–60 air samplers in the perimeter of the site and offsite. These are integrated air samples that capture emissions from multiple areas. Ambient air monitoring filters have been analyzed for americium, tritium, plutonium, uranium, gross alpha, and gross beta. All these analyses were not initiated at the same time.

In the 1990s, there were 30 stack monitors. Prior to this, there were more stacks with monitoring. Particulate, charcoal, and grab samples (H-1) were taken to monitor effluents from the Omega Reactor while it was in operation. Some early stacks (1940s) were unfiltered. It appears that some stacks on top of D Building were filtered. Evaluation of the building committee meeting minutes from TA-21/DP West indicates that these facilities underwent modification and improvement in ventilation. There is an ongoing investigation by the LAHDRA project into what type of filtration was present historically, especially for TA-1. Eventually, high efficiency particulate air filters and/or bag filters were installed at facilities. Controls for environmental emissions site-wide are continuously improving.

The main dose contributor to the maximally exposed individual (MEI) offsite is due to the releases from TA-53, LANSCE. Initially this facility had no stack monitoring. Ninety percent (90%) of environmental emissions came from Area A targets and can be attributed to short-lived activation products, such as C-11, Ni-13, and O-15. The dose is from the decay of positron emitters and the subsequent emission of 511 keV gammas. Using conservative assumptions in the early years, the dose from the LANSCE plume was estimated at 2.5 mr/hour. This was measured while the beam was on in the radiological areas within 200 m of Area A. Dose rates received by general workers located more than 1 km to the west were monitored by RCTs and were less than 100 mrem/year.

During the past 30 years, the most significant releases have been the gaseous activation products from TA-53. During the early years, the most significant releases were transuranics from TA-21. Information on releases from TA-1 during the 1940s is not readily accessible or does not exist.

Off-gassing of C-11 from LANSCE caused a release of this material to the environment. There were also releases of iodine from the accelerators. There were massive environmental releases of tritium from the TA-33 Tritium Facility. This facility was eventually shut down in the 1980s due to these releases.

There is contamination in alluvial groundwater, but this is not drinking water. The contamination in the aquifer is minimal and contributes a dose of <0.1 mrem/year to the public. Gross alpha and gross beta analyses are done for drinking water. Other radionuclide-specific analyses are also performed. The most substantial spills of radioactive material to the environment occurred in the 1940s and 1950s. Details on spills are documented in LANL reports.

The New Mexico Environmental Department performed monitoring activities at and around LANL. Data was mostly used to check LANL results. Occasionally, they measure something LANL misses. In this case, LANL confirms their data. The state of California has no jurisdiction over LANL. The Agency for Toxic Substance Disease Registry did perform some perimeter air monitoring on Pueblo lands, although the quality of this data is unknown.

There was some monitoring in the earlier years (1940s), documented in memos and progress reports, but these are not readily available. During the later years, the environmental monitoring program is described in the annual reports, which are available electronically. Annual environmental reports include both routine and episodic releases.

Natural background measured by environmental TLDs ranges from about 100 to 200 mrem/year depending on the location. An annual dose of > 200 mrem/year indicates there is possibly a contribution to external dose from LANL that requires further investigation. Background from natural terrestrial and cosmic radiation is subtracted from the LANL TLD data. No background studies were completed in the 1940s prior to operations that those interviewed recollect.

The environmental dosimeters are collocated with the air samplers to measure ambient external dose. Radiological Control Technicians (RCTs) also perform surveys with hand-held instruments in locations where workers spend a significant amount of time. RCTs ensure that the General Worker dose is less than 100 mrem/year. The TLDs in TA-3 that showed high doses for 2000 and 2001 were located inside a fenced, locked, and posted area. The dose to workers and the public was calculated from the TLD measurements and was reported in the annual environmental reports. The high doses measured in this area from 1975–1980 may have been from the Van de Graaff accelerator. TLDs were placed about 10 m from the lagoons, which were situated toward the east end of TA-53 where LANSCE is located, even though there is no regular access to this area. The nearest occupied office is greater than one kilometer to the west of the lagoons. These TLDs were used to calculate the doses at more distant locations. Environmental Dose to a General Worker from LANL operations would likely be < 100 mrem per year for someone who has not entered a radiological area.

During 1944 and 1945, Hillside 138 received untreated waste from TA-1 (Building D). This area has the worst potential for resuspension. Comparable locations onsite are the Material Disposal Area G and TA-21. There are air sampling stations near these locations to measure potentially resuspended activity. The resuspension of soil results in negligible dose (< 0.1 mrem/year.) Although the data often show significant contamination, this contamination extends over < 1% of the area of LANL. Aerial surveys of the laboratory were conducted in 1989 and 1998.

Incidents/Accidents

Historically, RadCon generally responded to incidents or accidents in full or half-face respirators. They would observe the conditions of the area and collect the air sample filters. Where decontamination was necessary, the specially trained janitors came in and cleaned up the area. Information was collected from the room supervisor. After the cleanup, there was a follow-up survey. Incidents and accidents were documented in an Incident Report or Accident Report. The information included the date and time of the incident, the radiological measurement results, a description, and the names of persons involved. These reports were sent to the records repository. These types of records were supposed to be maintained indefinitely.

An individual's collection of hardcopy incident files is available from 1944 through the early 1991. This does not constitute a formal incident collection and may not be comprehensive. HSR-1 maintains a database that covers a wider base of incidents including those not resulting in personnel exposure. This incident dates back to the early 1990s. The database contains Radiation Incident Reports (RIRs) that are maintained on any type of incident whether individuals were exposed or not. These reports include items like unusual events, continuous air monitor alarms, nasal smear records, etc. Once the RIR database was adopted, hardcopy incident reports were not maintained. An incident identification number is assigned to each entry in the database. This reference number allows cross referencing with the Dose Assessment incident database. Incidents are also traceable to the early hardcopy incident files maintained by Radiological Records.

When an incident occurs or a trigger level is hit, HSR-1 notifies the Dose Assessment Team and provides them with a description of the incident, type of material, nasal smear results, air sampling results, in vivo count data and other pertinent information to dose assessment. The incident is entered into an Incident Database. Special bioassay is assigned, according to criteria established in the Internal Dosimetry Technical Basis document. The Incident Database maintained by the Dose Assessment team contains all known electronic records of incidents for plutonium and americium. According to the LANL Dose Assessment team, all dose associated with incidents is incorporated into the dosimetry database.

Several incidents or unusual occurrences mentioned by site experts are included below. Some of these events were documented formally while others were not.

- There was an explosion associated with the Phoenix Project in 1990 that blew the glass out of a glove box. The cleanup crew was required to wear three pairs of anti-C's and self-contained breathing apparatus (SCBA). The room was closed for six months for decontamination. RCTs received elevated exposures during the recovery process. This incident is documented in an occurrence report.

- In CMR Wing 3, there was a small explosion beside the open glove boxes. The HAZMAT team and Fire Department were called in.

- In CMR Wing 5 and 7, there were plutonium (green) leaks from the piping. These pipes had to periodically be scrubbed down.

- There were Ballis Tank explosions associated with glove boxes.

- One LANL employee was fired because he had the x-ray machine on when a SPO was doing a security check/clearing on top of the roof.

- There were times when Security observed loss of negative pressure in the glove boxes.

- A crew was working on controls and limit switches under the hot cells in CMR Wing 9. They were in the process of upgrading controls. For work under the first hot cell, they wore supplied air. When it came time to do work under the second hot cell no respiratory protection was required. There was a puff of air. One individual ended up with a positive uptake.

- Personnel and clothing contamination has occurred with many personnel.

- Employees were wounded or burned with acid during work in radiological areas.

- Continuous Air Monitor alarms would periodically go off in the area.

The administration of chelation therapy was dependent on the severity of the particular contamination event. Los Alamos did not chelate individuals very often; however, when this was done, a notation was made in the bioassay database. There was a collaborative effort between health physics and medical to determine the significance of the uptake. Based on all the data provided, the medical director made the decision on whether to recommend chelation therapy. Ultimately, it was the individual's choice. Anyone receiving chelation therapy had to sign a release.

Zn-DTPA and Ca-DTPA have both been administered to workers at LANL. The administrations are primarily in aerosol form; however, intravenous and topical administrations have also been given. From May 31, 1992 through May 31, 2005, Medical has administered Zn-DTPA 56 times and Ca-DTPA 56 times. These were primarily given intravenously or in aerosol form. There have been ten topical administrations over this period of time. The number of administrations does not represent the number of individuals chelated. In 2000, a glove box failure occurred which resulted in large uptakes by individuals. As a result, there were five individuals chelated. Information on the number of chelations prior to this period would have to be obtained from Oak Ridge.

The Medical Department has procedures for radiation decontamination and treatment. Whenever someone comes in with a contamination incident, baseline blood is taken to monitor for blood changes that could result from treatment. There have been minor wound debridements or excisions at the lab. No lung lavage treatments have occurred to the knowledge of the current staff. This information would be documented under the Exposure tab.

The worst fire to occur at LANL was the Cerro Grande fire of 2000. Releases during the fire were small because the significant contamination was underground. Security and emergency personnel responded during the Cerro Grande Fire. Many were located downwind of the smoke. Security officers worked in all areas of LANL and the town of Los Alamos during the Cerro Grande Fire. Officers provided security and ensured that the entire LANL was evacuated. Officers conducted roadblocks. Security officers helped to evacuate the town of Los Alamos. Officers worked side-by-side with Fire Fighters delivering food, water, etc.

Criticality Incident

The most severe accidents at LANL were the criticality accidents. In 1958, operators were working on a plutonium recovery operation in Room 218, Building 2, DP-West. An operator was trying to treat a tank with nitric acid in an effort to clean it. As was standard operating procedure, the operator turned on the stirrer. At this point, he saw a blue flash and was knocked to the ground. The blue flash was also observed by an individual in an adjacent room. The operator managed to turn the stirrer off. Not realizing it was a criticality, the operator turned the stirrer on again and heard a rumbling. At that point he exited the room indicating that he was burning up. A second and third operator went to help the first operator get to the shower. They suspected he had an acid burn. The second operator turned the stirrer motor off.

A radiation alarm located in a nearby building alarmed. The supervisor called the Radiation Monitor in at about 4:30 pm indicating that a RAM had sounded and the situation needed to be evaluated. As he approached Building 2, he saw three plant operators sitting outside the building. This was unusual for the operations staff. One individual's coveralls were soaked. He was complaining of burning up. The Radiation Monitors first thought was also that the individual had been sprayed with acid. Most of the personnel were showering and getting ready to go home; however, the site was evacuated.

Upon interviewing the operators working in an adjacent room, he found out that they had seen a blue flash through the window. They indicated that the first operator was complaining of burning up.

The Radiation Monitor went down the long hallway in Building 2 to Room 218. He entered the room and noted that there was no displacement of the tank or unusual conditions. Radiation readings were taken at various distances and over a period of three days. William Mariman (Plant Manager) asked the Radiation Monitor if he thought there had been a criticality accident. Readings at 25 feet from the tank were 20 r/hr.

The individual nearest the tank died 35 hours later. The two other operators received substantial acute doses.

After the situation was under control, the Radiation Monitor realized he had forgotten to put on his film badge. Curiously, it was common to distribute dosimetry records to the field; however, during the month of the accident they did not receive a report.

Medical Exams

The Medical Division has been referred to by a number of names including H-2, HSE-2, QESHA, ESH-2, and HSR-2. Routine medical statistics, such as the number of exams, are fed up to the HSR Division for inclusion in reports. Historically, new hires at LANL were given extensive exams which included chest x-rays, a pulmonary function test, a hearing test, an ECG, a blood test with a chemistry profile and CBC, a urinalysis test to check for proteins and white blood cells, a vision test, and a general head to toe physical assessment for general health. In the past chest x-rays were done every year. Both a posterior-anterior and lateral view was taken. It was later realized that there would not be a significant change in the lung views within a single year so they began spacing them out. X-ray films for employees have been maintained in storage.

In the last 8–10 years, Medical has eliminated most routine physicals except in the case of individuals in Certification or Surveillance programs. Routine periodic physical exams are primarily for those individuals involved in Surveillance and Certification programs. Surveillance exams include those for individuals working with asbestos, carcinogens, beryllium, or other substances named in Occupational Safety and Health Administration regulations. Certification exams are given to individuals using respiratory protection including Self Contained Breathing Apparatus, or those requiring verification of fitness for duty, such as the Protective Forces or Department of Transportation (DOT) staff. A specific surveillance program may require specific tests, such as x-rays for asbestos workers, LPTs for beryllium workers, and blood lead levels for lead workers.

The frequency of these exams varies by the certification or surveillance program. For example, a DOT certification occurs every two years. The exam requirements for use of respiratory protection are based on age, with older individuals getting more frequent exams. The beryllium surveillance program is based on the potential for exposure. Industrial Hygiene is responsible for characterizing the environment and providing feedback to the Medical Department. Beryllium surveillance exams occur annually or every three years.

Termination exams were required for all employees at LANL. They are now based on information provided by the employee on a medical form. Medical reviews the responses given by the employee with regard to his/her work experience and evaluates their medical file. After this review, it is determined whether a termination physical is required.

From 1983 to 2003, the Medical Department used a General Electric Model DXD-35011. This unit was a single phase unit. In 2003, the Medical Department changed to a digital x-ray system. This unit was triple-phase high frequency unit. The mammography unit used at LANL was an Electric Senographe 600T Mammographic X-ray system. Mammography was provided to women as a preventative for a short period of time at LANL. Current medical staff was uncertain what equipment preceded the GE Model DXD-35011. There are no portable medical x-ray units or other sources of radiation (e.g., teletherapy units) associated with the medical department. Current Medical staff indicated that there was no photofluorography at LANL.

The Radiation Protection Group (HSR-12) is now responsible for medical x-ray equipment inspections. Up to July 2000, this responsibility was carried out by the Food and Drug Administration (FDA). The manufacturers also provided maintenance support.

Note: The FDA determined the retake rate for the General Electric unit to be 2.5%. With the new digital unit, retakes are rare.

Radiological Records

Radiation Dosimetry Records and Reports is responsible for maintaining historical and current dosimetry. This group also maintains occupational exposure records from previous employers. Bioassay records are maintained by HSR-4.

Areas on the site are known by three different designations: the Technical Area, the Descriptive Name, and the Group Number of Designation of the primary group in that area. This makes interpretation of records somewhat more challenging. There are also several abbreviations that may be encountered in historical records. Several are provided below.

- Oralloy Enriched uranium
- Tuballoy Tube Alloy
- D38Depleted Uranium
- UNatural
- U-235
- U-238
- Np-237
- Pu-238
- Pu-239
- WAWeapons Assembly
- GT Gary Tenni

This nomenclature goes back to 1942. Isotopes were assigned a two-digit number with the first number being the second digit of the atomic number and the second number being the last digit of the atomic mass.

Internal and external monitoring data is stored in a relational database. The external dosimetry data goes back to 1944. The plutonium bioassay data is also available back to 1944. There are some radionuclides that are not in the main database, such as polonium. The database is backed up nightly and hardcopy listings of the data are available from 1944. There are about three million dosimetry records. Measurements below the detectable level will show up as zero in the dosimetry records. The original dosimetry records were recorded in laboratory notebooks. The information in these notebooks has been converted to electronic form. The original notebooks were sent to archives.

The dosimetry records include skin dose, shallow dose, penetrating or deep dose, neutron dose, whole-body dose and tritium dose. These dose elements are defined below.

Skin dose = shallow dose + neutron dose + tritium dose
Shallow dose = open window (beta/photon) dose
Penetrating or Deep dose = shielded (photon) dose
Neutron dose = thermal neutron dose + fast neutron dose
Whole-body dose = deep dose + neutron dose
Tritium dose is reported as a separate component

In the database, the dose components are listed on a single line. For situations where more than one wrist dosimeter is worn, the highest dose is assigned as the extremity dose. Results from all extremity badges are available.

Z-numbers/PID numbers are assigned to those monitored onsite. In the mid-1990s, all previous employees without Z-numbers were assigned Z-numbers and PID numbers. This included previous employees, contractors, and visitors. The Z-number can be used to query a particular individual's record. Z-numbers can be cross-referenced to other databases, such as the personnel database. With this cross-referencing ability, one can determine demographic information and primary work location. Assignment of the primary work location may not be the actual worksite of an individual, such as those that provide support throughout the site.

Some job classifications information can be obtained from external dosimetry records. Mail stops can give some indication of where an individual might be located, but this is not full proof. There are also group codes and the HP employee checklist that may assist in determining work location. With Zia employees, it would be more difficult to track down work locations.

Records have been modified over time for various reasons (e.g., additional bioassay data, dose investigations). Dose investigations were triggered out of HSR-4 when there were questionable results, lost and damaged dosimeters, and when dosimeters were not returned. Results were reviewed by the supervisor, the employee, and dosimetry personnel. When the dose investigation was signed by all required parties, the dose of record was changed. No dosimetry or bioassay records were destroyed. Dosimetry records have not been removed from the site at any time.

In addition to plutonium data, tritium data and uranium bioassay data for some years have been included in a database. The tritium data is reported separately. This data, along with the plutonium data, has undergone quality control checks. LANL has pulled together what is available for tritium bioassay data. There is a database containing Po-210 bioassay information; however, it still requires some quality control checks. Jim Lawrence did considerable work to develop electronic databases, e.g., for Po-210. Some identification cannot be linked back to Z-numbers due to the ambiguity of workers' names. For example, there may be two Jim Smiths with no middle initial. The quality control verification of Po-210 data is not a high priority, as it deals with historical data. Bioassay data available in hardcopy includes gross counts, background counts, calibration efficiency, and recovery. Historically data was interpreted on a case-by-case basis. Current staff is uncertain how results from samples less than the detection limit were recorded in the past.

Medical records do contain some information on radiation exposure. The medical record contains a tab for exposures. This section will contain information from dosimetry including dosimetry report, in vivo count data, individual specific surveys, information on incidents, and medical treatments given as a result of exposures. Incident information provided to medical may include a detailed history of the event, the dose assessment, field radiological data, etc.

HSR-12 has a central repository of information. Field RadCon did not keep their data, but sent the information to the archive after a period of time. HSR-12 does not maintain any classified records. The relevant dosimetry information from classified reports has been captured in the dosimetry database.

NIOSH is provided with the recorded dosimetry results by badge cycle, available bioassay data, and other relevant records available on the claimant. Raw bioassay data rather than dose assessment results are provided, so that NIOSH/ORAU can perform their own dose assessment. LANL will provide NIOSH with results from multiple dosimetry and/or extremity dosimetry where available.

Radiological Reports

Annual exposure reports are provided to workers. Workers also have access to their dosimetry history online. Annual Occupational Dosimetry Reports have been issued to DOE electronically since at least 1993. There were manual reports prior to this. These reports do contain Job Classification Codes and Status Codes. The dosimetry department issues monthly external dosimetry reports. LANL receives routine dosimetry reports from NTS. This dose was incorporated into the LANL reports as far back as the 1980s, but probably back to the 1950s or the 1960s.

Audits and Assessments

Numerous independent or DOE audits have been conducted of the Radiological Control and Environmental Compliance Programs. The Audits and Assessment Group (AA-2) conducts some reviews of the Radiological Control program. There is coordination between DOE and AA-2 to prevent duplication of effort. Self-assessments are done by the RadCon organization. Audits cover eleven functional areas in Radiological Control. Previously, all the functional areas were assessed in a single year; however, the Radiological Control organization was told to spread them out over 3 years, so that 1/3 of the areas are assessed each year. The DOE Site Office Radiological Control Group has the right to perform for-cause reviews. For example, an investigation was completed when LANL changed from the use of ICRP 30 to ICRP 60 without an approved exemption. The Tiger Team, the Defense Nuclear Facility Safety Board, and other outside organizations have conducted independent assessments of the LANL health and safety program. During the Department of Energy Laboratory Accreditation Program, several audits and assessments were conducted on the External Dosimetry Program.

Currently, audits focus on the 28 Category 2 and 3 facilities onsite, with TA-55 and CMR being focal areas because of high radiological exposure potential. The method for performing audits includes multiple steps. The auditor develops an Assessment Plan for the area of concern. Prior to starting the audit, a guidance card is provided to the organization being audited. This makes them aware of the audit criteria. Following the actual assessment, a written report is prepared and provided to the contractor. The contractor then has 30 calendar days to develop a correction action plan. This plan requires review and approval by DOE. Each corrective action is documented on a finding certificate. Findings and observations from audits and assessments are put into the contractor I-TRACK database. This is a Corrective Action Database that allows tracking of issues and the corrective actions. Corrective actions are completed by the organization and a validation of the corrective action is done.

Some of the issues which have been identified over the past several years included (1) the absence of TBDs for key areas (e.g., Internal Dosimetry); (2) lack of documentation of RadCon program elements; (3) out-of-date procedures; (4) the absence of justification for not meeting the alpha release requirements; (5) contamination control issues in CMR and TA-55, and (6) a shortage of qualified staff including Radiological Control Technicians. There have been significant improvements in the RadCon program over the last two years.

During the Tiger Team inspection, the Tiger Team shut down what was referred to as the TA-21 Orange Room. This area served as an access control point. The lab stored waste drums in this area. There was visible dust and chipping paint. Guards spent 11 hours per day at this post. Officers stationed in the Orange Room were not allowed to leave the area. This meant meals and beverages were consumed in this area, surrounded by dust from various metals and radiological contaminants. “Line X” or the “pulsed radiation experiments” were also shut down as a result of findings during the Tiger Team review.

The LANL Medical Department was the first program in the Department of Energy to achieve external accreditation. Accreditation requires that policies and procedures are implemented. As a result of this accreditation, there are periodic reviews of the medical program. Prior to accreditation, routine audits and appraisals of the Medical Department did occur.

Chemical Exposures

There is a wide range of chemicals used at LANL. The type of chemicals used depends on the type of work being done. Some of the chemicals utilized included strong mineral acids (HCL, H_2O_2, nitric acid, hydrofluoric acid, perchloric acid, and sulfuric acid), beryllium, mercury, asbestos, and lead, to name a few. Although chemists and other employees worked with strong acids, it is not typical to see chemical burns. SM-39 Mec-1 Shop 4 and TA-3-39 were facilities where beryllium was handled.

The Fabrication group was involved in the forging of copper during building of the accelerator. During copper forging, they used trichloroethylene, freon, and other solvents as degreasers. The appropriate personnel protective equipment for the potential exposure was not provided during these operations. Offsite doctors have diagnosed cases of Toxic Solvent Disease and other chemical related maladies in LANL workers. A number of members of the PTLA force have been diagnosed with chronic beryllium disease and beryllium sensitivity.

LANL hired Eaton Corporation out of Los Angeles to test electrical equipment in TA-55, PF-4. The job occurred in 2002 and involved about 15 individuals (6 subcontractors and plant employees). Testing a circuit breaker involves injecting electrical current into the breaker. This makes the circuit hot and fumes can be released off the circuit breaker. Due to time constraints, higher levels of current were used on many of these tests making them even hotter. During the job, a LANL employee indicated to one of the subcontractors that a previous spill from a pipe near the ceiling had contaminated the wall and the electrical equipment about to be tested. This employee indicated that he was simply sharing information and did not know anything further. There was other equipment in the room that was also contaminated during this spill. The subcontractors were wearing red coveralls and gloves. They were not wearing respiratory protection. The job was done at night and did not require a shutdown. Several days after the two week job was completed, one worker had to go to the Los Alamos community hospital because he was throwing up blood. The illness seemed to get better; however, after a while the individual's health again began to deteriorate according to an interviewee.

Unauthorized Practices

LANL operations and management was very receptive to the Radiation Safety group. Field Radiological Control (RadCon) personnel generally did not observe unauthorized practices, such as eating in the radiation zone. Operations and management were cooperative during and after the occurrence of accidents, incidents, or contamination spreads. Personnel wore their film badge as required. Historically, when Radiation Monitors identified individuals not wearing their dosimeter into radiological areas, they were asked to go back and get it. Individuals in the early years that exceeded their MPBBs were transferred to other areas.

Concerns

Some interviewed workers have indicated that there may be validity issues with the dosimetry records. The dose records do not reflect the exposure conditions as measured by field instruments. A number of workers find it hard to believe the zeros measured by their dosimeters when they spent so much time in the radiological areas. For example, some of these workers point out that despite touring radiological areas, the typical measured dose for guards was zero. This does not make sense to those who spent considerable time in radiological areas. Some workers are having difficulty getting access to the radiation exposure records.

There is anecdotal information related to dosimetry data entry problems and entry of zeros. Workers have reported that doses in excess of 25 Rem were censored. For example, dose exceeding this value would be recorded as 24.9 Rem.

There are four cases of Lyomyosarcoma within the LANL population. This is a rare form of cancer. The four individuals worked at different areas of the laboratory. This was a whole-body cancer in the soft muscle tissue. The IREP code and SEC petition law do not include this cancer.

ATTACHMENT 3: KEY QUESTIONS AND RESPONSES FOR NIOSH/ORAU REGARDING SITE PROFILE DOCUMENTS

SC&A submitted questions related to the LANL Site Profile Documents to NIOSH on January 13, 2006. The NIOSH/ORAU team provided written responses to these questions on March 14, 2006. Both the questions and responses have been provided below. A summary of the conference call conducted between SC&A and the NIOSH/ORAU team with regard to these questions is available in Attachment 4.

Responses to SC&A Questions for the LANL Site Profile Document – Introduction, ORAUT-TKBS-0010-1; Site Description, ORAUT-TKBS-0010-2; and Occupational Medical Dose, ORAUT-TKBS-0010-3.

The current versions of these TBDs (ORAUT-TKBS-0010-2 and ORAUT-TKBS-0010-3) were published with acknowledged data gaps in information to allow processing of selected LANL claims. Planned revisions of these documents will include additional information collected since the publication of this TBD and any applicable information that comes from NIOSH responses to SC&A questions. ORAUT-TKBS-0010-1 will be revised as necessary to reflect revisions made to the TBDs.

Questions and Responses

General Questions

(1) Is there a classified version of the Technical Basis Document?

No.

(2) In general, what areas could not be included in the TBD for national security reasons? How were these compensated for in the TBD?

Areas would include weapons information. No special compensation has been incorporated into the TBD. Most exposures associated with LANL activities would have been covered by LANL's external and internal dosimetry which were based on their protocols and practices. Beyond that, NIOSH uses co-worker data, TIBs, and environmental monitoring and effluent data to address unmonitored or undetected exposures.

(3) What steps were taken to investigate whether individuals at LANL also received doses at the Nevada Test Site, Marshall Islands, Trinity and other test sites? Is dosimetry information from these other facilities available in the LANL radiation exposure file?

This question concerns information that is outside the scope of the LANL site profile.

(4) Was there movement of LANL personnel between LANL and Sandia National Laboratory? Which worker groups?

Yes, worker movement has occurred and we have been told that it was more common during the startup and earlier years of Sandia. Specific worker groups are not listed in the TBD.

(5) Is any of the work history, medical or radiation exposure data for claimants classified? Not to our knowledge. Are claimant files being redacted for national security reasons?

Not to our knowledge.

(6) What types of claims have been evaluated to date? Without access to a complete dataset, how is NIOSH/ORAU sure the reconstructed doses are bounded?

The first part of this question is outside the scope of the LANL site profile. Task 3 is not certain as to what is being referred to as the "complete dataset" in the second part of this question.

(7) Which Technical Information Bulletins are applied to LANL dose reconstructions (e.g., TIB-0006, TIB-0002, TIB-0028)?

TIBs are mentioned in the TBDs per the requests of Task 5 and NIOSH dose reconstructors.

(8) How has NIOSH/ORAU verified the completeness and accuracy of the data provided by LANL?

Bioassay data underwent QA/QC during the development of the LANL bioassay database. These efforts included sampling of reported urine concentration values found in lab notebooks and compared them to values in the database. Review of raw counting data, etc. was not part of this effort.

Regarding external dose, Task 3 did not verify completeness or accuracy of this data. This would require review of raw measurement data, etc. The same is true for environmental data.

(9) How have you integrated site expert input into the TBD?

Site experts such as Jim Lawrence, Bill Moss, John Voltin, Dawn Lewis, Bill Eisle, Ray Gilmette, Guthrie Miller, Tom Little, Mike McNaughton, David Christensen, and Jeff Hoffman highlights some of the experts that were consulted by Task 3. For example, current and former LANL staff assisted Task 3 (Jim O'Brien, et al.) in the development of the LANL bioassay database. Much of the other information provided by site experts helped to clarify issues related to dosimetry and radiation protection programs at LANL.

(10) What was the extent or lack thereof, to which waste management/disposal, maintenance and construction workers were monitored for exposure to radiation from 1945–1975?

Dosimetry may exist for some workers that fall into these job categories. Others that were unmonitored partially or entirely will be considered for co-worker data and other aspects of the dose reconstruction process.

(11) During the Manhattan Project, the U.S. government established a secret $1 million compensation program for metallurgical chemists and other scientific personnel exposed to radiation (Hacker 1987). Were any claims filed under this program, and if so, what were their disposition.

Task 3 does not have knowledge of this program.

Introduction (ORAUT-TKBS-0010-1)

(1) Page 6, fifth paragraph, shouldn't Co-60 be listed here also?

Not aware that Co-60 is a major source from an environmental dose standpoint. This paragraph is addressing ORAUT-TKBS-0010-4.

Site Description (ORAUT-TKBS-0010-2)

(1) Page 29 states:

> Gamma dose limits for the time was 0.1 R/day and neutron was 0.01 R/day. Based on reported exposures of 20% neutron and 80% gamma, health staff set a dose limit of 0.4 R/day by applying a safety factor.

It would appear that the total dose limit would be 0.110 R/day. How did they arrive at 0.400 R/day?

The 0.4 R/d is a transcription error; the correct value presented in the LANL document is 0.04R/d. The following is an excerpt from the LANL document in question:

Transcription:

> *In studying the health hazard present in Building X it should be borne in mind that a neutron exposure measured with a roentgenometer is considered to do approximately 10 times as much damage to the body cells as the same roentgen exposure by gamma rays. This is due to the much grater ionization density along the tracks of the protons produced by neutron exposure than along the electron tracks produced by gamma rays. Accordingly, whereas the normal tolerance dose for gamma radiation is 0.1r per day, as measured on the standard Victoreen pocket chamber, the standard safe neutron dose is 0.01r, measured in the same way.*

> *If personnel exposure were due to neutrons alone, there would be little question as to the value of the daily dose. However, a great deal of gamma radiation accompanies the neutrons. According to measurements made be Mr. De Vire (sp?), radiation received by X building personnel is composed of approximately 20% neutrons and 80% gamma rays. Accordingly, the daily dose has been fixed at 0.04r to include a small safety factor.*

This error will be corrected in the planned revision to the TBD.

(2) Pages 33 and 34 state that early exposure conditions can be found in the Omega notebooks (#101 – 733). However, they have not yet been located. Have they been located and do these notebooks contain additional dose information not contained in the *Monthly Health Division Reports* or the many *Photodosimetry Evaluation Books*?

These have not been located according to our knowledge. Task 3 is awaiting a response from LANL as to their existence. If located, any information from the notebooks deemed useful will be included in the planned revision to this TBD.

(3) Page 48 states that the monthly Health Group Progress Reports were available from Nov 1943 to Oct 1960. However, it appears that later issues are available that might provide information for dose reconstruction. Will the later issues of the Health Group Progress Reports be used in DR and did the H-1 quarterly progress report replace the monthly report?

Most of the information in these reports does not alter or is expected to alter how dose assessments are being performed. Additional content reviews of these reports will be completed to ensure that new information directly useful to the DRs is included in the TBDs.

In addition to Nov 1943 to Oct 1960, several Health Division reports were released from LANL within the last two weeks after their respective classification and legal reviews were completed by ADCs. Most of these are unmarked or marked unclassified but were required to go through reviews per LANL procedures prior to public release.

1947: May, July, August, September, October, November, and December

1948: January, February, March, April, May, June, July, August, September, October, November, and December

1949: January, February, March, April, May, June, July August, October, November, and December

1950: May, June, July, August, September, and October

1951: January, February, March, April, May

1952: January, February, March, April, May, June, July, August, September, October, November, and December

1953: January, February, March, April, May, June, July, August, September, October, November, and December

1954: January, February, March, April, May, June, July, August, September, October, November, and December

1955: January, February, March, April, May, June, July, August, September, November, and December

1956: March, April, May, September, and December

1957: February, April, May, July, and December

1958: January and February

1959: March, April, June, July, August, September, October, November, and December

1960: January, February, March, May, July, August, October, and November

1961: January, February, March, April, May, June, July, August, September, October, November, and December

1962: January, February, March, April, May, June, July, August, September, November, and December

1963: January, February, March, April, May, June, July, August, September, October, November, and December

1964: February, April, June, July, August

Occupational Medical Dose (ORAUT-TKBS-0010-3)

Approach used by Task 5 is summarized in the following table. For questions numbered 1–5, this table also provides input from Task 5. The information in this table is guidance taken from the current draft of the dose reconstruction guideline for Los Alamos National Laboratory, a dose reconstruction tool that has been provided for the use by Task 5.

Occupational medical X-rays

Item	*Action*	*Comment*
Records	Not supplied in case file. When requested give only dates and views taken.	Request if x-rays cannot be overestimated.
Frequency	Annual (assumed). Note that actual records show that this is a significant overestimate.	Request if case goes over criterion with assumed annual procedures.
Views	Each procedure from 1957 onward had PA and Lateral Views.	Tool supplies dose for both views.

NOTE: The calculation tool does all this.

Photofluorography	Used through 1956, assume in all cases.	Not possible to eliminate when actual records are used.
Best Estimate	Based on actual records for occupational medical x-rays only	Remember to divide the tool values by 1.3 (or use the doses listed in the TBD) and assume NORMAL with standard deviation of 30%.

(1) The introduction to the TBD states that LANL required a pre-employment and annual physical for all employees. It indicates that chest x-rays were **typically** included. Has NIOSH/ORAU established whether the protocol for company physicals did require a chest x-ray?

This statement will be clarified in the TBD. Interviews with medical staff suggested that all employees were examined at one time but no records were found to validate the verbal communication or to add information for the site profile regarding specific dates and duration of practices. Per personal communications with retired LANL workers, researchers who worked with animals and TB in the Health Research Laboratory were examined more frequently. Documentation on these frequencies was also not available during the writing of this TBD. Task 3 will submit additional requests to LANL for reference material pertaining to these procedures.

(2) The chest x-ray frequencies and workers, to which this applied, varied appreciably over time. Table 3.1 of the TBD seems to suggest that during 1964–1984, not all employees received annual chest x-rays. Can NIOSH/ORAU verify whether this is correct, and if a separate standard operating procedure (SOP) exists for this time period?

Dose reconstruction is performed using the x-ray TIB. The TBD just provides additional information that may be useful to the DRs. This information came from personal communication with a retired lab x-ray technician who worked at the lab from the early 1960s through mid 1980s. At the time the TBD was published, LANL was unable to locate these procedures although the former worker did believe SOPs did exist at one time. Task 3 will resume the search for these types of records and, if found, will include pertinent information and references in the planned revision to the TBD.

(3) After 1990, it appears that chest x-rays were given to only selected worker categories and at varying frequency. Does NIOSH/ORAU have any documentation, SOP, or policy basis to support Table 3.1, as no reference is provided in the TBD?

Dose reconstruction is performed using the x-ray TIB. The TBD just provides additional information that may be useful to the DRs. Task 3 will resume the search for supporting documents and records and will include pertinent information and references in the planned revision to the TBD.

(4) The TBD states that for chest x-rays given during the 1970s, SOPs for chest x-rays required both a posterior-anterior (PA) and lateral (LAT) view. The TBD says this

was consistent to protocols prior to 1960. Does NIOSH/ORAU have evidence to support this, or do they default to two views (PA and LAT) being used consistently until 1985? Does current chest radiography still include both PA and LAT views?

Regarding the first question, information in the TBD came from personal communication with a retired lab x-ray technician who worked at the lab from the early 1960s through mid 1980s. At the time the TBD was published, LANL was unable to locate these procedures although the former worker does believe SOPs did exist in the past. Task 3 will resume the search for these types of records and, if found, will include pertinent information and references in the planned revision to the TBD.

(5) In Section 3.2 of the TBD, it indicates that until 1956, all pre-employment exams were performed using a photofluorography (PFG) unit. In terms of annual physicals, it suggests a default use of PFG dose estimates if no claimant file documents that routine radiographs were given. This approach does not document when a PFG was given, in addition to radiographs. Does NIOSH plan to include PFG doses for all employees prior to 1956, in the absence of documentation to the contrary?

If known, site records, procedures, actual film size, and type of exam (PFG vs. other) is preferred when assessing dose for a particular claim.

A LANL report states that PFGs was used up until 1956. Per NIOSH, PFG would be assumed for a claim through 1956. Otherwise regular x-rays are assumed.

(6) The TBD states in Section 3.2 that between 1957 and 1964, the beam quality of Type 1 x-ray units was not known. It suggests that dose conversion factors (DCFs) from ICRP 34 is appropriate for that period. How does NIOSH/ORAU plan to assure that the estimated filtration of 2.5 mm Al is accurate? Given that Type II units, in use between 1964–1984, had added filtration of 6.75 mm Al, it stands to reason that earlier units may have been, likewise, heavily filtered. This will affect the DCFs appreciably, given a much harder beam.

Per NIOSH and the Implementation Guide, the approach used if no information is known about the energy spectrum is to conservatively assume a 30–250 keV photon range.

(7) The TBD suggests the use of the default values in Table 3.6 would be claimant favorable, in the absence of known examination factors. Given that LANL used appreciably higher filtration in its units until Type III units were utilized in 1985, this does not appear to be claimant favorable. Is NIOSH/ORAU going to reconsider the default values for PA and LAT chest exams until 1985?

Per NIOSH procedures, if the filtration is known, then that filtration should be used. Where it is not known, the Implementation Guide will govern.

(8) Section 3.3 of the TBD suggests that the periods, technique factors, and equipment descriptions are based upon documentation and interviews; however, no pertinent

references are provided. Can NIOSH/ORAU provide further evidence beyond (LASL 1972, LASL 1976) which would support Table 3.2 and Table 3.3 of the TBD in their entirety?

Available references will be added to the revised TBD.

(9) A major consideration, as stated in the TBD, is that the DCFs for the PFG and Type 1 units, in use until 1964, are really default assumptions. Another factor beyond the filtration is the assumption of a constant source-to-image distance (SID) of 72 inches. Does NIOSH/ORAU plan in future updates to the TBD to further document the justification of this assumption, as it could impact the DCFs given in Table 3.7, such that they are not claimant favorable?

Yes.

(10) Section 3.5 of the TBD states that dose reconstructors should use a value of 1.53 R for PFG exposures in place of LASL-specific data. NIOSH/ORAU should be advised that earlier recommendations were to use a value of 3.0 R, as shown as a default value in Table 3.6 of the TBD. Can NIOSH/ORAU clarify or fix this inconsistency?

Yes, this will be clarified in the revised TBD.

(11) The TBD discusses factors which induce error into the final dose. The TBD suggests an upper bound of ±51% for all errors, and recommends that +30% would be claimant favorable. SC&A feels that a factor of +50% is warranted. Will NIOSH consider the use of a factor of +50%, given the lack of substantial data, actual documented measurements, and surveys of the equipment?

DRs are using the most claimant-favorable values. Task 5 and NIOSH can address this question further.

Responses to SC&A Questions for the LANL Site Profile Document – Occupational Environmental Dose, ORAUT-TKBS-0010-4

The current version of ORAUT-TKBS-0010-4 was published with asserted data gaps of information before 1971 to allow processing of selected LANL claims. However, this section was designated for a future planned revision due to these existing data gaps. Planned revisions will include additional information pertaining to environmental monitoring and effluent data collected since the publication of this TBD and any applicable information that comes from NIOSH responses to SC&A questions.

Questions and Responses

(1) The TBD recognizes the need for a site-wide model to assure atmospheric doses from all sources are inclusive. Since it does not exist, how can NIOSH/ORAU assure that use of rather sparse environmental measurements, and very few source terms, will enable adequate overall environmental dose estimates?

Recently released LANL documents that are associated with the LAHDRA project are being reviewed to determine whether additional information is available to fill gaps in the TBD for sampling and effluent data. However, to clarify the content of the current TBD, NIOSH offers the following:

> *The LANL AIRNET network provides continuous air sampling at the majority technical areas (TAs) across the site. There are some TAs where samplers are absent; estimates were made for those areas based on emissions estimates. From these data and estimates, site wide maximum annual median intakes will be applied to all workers. This is a claimant-favorable assumption in that it is unlikely that the great majority of workers will encounter these maximum intakes in most work locations.*

The current TBD content will remain in place until better data become available.

(2) The TBD, as written, fails to test the adequacy of evaluating the cumulative (additive) effect of numerous source terms at differing locations, which are in different Technical Areas (TAs). Given that the current TBD recognizes this weakness, when does NIOSH expect to update the TBD to correct this deficiency?

Recently released LANL documents that are associated with the LAHDRA project are being reviewed to determine whether additional information is available to fill gaps in the TBD for sampling and effluent data. A revision to this TBD is currently being developed and will utilize newly acquired information.

However to clarify the content of the current TBD, NIOSH offers the following: Air monitoring data do not distinguish the source of emissions, and therefore, **do** evaluate additive effects. Although the ratioing method does not address cumulative effects, the use of site-wide maximum intakes lessens the importance of these potential effects. The best way to examine this is through the following example. The site-wide maximum annual median intake in 1992, for H-3, is estimated to occur in TA 41, where monitors are absent. This will be the value applied for environmental dose for unmonitored workers. Technical Area 2 is adjacent to TA-41 and also emits H-3 (which is measured in air at that TA); however, the air concentration at TA-2 is lower than in TA-41, and thus the contribution of H-3 originating from TA-2 in TA-41 will be negligible.

(3) The TBD recognizes that effluents from many TAs have not been well-reported over the last several decades. For example, no effluents from the Omega Reactors are presented (TA-2). Since this site will have appreciable releases of noble gases and

mixed fission products, how does NIOSH/ORAU intend to account for this deficiency, as it may appreciably impact site environmental doses to workers in all TAs beyond those assigned to TA-2? Has NIOSH had success in defining data for TA-1 during the 1940s? What is the basis for results presented in Table 4A-1?

Recently released LANL documents that are associated with the LAHDRA project are being reviewed to determine whether additional information is available to fill gaps in the TBD for sampling and effluent data. Another source of ongoing work that may help to address these questions involves development of co-worker data by Task 5 that could possibly be used in some instances to address unaccounted doses from releases.

(4) The TBD suggests that limited emissions data may reasonably fill gaps in the monitoring data in estimating dose. Without the use of a site-wide atmospheric model, how does NIOSH/ORAU assure that any emissions data at a different TA location can be reasonably translated to fill in gaps in monitoring data at different site locations? Given the data from different TAs represent different source terms, how can NIOSH justify this interpolation?

Emissions data are only used to estimate air concentrations within the same TA. The TBD does not attempt to use emissions data from one TA to fill in gaps in monitoring data at a different TA. Recently released LANL documents that are associated with the LAHDRA project are being reviewed to determine whether additional information is available to fill gaps in the TBD for sampling and effluent data.

(5) The TBD recognizes that LANL has not provided effluent data for the years 1945–1971. The TBD has relied on data derived from the LAHDRA project, yet the validation of that data remains in question. How does NIOSH/ORAU intend to validate this data against the missing effluent reports for 1945–1971? Independent inquiry at LANL suggests essential data as far back as 1958 does exist. Will NIOSH modify its results to incorporate this data?

Effluent data back to the 1940s and 1950s were viewed as not reliable or mature enough for dose assessment at the time this TBD was written and approved for Task 5 use. Recently released LANL documents that are associated with the LAHDRA project are being reviewed to determine whether additional information is available to fill gaps in the TBD for sampling and effluent data. Another source of ongoing work involves development of co-worker data by Task 5 that could possibly be used in some instances to address unaccounted doses from releases.

(6) The TBD details some of the known episodic releases, but fails to give significant estimates of dose, due to the 1957 fire, which released plutonium into the environment. How does NIOSH/ORAU intend to validate for the lack of these estimates and assure that workers present during the fire are assessed, considering this lack of dose estimate?

The purpose of the TBD is not to provide estimates of dose, but rather offers estimates of source term to be used to estimate dose under Task 5 activities. Effluent data used would often include quantities for both routine and episodic releases and the authors recognize current gaps exist in this information. Recently released LANL documents that are associated with the LAHDRA project are being reviewed to determine whether additional information is available to fill in gaps in the TBD for sampling and effluent data.

(7) The TBD notes that there is a paucity of information regarding episodic releases resulting in potential environmental contamination of workers. Did NIOSH/ORAU gain access to unclassified documents detailing environmental releases of radioactivity, i.e., (Rogers 1977), (LANL 1992) and (DOE 1991)

Access to Rogers (1977), LANL (1992), and DOE (1991) is available. However, these documents do not provide sufficient quantitative information with which to estimate releases of radioactive materials. Rogers (1977) gives a good historical perspective on waste disposal activities, sites, and some incidents potentially causing releases to the environment at LASL/LANL, and provides many references pertinent to air monitoring activities. These references were previously consulted in developing the current approach to estimating intakes. LANL (1992) is a RFI Work Plan for TA-49, and thus describes the extent and location of contamination, but does not provide quantitative information for estimating historical episodic releases. Air monitoring results are available for this location after 1970. DOE (1991) is the Tiger Team Assessment of LANL, and as such, does not provide a historical perspective on releases.

DOE (U.S. Department of Energy), 1991, *Tiger Team Assessment of the Los Alamos National Laboratory, September 23 –November, 8, 1991*, Office of Environment, Safety and Health

LANL (Los Alamos National Laboratory), 1992, *TA-49 Operable Unit RFI Work Plan, MDA AB, Chapter 7*, May 1992

Rogers, M. A, 1977, *History and Environmental Setting of LASL Near-Surface Land Disposal Facilities for Radioactive Wastes (Areas A, B, C, D, E, F, G, and T)*, LA-6848-MS, Vol. I, June 1977. (Numerous radioactive waste site fires are described in this report, which are referenced to official documents)

(8) The TBD in Section 4.2.1.1.2 concludes that worker exposures to La-140 due to work performed in and around Bayo Canyon is to be considered as gamma exposure only, with little contribution due to resuspension and inhalation. Without documentation as to when the number of workers who frequented Bayo Canyon, how will NIOSH validate that inhalation was not significant for dose reconstructions involving La-140?

Lanthanum-140 has a half-life of approximately 40 hours. Thus, the great majority of dose received from exposure to La-140 is within a relatively short time of the detonation (within 16 days, 99.9% of the radionuclide has decayed). Therefore, the likelihood of unmonitored workers frequenting Bayo Canyon within that time period after a detonation is low. The number of workers involved in these activities was small per personal communication with Jim Lawrence. Task 3 is also currently working with LANL Archives staff to validate an estimate of the number of workers involved in RaLa operations.

Kraig (1997) implemented a Gaussian model to estimate dose to offsite individuals, and found that the dose contributed by groundshine (i.e., external dose) was approximately 3 orders of magnitude higher than that from inhalation and immersion. The mechanisms of exposure at the Bayo Canyon site would have been similar.

Kraig, D. H., 1997. *Dose Reconstruction for Weapons Experiments involving ^{140}La at Los Alamos National Laboratory, 1944–1962*, Health Physics 73(4). – LMB

(9) The TBD indicates that reported levels of Am-241 releases during the early years are not consistent with the reported plutonium releases. How does NIOSH/ORAU intend to adjust for any potential under reported Am-241 effluents?

Per NIOSH, this question has been addressed during prior SC&A and NIOSH discussions about other site profiles (i.e., Hanford and RFP). Plutonium handled at LANL during these periods was effectively the same as that of plutonium handled at Hanford and RFP. In the early years, Am-241 was not an issue with regard to plutonium.

(10) The TBD supports a "ratioing" approach to estimating airborne concentrations in TAs that had effluent data, yet little or no ambient monitoring data. This approach is based upon data derived from TA-3 and TA-21. The projected correlation co-efficient for these TAs, using this method, are strong to moderate. For this to be used, the dose reconstructor must assume that atmospheric and dispersion conditions are the same in all TAs, for all years. Is NIOSH likely to reevaluate this position since, in many TAs with differing releases and effluent characteristics, environmental dose could be appreciably underestimated?

For some TAs, there were multiple monitoring stations. For years and locations when monitoring data were not available, an estimate was made based on the relationship between source emission rate and air concentration at TA-3 and TA-21. The estimated air concentration based on this ratioing procedure is compared to other estimated and measured concentrations, and is only used if it exceeds the measured site-wide maximum annual median. This is a claimant-favorable approach in that it is unlikely that the great majority of workers will encounter these maximum intakes in most work locations

It is a reasonable request that the applicability of this be reevaluated, probably more from the standpoint of differing releases and effluent characteristics, than annual average atmospheric and dispersion conditions, which are likely to be similar across the site. The approach should be refined, if necessary, to assure claimant favorability.

Recently released LANL documents that associated with the LAHDRA project are being reviewed to determine whether additional information is available to fill in some of the gaps in the TBD for sampling and effluent data.

(11) In Section 4.2.1.4.1, the TBD addresses pre-1971 intake assessments. In summary, the TBD concludes that pre-1971 intakes cannot be accurately assessed, due to plausible discrepancies noted in effluent data. This poses two distinct questions that

need to be addressed by NIOSH/ORAU: (1) does the discrepancy in effluent data suggest the need to reconsider the use of the "ratioing" method to estimate ambient air concentrations? and (2) does NIOSH/ORAU intend to offer an alternative to estimating pre-1971 intakes?

Recently released LANL documents that are associated with the LAHDRA project are being reviewed to determine whether additional information is available to fill in some of the gaps in the TBD for sampling and effluent data.

(12) Section 4.2.2 of the TBD recognizes that assessments of resuspension are an ongoing effort, which has not been completed. Current efforts seemingly rely on the use of a constant resuspension factor of 1 x 10^{-9}/m, which is not considered appropriate over time. Will NIOSH/ORAU address this deficiency in future updates to the TBD and provide a timeframe wherein the resuspension factor issue will be more fully addressed?

This subject is part of an ongoing SC&A/NIOSH discussion and should be addressed outside the scope of this TBD.

(13) The TBD does not clarify the possibility that substantial ambient radiation levels existed in the canyons up until the mid-1970s that should be added to estimated worker external dose. Little data (and none before 1965) are presented to substantiate the estimates presented in Table 4.30. Will NIOSH/ORAU consider evaluating occupancy at the 100% level in all affected canyons until decontamination is verified, and will that amount be added to ambient airborne inhalation estimates to be claimant favorable?

Recently released LANL documents that are associated with the LAHDRA project are being reviewed to determine whether additional information is available to fill in some of the gaps in the TBD for sampling and effluent data.

(14) The most significant contributor to dose due to noble gases and mixed activation products occurred at TA-53. Estimates in Table 4-28 demonstrate that workers at those sites might have received several hundred millirem exposure during operation years after 1976. Can NIOSH/ORAU comment on the need to clarify that most environmental dose is attributable to this pathway?

It is unlikely that workers received several hundred millirem of exposures from releases associated with TA-53 since most of these releases occurred through elevated exhaust stacks. It is true that since the mid to late-1970s the highest reported doses at the site boundary are attributed to TA-53 releases.

(15) The TBD addresses uncertainty as being ±20%. In future TBD updates, will NIOSH/ORAU demonstrate that this figure is conservative, given that data pre-1970 is sparse and no actual documentation of uncertainty analyses is presented?

Yes, attempts will be made to better define uncertainty values in the planned revision to the TBD. However, Task 5 has uncertainty values that they apply in the dose assessments. Task 5 values are equal to or higher than those stated in the TBD.

Responses to SC&A Questions for the LANL Site Profile Document – Occupational Internal Dose, ORAUT-TKBS-0010-5

The current version of ORAUT-TKBS-0010-5 was published with asserted data gaps of information to allow processing of selected LANL claims. However, this section was designated for a future planned revision due to these existing data gaps and the ongoing development efforts of the new LANL bioassay database. Planned revisions will include descriptions of the new LANL bioassay database, additional information pertaining to in vitro and in vivo monitoring since the publication of this TBD, and any applicable information that comes from NIOSH responses to SC&A questions.

Questions and Responses

(1) What type of bioassay data is LANL providing to NIOSH/ORAU? Does it include data from all radionuclides handled at LANL?

LANL is currently providing only in vitro bioassay data on uranium, plutonium, americium, tritium and polonium. In vivo measurements are available from about the mid 1960s for gamma-emitting fission and activation products and plutonium and americium. In later years, uranium has also been added to the standard in vivo analyses. There was some screening done in the 1950s through 1970, but the in vivo program was not well established at that time.

Some bioassay results may be available for other radionuclides handled in limited amounts, such as Sr-90 and Ac-227. However, these data have not been provided to date.

When rev 0 of the TBD was issued, LANL had only submitted limited plutonium, americium and tritium data to NIOSH. The results are now being submitted in the form of an electronic database. The proposed revision of the TBD will address the format and basis of the results in the database. Meanwhile a detailed explanation that is appended to the file which contains the bioassay results for each worker is available to the dose reconstructor.

(2) On page 25 of the internal TBD, it states that the Kanne Chamber was calibrated high by a factor of 10. Please explain this statement.

A Kanne Chamber measures tritium. This was noted so that, should there be an attempt to correlate tritium release with hypothetical or measured environmental or occupational exposures for that period, the over-response would be noted and could be factored into the calculation if necessary.

(3) Please explain the inconsistency between the list of incidents in the site description and that in the internal dosimetry TBD.

Section 5.5.2 of the TBD states these are examples of incidents. These were never intended to be a complete list of every incident that occurred. These were included to give some guidance to anyone trying to look at maximum intakes and other projected doses. Also, the incidents referenced in Table 5-22 are related to intakes or potential intakes. The incidents discussed in the site description are related to the site in general, including external and environmental exposures. The more complete list will be referenced in an appendix to the TBDs.

(4) How will dose reconstruction be done for those individuals working at the lab in the early days before bioassay or before reasonable sensitivity was obtained for urine analysis considering that nasal swipes were used for monitored and used to determine if urine sampling should be done?

Section 5.6 and 5.6.1 establish potential intakes, based on air samples, for unmonitored workers based on air sampling data and assumed estimates of potential intakes. Co-worker dose is now being assembled using the bioassay data that was recently released from LANL to NIOSH. The dose reconstructor may also assign missed dose based on detection levels for all or part of the employment periods. Intakes of radionuclides, such as plutonium are detectable many years after the intake because of their biological kinetics. All of these options are available to the dose reconstructor for monitored workers with results below the limit of detection, unmonitored workers, and workers that the dose reconstructor determines may have been inadequately monitored. Assigned claimant-favorable bounding estimates seem to be lacking. For example, a hypothetical intake of the plutonium for the period of 1943 through December 31, 1946, would have resulted in a body burden of approximately 2 nCi. This is approximately 30% of the body burden of members of the UPPU club, who had known and significant intakes of plutonium during that time period.

(5) How will dose reconstruction be done for these early period unmonitored individuals? (Secretaries working in contaminated areas, early military workers that were unmonitored, in areas where only select individuals were monitored, etc.) How will the dose reconstruction take into account questionable air monitoring sensitivity, calibration uncertainties, variability of sampling methods, differences in high surface contamination levels throughout the work areas, and the lack of data from lung counting data for many workers not monitored?

As with other sites, co-worker data is becoming available for LANL as previous discussed in the response to question 4. OTIBs address the use of these data and the assignment to various types of workers. Co-worker dose is being assembled for LANL, as stated in questions 4.

Uncertainty values are incorporated into these data and the results are claimant favorable.

Very little Am-241 is expected in LANL Pu mixtures because of the Pu-241 content of the original material is low. Urinalysis can assess Pu.

(6) What claimant-friendly factors will be used for dose reconstruction calculations for those individuals working in the early days under the recognized "deplorable" conditions as discussed in the TBD Chapter 5, pages 48–51.

The statement in the TBD was "deplorable by present-day standards". The state of the art of monitoring and engineering contamination control has improved vastly since the early days. Assuming that contamination was more prevalent in the working environment in the 1940s unmonitored workers' dose can be reconstructed using the assumed intakes in Section 5.6. Tritium was not on site until 1950, at which time bioassay was available. See the comments in response to questions 4 and 5.

(7) How were average airborne contamination levels derived in Table 5-20?

The airborne concentrations reported in Table 5-20 were obtained from LANL reports. The reports were referenced in the TBD. This is the best available information at the time the TBD was written. Recently released LANL documents are being reviewed to determine whether additional information is available to fill gaps in the TBD for sampling and effluent data. If warranted, new information will be included in the planned revision to this TBD.

(8) How will dose reconstruction be accomplished with no lung counting equipment available or very poor sensitivity until about 1970? Page 29 states that whole body counting was not fully implemented until 1970.

As stated in question 5, lung counting is not the primary method of determining intakes of plutonium and uranium. Urine analysis was typically used and still is. In-grown Am-241 is typically determined by calculation from the assumed plutonium mixtures in used at the time of the intake.

Lung counting is typically a bounding result, and not required to do dose reconstruction. The most claimant-favorable solubility class is used in the calculation of the POC. This has been discussed repeatedly in other TBD reviews.

Fission and activation products are determined by whole body counting, not lung counting, since some radionuclides, such as Cs-137, do not concentrate in the lung. Very little bioassay, urinalysis or in vivo counting, is available prior to 1970. A revision of the TBD will describe these data. Note that engineering controls, respiratory protection, and air monitoring were the primary means of control.

OTIB-0018 is applicable for LANL from 1948. This document provides claimant-favorable intakes for unmonitored workers. All LANL pre-1964 claims are on hold until fission products can be addressed.

(9) How can dose reconstruction be accomplished for fission products and other radioisotopes where the TBD, page 30, notes that many are not accounted for in the site's exposure analysis of generated fission product sources?

See response to question 8.

(10) What other sources of accidents and incidents are going to be used? The 45 noted in the TBD, pages 47–48, for the years 1943–1996 cannot be realistic and page 46 notes that information is not available for every year of operation.

Additional information is available and will be considered for the revision to the TBD. However, the TBD cannot attempt to chronicle every incident that has ever occurred, nor is it reasonable to expect it to do that. Incident information is made available to guide the development of co-worker dose and maximum assumptions of dose for overestimates and unmonitored individuals to expedite the dose reconstruction process and provide a claimant-favorable assessment. If accounts of a particular incident are available and are linked to a claimant or groups of claimants then that information will be considered in resolving claims. Previously discussed in response to question 3.

(11) How can the assumption, made on page 22 for absorption type assigned for plutonium, be assumed for americium? Americium is chemically much more soluble and is preferentially excreted, so this may not be claimant friendly for cancer organs other than the lung.

Per NIOSH, this has been addressed as part of Rocky Flats TBD review.

(12) How can all results for all periods be listed as actual values, when results before 1980 reported results below MDA as less-than values?

If reviewer(s) are referring to the results in the new database, LANL is responsible for the results in the data base and the derivation of the results. The raw data has been used to derive actual values, negative and positive and zeros rather than simply <MDA. This is a much more correct way of interpreting the results. These data are then used to complete the dose assessments.

(13) Was DAC-hour tracking done and is that information available for workers in plutonium work areas?

Intake and doses were not tracked in DAC-hrs (or MPC-hours). Intakes were controlled according to body burden and lung burdens.

(14) How can the TBD consider no dose from Am-214 as noted on page 19 when the in-growth rate for this isotope is approximately 20 ppm per month when 0.5% 241Pu? Tables 5-3, 5-4, 5-6, and 5-7 on pages 16–20 are unclear and appear inconsistent for the 241Pu present in fresh plutonium mixtures.

This is incorrect that no dose from americium is considered. The dose from Am-241 is handled similar to the Hanford process. The tables provide a graduated approach based on the age of the complex. Aged americium is used as appropriate. The tables provide a way to calculate the amount of Am-241 at a given age and original percentage of the mixture. The TBD doesn't calculate or assume the dose or absence of dose from Am-241. The TBD does provide tables for the amounts of americium in mixtures depending on age of the mixture. The IMBA program, used by the dose reconstructors, assumes the dose from the daughter radiations when calculating dose from Pu-241 and has an option to calculate and project the amount of americium which will in-grow over time post-intake. The TBD also does not attempt to provide specific instructions to the dose reconstructor. These instructions are provided by Task 5.

Tables 5-3, 5-4 and 5-7 list the ratios by activity as the titles imply. Table 5-6 lists the ratios by weight. The first three tables present values for different mixtures of plutonium. These tables are used in other site TBDs and are typically integrated by Task 5 into spread sheets so that the dose reconstructor can determine the amounts of Am-241 and plutonium isotopes present given the intake of either Pu-239 or total plutonium-alpha. It is not clear what the perceived inconsistency is.

(15) How will the dose reconstruction include the exposure from americium when the TBD indicates that workers participated in the americium bioassay program only if there was potential for exposure to pure americium? (page 22).

Americium workers were part of an additional bioassay program and bioassay results are available to the DRs and used as part of the standard dose reconstruction process.

(16) How will dose reconstruction for uranium be possible considering the inconsistency of the data noted on page 28 and the problems with analysis results between U-235 and U-238 noted on pages 27 and 28?

When the TBD was issued in 2004, no uranium data had been submitted and, therefore, the only information available to the TBD was that found in LANL documents. Since that time, the uranium data have been put into the electronic data base. Task 3 and Task 5 personnel have worked extensively with LANL to define the uranium data and to ensure that the dose reconstructor has the best information to properly interpret it. Internal guidance documents have been developed by Task 5, with the assistance of Task 3. The information is currently being refined. This refined information will be included in the revision to the TBD which is being developed.

(17) What controls were in place before computers for locking Zia workers out of plutonium areas were used if participation in a plutonium bioassay program was not recorded within 425 days? Were Zia data purged as stated by employees in the June 18 meeting and suggested by Ken Silver (Silver 2005)?

Whether or not Zia workers were locked out of plutonium areas if they failed to submit the appropriate urine bioassay samples does not impact how missed or co-worker dose is applied. If monitoring data or termination bioassay are available, these are used; if not, co-worker or other standard methods, such as OTIB 002 or 0018, are used to determine missed dose. Plutonium has an extremely long excretion pattern so bioassay taken much later can be used to assess intakes.

From Silver 2005:

A specific event was described by a former worker in which "the Lab hired summer students to purge the medical records" of Zia employees. It is unclear whether dose records were purged, but the former worker thinks probably so. According to this former worker, the purpose was to shield the Lab from potential liability related to a change in the maintenance contractor from Zia to another company.

The TBD (Internal Dose Section) writer has no indication that the statement concerning purged records is valid. (The quoted statement was excerpted from comments in Silver 2005 on external dosimetry not internal dose.) There is no evidence that Zia records for bioassay were purged. The data currently being supplied to NIOSH was generated from the bioassay databases not from individual records.

However, dose reconstruction protocol involve the use of missed and co-worker dose when it is indicated that the worker may have been unmonitored or inadequately monitored. Statements in the TBD, which have carried over to DR guidance, state that there is a possibility that maintenance workers may not have been consistently monitored; therefore, these individuals would be selected for assignment of co-worker dose if dosimetry records were not present.

How will dose reconstruction be handled for those Zia workers potentially doing maintenance work in plutonium areas for 425 days before being locked out by the system?

Monitoring of workers in general has been repeatedly discussed in many TBD reviews (per NIOSH). Standard dose reconstruction methods will be used for measured and missed doses.

Potential missed dose is routinely assigned in the dose reconstruction if bioassay results are reported as less than MDA. OTIB-0018 and OTIB-0002, co-worker data, and assigned data are available to the dose reconstructor and used individually or in combination as deemed appropriate by the DRs and NIOSH.

(18) Are the uncertainty values reported for in-vivo and in-vitro measurements the only counting uncertainty? The TBD, pages 41and 42, indicates that the measurement uncertainty for in-vitro measurements at one standard deviation and the biovariability are listed with the results. How were these determined?

The uncertainty listed as one standard deviation is a counting uncertainty only. The biovariability is a Bayesian statistical parameter that is used at LANL. However, this parameter is not part of the dose reconstruction protocol and the dose reconstructor was advised as such in the TBD. This parameter is no longer reported in the current data supplied to NIOSH. Per NIOSH, standard protocols are in place to address bioassay uncertainties.

(19) How can the TBD state that the OWR Facility (TA-2) not be a source of radioiodine when Table 2-1 gives I-131 as a radiation source?

This was a typo discovered some time ago and reported to DRs and will be corrected in the upcoming revision to the TBD.

(20) How can the statements of Section 5.3.2 starting with the third paragraph be accurate considering the in-growth of Am-241? The TBD does address the issue of high-fired oxides on page 40 where in-vitro is not capable of estimating the lung deposition.

High-fired oxides are being addressed across the sites. This is being addressed outside this TBD; please refer to those discussions (e.g., Rocky Flats).

(21) How were the values given in Table 5-24 and referred to on page 46 derived? Are they 8 hr time weighted averages? Were there 'hot' spots at the release points? Can it really be assumed that the individuals were wearing respiratory protection? Were the respiratory equipment fit-tested, or, was a protection factor just assumed?

See previous discussion on OTIB 0018. According to the documentation that has been found, the values in Table 5-24 were derived from current standards for airborne radioactivity during the time period. These values aren't measured values; rather they are limits for work-day exposures assuming respirators were not worn. The limits were based on occupational exposure limits and did not factor respirator protection. "Hot spot" was a term used in some of the reports that were reviewed. No particular definition of that term was available. Respirators were requested by Oppenhiemer in 1943, see the referenced telex communication. A respirator program has been in place since then. The technology of the respirators and the programs has obviously improved significantly over the years. Whether every worker was assigned or, if assigned, wore the respirator properly and consistently cannot be determined. That is a reason that the dose reconstruction routinely assigns potential missed dose based on detection levels to the entire employment period for workers who participated or should have participated in the bioassay program.

LANL was considered a forerunner in the early development of respiratory protection equipment and protocols. Protection factors are not listed for respirators in the early years. Industry standard protection factors are assumed once these standards existed. However, according to NIOSH guidance no assumption of respirator use is made when evaluating airborne concentration levels.

NIOSH, (2002) *Internal Dose Reconstruction Implementation Guideline*, Rev 0, OCAS-IG-002, National Institute for Occupational Safety and Health, Office of Compensation Analysis and Support, Cincinnati, Ohio.

(22) What consideration is given in the dose reconstruction for chronic uptakes by workers and even support personnel? The TBD notes that nasal swipes were used to determine uptakes before urine bioassay was really perfected and dependable, and, page 46 states that "Rather

than preventing intakes completely, the focus of the respiratory protection program, especially in the early years of operation, was to not exceed allowable concentration limits."

Standard NIOSH methodology assumes chronic intakes and most claimant-favorable parameters, as stated in previous TBD reviews (per NIOSH). Potential missed dose is routinely assigned for the entire employment periods and is assumed to be a chronic intake of the most claimant-favorable absorption type for the type of cancer, e.g., Type S would be assumed for a lung cancer and Type M may be assumed for the highest non-metabolic organ used for a prostate cancer (the modeled organ being assigned according to OTIB-0005). While it is highly unlikely that any worker was routinely exposed to a chronic intake every day of their employment, this is often assumed in the dose reconstruction to be claimant favorable. Therefore, even if there were occasional acute intakes followed by periods of no intake, which is the more probable situation, the assumption of chronic intake over the entire period of employment is adequate to cover the situation. Also, co-worker dose can be assigned if additional exposures are assumed.

Responses to SC&A Questions for the LANL Site Profile Document – Occupational External Dose, ORAUT-TKBS-0010-6

(1) Page 8 states that this TBD does not currently address reconstruction of skin dose. However, skin dose exposures are covered in the TBD. Will skin dose reconstruction be covered in a revised TBD or TIB?

ORAUT-OTIB-0017, "Interpretation of Dosimetry Data for Assignment of Shallow Dose" now provides guidance for skin cancer assessment. The referenced statement will be removed.

(2) Page 12 states that the impressions of the ridges of the fingertips should be used as indicators of radiation exposure and should be continued (1959). Isn't this rather an extreme dose indicator that would result from overexposure?

This background information is not being used for dose reconstruction. Yes, blood counts and finger-tip impressions were measures taken in the early years at Manhattan Project sites as surveillance for effects from radiation exposure that appear extreme by modern-day standards. The scientists eventually realized that they were not useful indicators of radiation damage for any doses short of significant overexposures, and dropped the practices.

(3) Page 12 states that as of April 1960, a large percentage (50% to 100%) of workers wore film badges. However, in the next sentence it states that film badges were issued "only to personnel who need them." Is this a contradiction, please explain?

The percentage of people badged varied significantly by work group, depending on the nature of the work performed and/or areas accessed. Badges appear to have been assigned to people judged to "need" them, with that fraction varying from group to group. No contradiction is apparent.

(4) Pages 12 states that as of April 1960, it was proposed that film badges be issued to all LANL and AEC personnel on a regular basis. Did this occur? If so, for how long?

That proposal was not accepted. Records indicate that 100% badging was never put into practice.

(5) Pages 11, 14, 15, 17, 19, and 26 present conflicting information on the period in which NTP was used and when NTA film took its place. Were NTP only used during 1949–1951 and then replaced by NTA film? Or was NTP used from 1949–1956 or 1959?

Neutron-to-photon ratios are provided in the TBD for use in reconstructing neutron doses during the period when NTP and/or NTA technology was in use.

(7) Site expert James N.P. Lawrence added further comment stating that the use of Nuclear Track Plates was discontinued when NTA film became available, and was not re-instituted in a later year. He suspects typos (or careless use of the term) in whatever documents indicate otherwise. The referenced text will be clarified.

(8) Page 13, Table 6-2, provides data on the average external dose to worker at LANL from 1944–2003. However, for twelve randomly selected years from 1974–1991, neither the total dose nor the number of workers monitored listed in the table agree with the values listed in the DOE reports for those years. The ratio of average total dose (rem) from the DOE report compared to the values listed in Table 6-2, Column 4, range form 1 to 5, with most being greater than 1. Why are the values listed in the TBD usually lower than those listed in the original DOE report?

As noted in its title, the values included in Table 6-2 of the TBD represent external radiation doses. The values for LANL reported by DOE (such as in DOE/EH-0287P for 1990) were total doses, external plus internal. The numbers of workers monitored that are given in Table 6-2 include **all** persons that were monitored, in accordance with modern-day reporting guidelines, including workers in the following categories: LANL, Johnson Controls Inc. (analogous to Zia Company in earlier years), visitors, subcontractors, and DOE's Los Alamos Area Office. In accordance with the requirements of DOE Order 5484.1 at the time, LANL did not include subcontractors or visitors with zero doses in the numbers of workers reported each year.

(9) Pages 16 states "On some rare occasions when the 'personnel control film' showed some exposure due to fallout from Nevada test operations, the 'control' film was evaluated and its exposure was subtracted from all personnel film for the period." Why would a dose that workers actually received from AEC operations be subtracted from their recorded dose?

This subtraction is not being performed by the ORAU team or presented as a recommended practice in the TBD. The decision to subtract (on "rare occasions") doses from NTS fallout in Los Alamos from personnel film badges was made by LASL dosimetry group personnel, apparently so that their reported dosimeter results would reflect exposures to LASL workers from LASL operations.

(10) Page 17 – How much beta dose was required before it was considered that “it forms a significant part of the total exposure”? Could this practice have led to missed extremity doses?

No quantitative criteria have been identified as those used to distinguish “significant” beta exposure. Yes, the practice of reporting beta exposures only when they were judged to be a significant part of total exposures could have resulted in under reporting of extremity doses. Estimation of missed doses, as described in Sections 6.5.1 and 6.5.2 of the TBD, can be based on the nature of the dosimeters in use, MDLs, and exchange frequencies. Missed neutron doses prior to 1979 are estimated based on reported photon doses, adjusted per Table 6E-3, and use of the applicable neutron-to-photon ratio.

Site expert James N. P. Lawrence indicates that, in the 1949–1950 timeframe, beta exposures were considered ‘skin’ doses. The allowable whole body dose was 0.3 R/wk and the whole body plus skin dose was 0.5 rad/wk. Early film badges did not have an ‘open window’ (OW) to make an estimate of beta exposure, so none was made. When the film badge with an OW was put into use, beta doses would have been evaluated if the was a source of beta radiation where the film badge was used. For example, in the areas where depleted (or normal) uranium was worked, beta exposures would have been evaluated, if the developed film density in the OW area was measurably greater than under the ‘metal filter’ area. And in areas where plutonium was worked, there was no ‘beta radiation’ (only low energy x-rays from the plutonium), so no beta exposures were evaluated. In the 1949–1950 time period, using the film available at that time, the minimum measurable density of the developed film corresponded to about 10 mR. If the OW density was the minimum measurable and the ‘metal filter’ density was not different from developed, but unexposed film, then the whole body dose would have been recorded as 0 mR and the whole body plus skin dose would have been recorded as 10 millirad.

(11) Page 20 states that between 1981 and Sept 1990 doses less than 10 mrem were reduced to 0 mrem for the records. Is this being corrected to be claimant favorable in the dose reconstruction (DR) process for that time period?

Per NIOSH, this issue has been dealt with across the nuclear weapons complex in other discussions. This is an issue of accounting for missed doses, which is done using standard missed dose procedures that have been previously discussed.

(12) Page 24 states that the Model 7776 dosimeter was not designed to perform low-penetrating beta or beta/low-energy photon dosimetry. Did this result in missed low-energy doses at LANL during their period of use?

Per NIOSH, this issue has been dealt with across the nuclear weapons complex in other discussions. This is an issue of accounting for missed doses, which is done using standard missed dose procedures that have been previously discussed.

(13) From the information on Page 26, and elsewhere in this TBD, it would appear that was no dependable personnel neutron monitoring system for recorded dose at LANL during the time period of 1943–1949. Is this correct?

As previously stated, missed neutron doses prior to 1979 are estimated based on reported photon doses, adjusted per Table 6E-3, and use of the applicable neutron-to-photon ratio distribution as described in Section 6E.7.

(14) Pages 26 and 36 state that LANL became aware of the NTA film's under response to neutrons below 0.8–1.0 MeV around the late 1960s. Page 38 states that a study released in 1978 showed that the average neutron energy field at TA-55 was approximately 200 keV and that explains why very little neutron dose was observed using NTA film at the facility. Page 41 states that a study showed that the average neutron energy field at LAMPF in 18 locations was <100 keV and that explains why very little neutron dose was observed using NTA film at the facility. Page 43 states that a fission neutron energy spectrum (0.1 to 1 MeV) is to be assumed at all LANL reactors for dose purposes. How will NIOSH/ORAU provide claimant-favorable neutron doses for workers when this entire spectrum is essentially below the practical 1-MeV detection limits of NTA film used in the workers' badges?

Was anything done by LANL to correct the under response of NTA film to neutrons less than 1 MeV in the worker's record of dose over the years? Will it be addressed during DR, and how?

NTA film data are not being used to reconstruct neutron doses to workers. NIOSH/ORAU is providing neutron-to-photon ratio distributions that are based on doses measured at LANL after NTA film was replaced. These ratios can be used with measured photon doses to estimate neutron exposures to workers.

(15) Page 26 briefly refers to NTA film being sealed in plastic to minimize fading due to high humidity around 1989. It was demonstrated at Mound Labs (Meyer 1994) that NTA film fading is significant (33% in the first week and 56% in the second week). Were any steps taken to correct the recorded neutron dose for the many years of records prior to 1989 when the recorded neutron dose must have been underestimated because of track fading?

NTA film data are not being used to reconstruct neutron doses to workers. NIOSH/ORAU is providing neutron-to-photon ratio distributions that are based on doses measured at LANL after NTA film was replaced. These ratios can be used with measured photon doses to estimate neutron exposures to workers.

Site expert James N.P. Lawrence indicates that the 'Dosimetry Bible' contains results of NTA film fading studies made during the 1950–1980 time period. Since Los Alamos is a 'low humidity' environment (different from Oak Ridge or the Marshall Islands), NTA track fading was never considered a significant problem for film badges issued for one month intervals. His recollection is that less than 10% fading was observed in the studies. No corrections were applied specifically for fading, since the calibration exposures were also subject to the one month issue period.

(16) Page 27 describes the use of the Model 8823 badge to correct for the employee-specific neutron correction factor to be applied to the Model 7776 badge readings used from 1980–1998 because of the Model 7776 shortcomings concerning energy response. Was this done by LANL on the worker's dose records at that time, or does this need to be done during DR?

These neutron correction factors were applied by LANL at the time of badge processing.

(17) Page 29 makes a statement concerning a memorandum of 8/24/62 that refers to using Co-60 calibration to evaluate beta, gamma, and thermal neutron exposures. How was Co-60 used to calibrate for thermal neutrons?

As described in various LASL reports and memoranda (including LASL 1969; 8/24/62 and 11/27/63 memos), in the evaluations of doses using the Cycolac badge, the thermal neutron dose was determined by subtracting the Co-60 exposure corresponding to the density under the more sensitive thermal neutron filter (Filter 20) minus the Co-60 exposure corresponding to the density under the less sensitive thermal neutron filter (Filter 21). Details of the method can be provided.

(18) Page 29 states that a 3/5/63 memorandum concerning the Pu areas at DP West instructs them to divide the exposure results in R by 2 to get rem. However, later in the same paragraph it states that the factor of 2 for Pu and soft x-rays was abandoned in January 1963 (i.e., before the 3/5/63 memo came out). Can you clear up this apparent conflict?

There is no conflict. The factor of two was used before January 1963 and discontinued in January 1963. The text from the 3/5/63 memorandum does not provide new instructions for processing of badges at DP West, rather a description of practices that had been in place for some time for evaluating doses using the brass-cadmium badges in plutonium areas.

(19) Page 32 states that PuBe-238 and Cf-252 sources were used to calibrate NTA film (1990 report). However, the NTA film was measuring primarily 10–60 MeV neutrons at LAMPF. How can 2–4 MeV neutron sources be used to calibrate for 10–60 MeV neutrons, except on a relative basis?

While neutron energies in areas near accelerator beams were certainly higher, measurements at various accessible locations around LAMPF where workers were much more likely to have received neutron exposures indicated an average neutron energy of <100 keV at LAMPF (Blackstock et al. 1978; see Section 6.2.3.6.2). As shown in Table 6-21, neutron energies around LAMPF are assumed to be distributed as follows: <10 keV (30%), 10–100 keV (30%), 0.1–2 MeV (20%), and 2–20 MeV (20%).

(20) Page 35 provides calculated errors (Table 6-12) concerning the Cycolac badge response to low-energy photons. Was the worker's dose record corrected by LANL to reflect this low response to 20 keV photons (360% low), or will this have to be done by the DR?

As described in Section 6E.1, to ensure that dose is appropriately attributed to the low energy photon or electron categories in dose reconstructions, nonpenetrating dose can be estimated as skin dose minus (deep dose + neutron dose + tritium dose). Many plutonium workers will also have a glovebox correction factor applied in accordance with Task 5 methods.

The 3/5/63 memorandum cited on Page 35 discusses errors that were expected when using the Cycolac badge with low energy photons (<45 keV). It states that "when significant exposures to soft radiation (<45 keV) are measured or anticipated, a special evaluation will be made." Per James N.P. Lawrence, no changes were made to the previously recorded doses, but when these 'special evaluations' were made, the 'special evaluation' doses were the values recorded.

(21) Page 36, Section 6.2.3.5 is titled "Uncertainty in Beta/Photon Recorded Dose." However, it only refers to Table 6-14 that list beta and photon energies and percentages. How is this a description of uncertainties?

This is a carryover from early TBD 6 drafts for other sites. The title will be revised.

(22) Page 44, Section 6.2.3.8 is titled "Uncertainty in Neutron Dose." However, it only states that the measurement of neutron dose in the workplace is difficult and that NTA film under responds. How is this a description of uncertainties?

This is a carryover from early TBD 6 drafts for other sites. The title will be revised.

(23) Page 47 provides an example of a neutron dose calculation according to each neutron energy range. Where does the factor of 2.055 come from?

Per NIOSH, the referenced text is illustrative of the process, but specific procedures for doing dose reconstructions are determined by Task 5.

The referenced value is calculated from data in the 4th and 5th columns of Table 6-20; more specifically, it is based on the estimated value from column 5 representative of the <10–100 keV neutron energy range divided by the estimated value for that same energy range from Column 4. Some estimation of appropriate values from Columns 4 and 5 is necessary because the energy range does not cleanly coincide with single values of average quality factor and neutron weighting factor in Table 6-20 as is the case for the other two energy groupings in the example calculation.

(24) Page 48, Table 6-22, and Page 71, Table 6E-9, provide minimum and maximum values for neutron-to-gamma ratios for several different work areas at LANL. How will the DR know what value to use within the wide ranges listed?

The TBD has been revised to specify median and 95th percentile values for recommended distributions of neutron-to-photon doses. These are the parameters that were requested by Task 5 personnel.

(25) Pages 49 and 50 provide information concerning calculating missed neutron doses from 1951–present. What will be done in the DR process to account for neutron exposures during 1943–1950 when adequate personnel neutron monitors were not available?

Per NIOSH, the referenced text is illustrative of the process, but specific procedures for doing dose reconstructions are determined by Task 5.

Estimates of missed neutron doses from 1943 to 1951 can be based on reported photon doses, adjusted per Table 6E-3, and use of the applicable neutron-to-photon ratio distribution.

(26) Page 64, third bullet point, lists nonpenetrating doses as not including the tritium dose (and again on Page 69). Is this tritium dose from bioassay measured internal tritium dose or external emersion tritium dose?

This is the tritium dose from the bioassay program.

(27) Pages 65 and 66 provide the statistics on gamma doses and recommends that the DR use the median gamma dose for unmonitored workers. The median dose is the smallest of the doses listed. Is this NIOSH policy and is it claimant favorable?

Per NIOSH, the referenced text is illustrative of the process, but specific procedures for doing dose reconstructions are determined by Task 5.

NIOSH is developing methods for use of co-worker data, and is preparing additional TIBs that will address evaluation of unmonitored workers.

(28) Page 67, Table 6E-3 recommends that the reported photon doses during 1950–1962 be divided by a factor of 1.2. Is this not in contradiction to the statement in the middle of Page 45 of the TBD that states "…reduction of reported doses, correction factors are not recommended…"?

There is no contradiction. In some cases, there is not sufficient evidence to justify application of a correction factor that reduces doses. In the referenced case, there **is** sufficient evidence that use of film badges as documented resulted in doses to workers in plutonium areas being significantly over estimated, so a downward correction is warranted.

(29) Page 67 provides some estimates of the standard errors involved in dosimetry at LANL. However, the statement is made that, for mixed beta and photon fields, the errors are larger than 30%. Is there any guidance for the DR on how much greater than 30%? Also, what neutron energy range does the stated standard error of ±50% for NTA film apply to?

Task 5 dose reconstructors have a process that uses standard assumptions when representing the uncertainty of external dosimetry data across the nuclear weapons complex. In general, this process overrides site data. NTA film data are not being used to reconstruct neutron doses to workers.

(30) Page 67, Table E-4 recommends uncertainty factors for reported LANL doses. The uncertainty for neutron doses is listed as ±8% for the Model 7776 Dosimeter. This appears to be a very small uncertainty considering the discussions of this model dosimeter in the rest

of the TBD (i.e., pages 26 and 27). Additionally, the Model 8823 uncertainty factor is listed at ±8% also. However, this model needs to be supplemented with NTA/TED to cover the necessary neutron energy ranges at LAMPF. Shouldn't a larger neutron dose uncertainty factor be used in the DR process, or a limited energy range for which the ±8% is applicable be stated?

Task 5 dose reconstructors have a process that uses standard assumptions when representing the uncertainty of external dosimetry data across the nuclear weapons complex. In general, this process overrides site data.

General Questions on Occupational External Dose

(1) What were the limits involving potential exposure to neutrons at facilities handling fissile materials that likely evolved over time at LANL relative to subcritical emissions?

Extensive documentation exists. References can be provided.

(2) When were workers first measured for exposures to neutrons from (alpha-neutron) reactions at LANL?

Exposures to neutrons from alpha-neutron reactions would have begun around 1945, during a period when neutron monitoring was not well developed.

As previously stated, missed neutron doses prior to 1979 are estimated based on reported photon doses, adjusted per Table 6E-3, and use of the applicable neutron-to-photon ratio distribution as described in Section 6E.7.

(3) Were there any positive whole-body counting measurements for Na-24 observed at LANL for reactor workers or workers handling fissile materials, as was done at Hanford?

This question should more appropriately be posed to the authors of the internal radiation dose section of the TBD.

Methods for criticality accident dose estimation (including those based on measurement of hair and blood-sodium activation) were developed and applied at LASL, as described in 1967 by Dale E. Hankins (LA-3910).

(4) Has a method been developed to integrate nonstandard radiations (e.g., mesons, heavy particles) into dose reconstruction?

Documentation of methods of this type has not been identified to date. James N.P. Lawrence states that never to his knowledge have such 'non-standard' radiations been included in recorded personal exposures. Mesons and heavy particles from accelerators occur in beams, and he is not aware of any personnel being exposed to such beams at LANL.

(5) How are criticality accidents being evaluated for both those involved and the responders?

Criticality accidents have been evaluated as special cases by LANL personnel, and values added to worker dose records.

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ATTACHMENT 4: SUMMARY OF CONFERENCE CALL ON SC&A QUESTIONS PROVIDED TO NIOSH

Introduction

SC&A submitted written questions to NIOSH pertaining to the LANL Site Profile on January 13, 2006. NIOSH/ORAU provided written responses to these questions on March 14, 2006 in preparation from a conference call with SC&A. The questions and responses are provided in Attachment 3. Information provided by NIOSH/ORAU gives SC&A a more in-depth knowledge of the rationale for assumptions made within the TBD and the source documents that provide the basis for the TBD. The summaries below are not verbatim discussion, but include information supplemental to the written responses provided by NIOSH/ORAU. They are arranged by general topics since there was overlap in discussions conducted during the conference calls. The information provided by NIOSH/ORAU is listed under each topic. SC&A has provided comments towards the end of the summary. Actions items resulting from discussions in the conference call are listed at the bottom of each summary.

LANL Site Description TBD Conference Call Summary

Date:March 23, 2006
Subject:Los Alamos National Laboratory-Site Description, ORAUT-TKBS-0010-2
Time:1:00-3:00 pm EST

Individuals who participated included:

ORAU:Jack Buddenbaum, Paul Johnson, Don Stewart
NIOSH:Sam Glover
SC&A:Harry Pettengill, Kathryn Robertson-DeMers, Tom Bell, Joe Fitzgerald

General Comments

The current versions of these TBDs ORAUT-TKBS-0010-2 (Buddenbaum 2004) and ORAUT-TKBS-0010-3 (Johnson 2004) were published with asserted data gaps in information to allow processing of selected LANL claims. Planned revisions of these documents will include additional information collected since the publication of this TBD and any applicable information that comes from NIOSH responses to SC&A questions. ORAUT-TKBS-0010-1 (Buddenbaum 2005) will be revised as necessary to reflect revisions made to the TBDs.

There is currently no classified version of the Technical Basis Document, nor is there a plan to develop a classified version. A majority of classified information has no relevance to the Site Description TBD. Workers involved in classified operations were badged or put on a bioassay program.

Dose received at the Nevada Test Site (NTS) and Pacific Proving Grounds (PPG) is available. In the cases where badges were provided by another organization, this information was provided back to LANL. LANL has done a verification ensuring this dose has been incorporated into the LANL dose record at least back to 1951.

There are a number of Technical Information Bulletins used in support of the LANL dose reconstruction process. OTIB-0002 (Rollins 2004) and OTIB-0018 (Brackett and Bihl 2005) are used on an occasional basis. Which TIBs are applied is claim specific.

LANL claims were on hold prior to LANL providing the recently obtained dataset of bioassay data.

There are plans to locate and review the Omega notebooks referenced in the Site Description TBD on pages 33–34. The search is in process now. Since Omega was a common term at LANL, NIOSH/ORAU is expanding the search to include terms relating to the reactors and/or reactor areas.

NIOSH/ORAU has reviewed Health Division reports and retrieved copies covering the years 1947–1964. Some of these reports were only recently obtained. These reports are very general in nature, but provide hints to sources of exposure. Experience with the information provided in these reports is that they are not useful due to the lack of detail.

There were no further discussions related to Question #1 (Introduction Questions), Questions #4, #5, #8, #9, #10, and #11 (General Questions), and Question #1 (Site Description) in Attachment 3, *Responses to SC&A Questions for the LANL Site Profile Document, Introduction, ORAUT-TKBS-0010-1; Site Description, ORAUT-TKBS-0010-2*; and *Occupational Medical Dose, ORAUT-TKBS-0010-3*. Based upon the written response no further discussion was necessary.

SC&A Conference Call Comments

There are no comments at this time.

Action Items for NIOSH/ORAU

(1) Provide a list of planned changes to the Site Description TBD
(2) Provide a list of documents recently received from LANL
(3) Provide an updated response to General Question #3 regarding dose received at test sites
(4) Elaborate on the use of TIBs in dose reconstructions for LANL claims
(5) Make the following reference cited in the TBD responses available to SC&A.

U.S. Department of Energy, 1991, *Tiger Team Assessment of the Los Alamos National Laboratory, September 23–November, 8, 1991*, Office of Environment, Safety and Health.

Action Items for SC&A

(1) Provide NIOSH with a list of Action Items from the conference call.

LANL Occupational Medical Dose TBD Conference Call Summary

Date: March 23, 2006
Subject: Los Alamos National Laboratory-Occupational Medical Dose, ORAUT-TKBS-0010-3
Time: 1:00–3:00 pm EST

Individuals who participated included:

ORAU: Jack Buddenbaum, Paul Johnson, Don Stewart
NIOSH: Sam Glover
SC&A: Tom Bell, Joe Fitzgerald, Harry Pettengill, Kathryn Robertson-DeMers

General Comments

The current versions of these TBDs ORAUT-TKBS-0010-2 (Buddenbaum 2004) and ORAUT-TKBS-0010-3 (Johnson 2004) were published with asserted data gaps in information to allow processing of selected LANL claims. Planned revisions of these documents will include additional information collected since the publication of this TBD and any applicable information that comes from NIOSH responses to SC&A questions. ORAUT-TKBS-0010-1 (Buddenbaum 2005) will be revised as necessary to reflect revisions made to the TBDs.

Dose reconstructions prior to 1970 are being held up due to the continuing evaluation of environmental dose. Bioassay data was also provided belatedly. As dose reconstructions are being completed, the dose reconstructors also come up with additional questions and issues.

Site specific information relating to the medical x-ray program will be further substantiated based on additional information retrieved from LANL or provided by site experts. There was very limited information at the time the Occupational Medical Dose TBD (Johnson 2004) was written.

Medical Record Access

The records provided by LANL include internal and external radiation records and very little medical information. They are not sending x-ray records that are not under LANL control.

There are some issues associated with early LANL medical records. The Los Alamos Hospital was originally owned by the Army. The records were transferred to the Atomic Energy Commission, then to ERDA. They are physically located at the hospital which is now a private organization. DOL, DOE, and NIOSH are currently working with Senator Udall’s office to gain access to these medical records.

Chest X-ray Frequency

The original information gathered regarding physical exams for employees was based on personal communications with a retired technician. NIOSH/ORAU is currently looking for additional documentation and medical records to support the personal communications. Additional references will be cited in the TBD. Based on personal communications to date, researchers who worked with animals and tuberculosis experiments in the Health Research Laboratory were examined more frequently than others.

Default Assumptions

Dose reconstruction is performed using the x-ray OTIB-0006 (Kathren and Shockley 2005). Where site specific information is available, the TBD will reflect this information. NIOSH/ORAU assumes an annual chest x-ray as a default. The dose reconstructor applies photofluorography (PFG) through 1956. Both a lateral and a posterior-anterior view are assumed when the views are unknown beyond this. X-ray dose is typically only assigned in non-compensable cases.

NIOSH/ORAU used actual examination factors (e.g., filtration) values if there are known. Where they are not known, values from the Implementation Guide (NIOSH 2002a) are used. NIOSH/ORAU is currently trying to retrieve additional site specific records.

The PFG exposure values recommended in the current version of the TBD were not determined based on the latest revision of the TIB. Revisions to the TBD will reflect the current version of the x-ray TIB. The TIBs offer a means to update methodology quickly. These updates are reflected in the dose reconstructions.

There were no further discussions related to Question #8 listed in Attachment 3 (Occupational Medical Dose), *Responses to SC&A Questions for the LANL Site Profile Document, Introduction, ORAUT-TKBS-0010-1; Site Description, ORAUT-TKBS-0010-2*; and *Occupational Medical Dose, ORAUT-TKBS-0010-3*. The written answer provided was adequate to answer the question.

SC&A Comments

NIOSH/ORAU is encouraged to look into additional site specific records describing the medical x-ray procedures and examination programs.

Establishment of the date for use of PFG is important especially in light of the fact that medical records are not available to identify use of small films.

The uncertainty associated with x-rays should also consider errors associated with retakes and poor processing equipment. These are not addressed effectively in the TBD or TIB.

Action Items for NIOSH/ORAU

(1) Provide a list of planned changes to the Occupational Medical Dose TBD
(2) Provide a list of documents recently received from LANL
(3) Provide access to the records referenced in the responses to the Medical TBD questions
(4) NIOSH/ORAU will provide clarification on when PFG is applied by dose reconstructors

Action Items for SC&A

(1) Provide NIOSH with a list of Action Items from the conference call.
(2) Provide a summary of the conference call discussion.

LANL Occupational Environmental Dose TBD Conference Call Summary

Date: March 7, 2006
Subject: Los Alamos National Laboratory-Occupational Environmental Dose, ORAUT-TKBS-0010-4
Time: 2:00–4:00 pm EST

Individuals who participated included:

ORAU: Jack Buddenbaum, Laura McDowell-Boyer, Don Stewart
NIOSH: Sam Glover,
SC&A: Harry Pettengill, Kathryn Robertson-DeMers
LANL: Jim Lawrence

General Discussion

The current version of ORAUT-TKBS-0010-4 (Cehn and McDowell-Boyer 2004) was published with asserted data gaps of information before 1971 to allow processing of selected LANL claims. However, this section was designated for a future planned revision due to these existing data gaps. Planned revisions will include additional information pertaining to environmental monitoring and effluent data collected since the publication of the TBD and any applicable information that comes from NIOSH responses to SC&A questions.

Records collected as part of the LAHDRA project have provided valuable information. The early efforts of the LAHDRA project were begun in 1999. This project included an extensive effort to evaluate records primarily pertinent to environmental dose reconstruction. In 2003, the project was shutdown due to lack of resources. As a result many of the records requested were tied up in review by the site. The project was restarted in February 2005. These records previously recovered are now starting to trickle out of Los Alamos. Not all data are relevant to the NIOSH Dose Reconstruction task. This information needs to be reviewed and its relevance or appropriateness for the TBD determined. This revision to the TBD will not occur until this data has been reviewed.

Site-wide Model

Unlike other sites, LANL has not developed a site-wide model for environmental dose. Effluent and sampling data are available in the recently retrieved data. Earlier data may not be reliable and must be verified. LANL AIRNET provides air sampling data for some technical areas. The air samplers have been added, shutdown, and changed. For some technical areas we can't find data.

Cumulative (additive) Effect of Numerous Source Terms

The air samples provide a cumulative value and will reflect all releases from the immediate area. The median dose at each location (i.e., TA) throughout the site is determined from these data. The maximum value of these medians is used as the maximum dose. Doses are assigned by radionuclide. This is the value assigned to workers. The median doses were obtained (or calculated) from LANL reports for each TA. The reports provide the average value calculated for all air samples collected monthly at the particular sampling location.

Accounting for the Deficiency or Absence of Effluents Data from All TAs

The TBD was written with the data available at the time. NIOSH/ORAU hope to fill gaps with the data retrieved. This data does not necessarily include effluent and airborne data from Omega West Reactor. In the absence of data, the gaps are addressed using bounding parameters. Argon effluent data for TA-2 is available. The site-wide maximum value is applied in cases where there is a deficiency or absences of effluent data. There was no appreciable release from the Omega West Reactor. The Omega West Reactor was a single boiling, water cooled, reactor with sealed elements.

Pre-1971 Effluent Data

The new information recently retrieved has some pre-1971 data; however, there is little confidence in the effluent data at this time. A further evaluation is required. Any data would have to be validated with supporting documents. The use of maximum release rates is not a good reflection of release in individual technical units. NIOSH/ORAU will be looking at release by year and determining if any gaps can be filled.

Episodic Releases

NIOSH/ORAU has access to unclassified documentation detailing environmental releases of radioactivity (Rogers 1977; LANL 1992; and DOE 1991). These references have been consulted. Effluent data used as a basis for the TBD often include both episodic and routine releases. There is no significant source data for episodic releases from burning or hydrotesting.

Assignment of Dose Where Gaps Exist

In lieu of environmental data, co-worker data can be used. Also, in the absence of data, co-worker dose can be used. We have data for plutonium, uranium, tritium and limited fission product data. For internal dose we can apply OTIB-0002 (Rollins 2004) and OTIB-0018 (Brackett and Bihl 2005). The dose reconstructor choices the method and justifies it in the dose reconstruction. This is a clear overestimate and is applied in likely non-compensable claims.

RaLa Project

Inhalation from resuspension of soil was not an issue with the RaLa project. Following the detonations at the RaLa Project, only a few individuals were sent in immediately to put out the brush fires (i.e., firemen and Radiation Monitors). The explosion cloud passage was required before re-entry into the area. This was about 30–60 minutes post explosion. There was no air sampling done during these events. Small amounts of material could cause beta burns and did with some chemists during the separation process.

There wasn't a large population of workers associated with this project. There is not much likelihood of unmonitored workers being exposed. Co-worker dose can be assigned to a claimant, if necessary.

A Gaussian Model (CAP 88) has been used to estimate dose to offsite individuals. The external dose contributed from groundshine was three orders of magnitude higher then immersion and inhalation.

Adjustment of Any Potential Under-Reported Am-241 Effluents.

The plutonium used during this period of time was short irradiated plutonium. As a result there was very little Pu-241 impurity in the plutonium and thus not much Am-241.

Reevaluation of "Ratioing" Approach

The ratioing method is used only when data are not available for a particular TA. It uses the source emission rates and the air concentrations from TA-3 and TA-21. The estimated air concentration using this method is compared to the maximum site-wide median value. If the ratioing method value is higher, it will be used instead of the site-wide maximum. The NIOSH/ORAU team hopes new documents will fill in some of the gaps.

Deficiency in Resuspension Factor of 1 x 10^{-9}/m

The justification for a 1 x 10^{-9}/m resuspension factor has come up in other TBD reviews and is being addressed generally.

Ambient Radiation Levels in the Canyons

There are no data to track where an individual was and when. The occupancy factor is assumed to be 24 hours a day, 7 days a week for the early years. In general, onsite ambient dose would not be a factor. There is only sparse data prior to the 1970s. No systematic air sampling program was in place during this era.

Dose from Noble Gases and Mixed Activation Products from TA-53

NIOSH/ORAU had no additional information to add regarding this. SC&A indicated there may be follow-up questions.

Uncertainty Analyses of ±20%.

The 20% uncertainty in the TBD does not include all uncertainties applied to the dose reconstruction.

SC&A Comments

Based on the information provided in the conference call and the recent retrieval of additional data by NIOSH/ORAU, SC&A may have further questions which will be referred to NIOSH if necessary.

Action Items for NIOSH/ORAU

(1) Provide a list of planned changes to the Occupational Environmental Dose TBD
(2) Provide a list of documents recently received from LANL

Action Items for SC&A

(3) Provide NIOSH with a list of Action Items from the conference call.
(4) Provide a summary of the conference call discussion.

LANL Occupational Internal Dose TBD Conference Call Summary

Date: March 7, 2006
Subject: Los Alamos National Laboratory-Occupational Internal Dose, ORAUT-TKBS-0010-5
Time: 10:00–12:00 pm EST

Individuals who participated included:

ORAU: Jack Buddenbaum, Don Stewart, Rowena Argala
NIOSH: Sam Glover,
SC&A: Bob Bistline, Kathryn Robertson-DeMers
LANL: Jim Lawrence

General Discussion

The current version of ORAUT-TKBS-0010-5 (Argall 2004) was published with asserted data gaps of information to allow processing of selected LANL claims. However, this section was designated for a future planned revision due to these existing data gaps and the ongoing development efforts of the new LANL bioassay database. Planned revisions will include descriptions of the new LANL bioassay database, additional information pertaining to in-vitro and in-vivo monitoring since the publication of this TBD, and any applicable information that comes from NIOSH responses to SC&A questions.

NIOSH/ORAU has received an updated database with additional bioassay information not previously provided by LANL. As a result, NIOSH/ORAU is working on a revision to integrate the new bioassay data. This is not expected to be complete for a couple of months. The revision will integrate the new bioassay database, clarify the uranium MDA, provide more air sampling data, and integrate information from additional sources including information from classified document review. Clarifications related to comments from Ken Silver's report will be incorporated. In the interim, some issues could be addressed with page changes.

Much of the additional data has come from data retrieval efforts for the LAHDRA program. This material has been undergoing classification reviews for the last two years. The additional documentation will not be available for SC&A review for a couple of months. The Center for Disease Control website has a database of LAHDRA documents.

Dose Reconstruction for Sr-90, Ac-227, and Other Unusual Radionuclides

Am-241 and Pu-238 bioassay results are readily available in the database. Isotopic plutonium analysis was available from the time that pure Pu-238 would have been present on site. As stated, Am-241 urine bioassay was only performed when exposure to pure Am-241 was suspected. These two nuclides are not in question. Ac-227 is the one special radionuclide in question and possibly Np-237. During the decommissioning of TA-21, Building 153, Ac-227 was identified in the characterization. There was some chemistry work with americium and neptunium at the lab. There has also been work with Pu-238.

Sr-90 can be an impurity associated with the RaLa project. There would have been a limited amount of strontium activity collectively over the entire period of the RaLa program. This is a small quantity. The primary hazard related to this project was external exposure. There is no bioassay data available for this project.

The data for unusual radionuclides is not easily accessible. There is some data available in logbook. Retrieval of these individual specific results from these logbooks is not planned since there is only limited data for these radionuclides. The population likely to be exposed would be those operators handling the material. NIOSH/ORAU relies on the CATI interview process for identification of other radionuclides. You cannot rely on these data being provided in the information provided by LANL. There are not pointers for exposures to other radionuclides in the records other than those possibly mentioned in the medical records. Information may be in the individual's medical record, if they were involved in an incident that required medical attention.

Co-worker Dose Assignment

The procedure for assignment of co-worker data is the responsibility of Task 5. The co-worker questions should be addressed with Stu Hinnefeld.

The LANL site database is not used by the dose reconstructors. This is primarily used for determining co-worker dose.

As with other sites, co-worker data is becoming available for LANL as previous discussed in the response to question 4. OTIBs address the use of these data and the assignment to various types of workers. Co-worker dose is being assembled for LANL, as stated in #4 of Attachment 3, Responses to SC&A Questions for the LANL Site Profile Document – Occupational Internal Dose, ORAUT-TKBS-0010-5. Uncertainty values are incorporated into these data and the results are claimant favorable.

The procedure for assignment of co-worker data is the responsibility of Task 5. The co-worker questions should be addressed with Stu Hinnefeld. The TBD states that there may have been individuals who were not monitored or were not adequately monitored, especially in the early years. The unmonitored worker scenario for early years (1940s) uses either average annual air concentration results or airborne limits. Additional information is helpful in order to be able to adjust doses downward when it is available.

Air Concentration Data

The unmonitored worker scenario for pre-1947 years is derived from air sampling results and limits. A hypothetical intake for this period would equate to about 30% of the Maximum Permissible Body Burden or the average of the intakes received by the UPPU Club Members, who had known and significant intakes of plutonium during that time period.

The following statement was made on page 51 of the TBD (Argall 2004):

No bioassay data, except plutonium and americium urine and fecal analysis, have been submitted to date. Therefore, the experiences of workers with monitored intakes cannot be used to develop a scenario for workers who were not monitored. Potential intakes will be derived from removable contamination levels, tolerance and MAC air concentration levels, and airborne concentrations of significant radionuclides.

When the TBD was written, information on other significant radionuclides, such as uranium, was not available. Now that data have been submitted in the form of the new database, bioassay data are now available to permit the development of scenarios for workers who were not monitored. Co-worker doses can be and are being calculated. The statement above does not reflect the additional data received since the issuance of the TBD.

The average airborne levels derived in Table 5-20 in the internal dose TBD were taken directly from LANL reports. No procedures have been located explaining the exact method used to calculate these results.

Claims for Energy Employees hired prior to 1964 are being held for dose reconstruction in the future.

Plutonium and Americium

Since americium and plutonium are linked inside a matrix, NIOSH/ORAU does not have to deal with the bioassay differential. In the case of either Type S or Type M material, they are chemically bound and will leave the body together. They also stay together when deposited in the lung. When it reaches the systemic organs, then americium and plutonium may have a differential excretion rate. This has been addressed as part of the Rocky Flats TBD (Furman and Lopez 2004) review.

Tenneman's chemistry group handled pure Am-241. Individuals involved were monitored. Today there are approximately 100 individuals monitored for Am-241. Am-241 was never an issue in the context of plutonium processing. There was no monitoring for Am-241 in the early days. In later years, there were specific processes that handled Am-241. The individuals assigned to this work were monitored. Today the Am-241 bioassay monitoring program includes about 100 individuals.

The TBD does consider dose from Am-241as a contaminant in the plutonium process. The dose reconstructor assumes the most claimant-favorable plutonium mixture. Fresh weapons-grade may be assumed for a person working with plutonium extractions. Aged weapons-grade may be assumed for a person working with decommissioning or other places where aged might be assumed. These assumptions would be best estimates. For overestimates, 10-year aged fuel grade is usually the most claimant favorable and would be assumed even though this is not the mixture normally handled at LANL. There is no in-vivo count data for the earlier years. The plutonium received at LANL in the early years was from short run fuel so there was less of a buildup of Pu-241. Until May 1945, there were only microgram quantities of plutonium onsite.

This has been chronicled in the TBD and its references. For those monitored for Am-241, bioassay data is used.

High-fired Oxides

The issue of high-fired plutonium oxides is being addressed in the Rocky Flats (SC&A 2005) review. The methodology developed will apply to facilities complex wide.

Bioassay Uncertainties

The uncertainties associated with the in vivo and in vitro measurements represent counting uncertainties. The dose reconstructor also applies additional uncertainties during the reconstruction process.

Missed Dose

OTIB-0002 (Rollins 2004) and OTIB-0018 (Brackett and Bihl 2005) are used in maximizing cases. They overestimate the dose to a worker. The OTIB-0018 values were actually generated based on LANL data. OTIB-0002 is used infrequently and is not used for lung cancer cases.

Locking Zia Workers Out of Plutonium Areas

There was not a program that locked Zia workers out of the plutonium areas if participation in a plutonium bioassay program was not recorded within 425 days. The term "locked-out" is incorrect. Individuals were escorted out of the area.

Locking Zia Workers Out of Plutonium Areas

"Locked out" is a computer term, meaning access is denied. It has nothing to do with physical locks and keys. If it was noted that they were not participating in the bioassay program, they wouldn't be granted access. It appears that the program may have been written and documented in the referenced paper but never fully implemented. The issue will be clarified in the revision of the TBD.

Retrieval and Submittal of Incident Records to NIOSH/ORAU

Many of the incidents occurring at LANL are already provided in the TBD. Some incident reports are available from the medical files. The dose reconstructor does not typically have access to incident information from the claimant files unless it is available in the medical or work history file. We have discussed this with Medical Department personnel, but we are not allowed free access to their medical records. There is also a comment field in the database provided by LANL that indicates an incident occurred. Although the comment field will indicate that an incident occurred, it will not provide details. Incidents listed in the TBD cannot be connected directly to an individual.

Incident reports are available starting in the 1940s. In 1980, Jim Lawrence put together a file of hardcopy Health Physics incidents from various reports and correspondence. Many of the incident reports from 1943–1965 are in the form of memorandum. The collection includes accident and incident reports from facilities site-wide. The TBD authors reviewed the incident files and copies were made of relevant incidents. In addition, the LAHDRA documents were checked for incident reports. Incident reports include an event description, the names of individuals involved, the date and time of the incident, the name of the technician, and whether a follow-up bioassay was collected. These reports do not typically include the results of bioassay, and are useful only for general information and possibly development of highest dose scenarios. Many of the early incident reports were initially classified. There were a lot of incidents that were not reported.

From a dose reconstructor's view, incident reports are not necessary. A constant chronic intake from the start date of employment is often assumed, used in many cases, and exceeds the dose that would be calculated as a result of an incident. If an incident report is provided, that this will allow the dose reconstructor to fix the date of intake and determine the nature of the exposure when the probability of causation (POCs) near 50%.

Data Purging

The allegations of data purging do not affect the dose reconstruction process. A chronic intake from the start date of employment is often assumed. The dose reconstructor uses positive bioassay results to assess the dose and MDA results to assess missed dose. The doses are compared and the most claimant-favorable annual doses are assigned. Results are consistently found in Zia worker files. There is no indication of missing data.

Unmonitored Military Personnel

Dose for military personnel is not covered under this program. There is a separate program for these individuals.

SC&A Conference Call Comments

- SC&A will review the complex wide methodology developed to address high-fired plutonium oxide as it relates to the LANL TBD.

- NIOSH/ORAU indicated that in the case of Type S or Type M material, americium and plutonium are chemically bound, and will leave the body together. The internal TBD (Argall 2004, pp. 20–21) contradicts this statement by indicating the plutonium-to-americium ratio in urine will differ from that of the material inhaled. Consideration should be given to the preferential excretion of americium not only in high-fired oxides, but also in more soluble forms of americium.

- The Am-241 activity values in plutonium are provided in Tables 5-3, 5-4 and 5-7. The percentage of Pu-241 in Table 5-6 is the same as Rocky Flats for weapons grade Pu, which grows in Am-241 at a rate of ~20 ppm per month. At one year the Am-241 will be around 300 ppm and over 500 ppm at 2 years. For individuals working with higher Pu-240 mixtures, the default values may underestimate the dose.

There were no further discussions related to Questions #2, #16, #19, and #21 listed in Attachment 3, *Responses to SC&A Questions for the LANL Site Profile Document – Occupational Internal Dose, ORAUT-TKBS-0010-5*. The written answer provided was adequate to answer the question.

Action Items for NIOSH/ORAU

(1) Provide a list of planned changes to the Occupational Internal Dose TBD
(2) Provide a list of documents recently received from LANL
(3) Explanation of when the dose reconstructor uses OTIB-0018 verses OTIB-0002
(4) The location of the LANL Database containing bioassay for the LANL population.

Action Items for SC&A

(1) Provide NIOSH with a list of Action Items from the conference call.
(2) Provide a summary of the conference call discussion.

LANL Occupational External Dose TBD Conference Call Summary

Date: March 21, 2006
Subject: Los Alamos National Laboratory-Occupational External Dose, ORAUT-TKBS-0010-6
Time: 12:00 pm – 2:00 pm EST

Individuals who participated included:

ORAU: Jack Buddenbaum, Tom Widner (TBD Author), Don Stewart
NIOSH: Sam Glover,
SC&A: Ron Buchanan, Kathryn Robertson-DeMers, Tom Bell, Joe Fitzgerald
LANL: Jim Lawrence

General Comments

Since January 2005, approximately 900 new documents have been screened and provided to the LAHDRA project. The LANL TBD team has access to these documents. Nine additional boxes of LAHDRA documents are currently being processed. These documents may or may not be relevant to external dose reconstruction, and are currently being reviewed for their relevance to the NIOSH dose reconstruction process. The LANL external dosimetry technical basis document will undergo revision following receipt of comments from S. Cohen and Associates (SC&A, Inc.) and review of applicable records identified in the LAHDRA documents recently received from LANL. The revision will incorporate recommendations from Ken Silver and SC&A. NIOSH/ORAU does not plan on sending specific responses to recommendations provided by Ken Silver. Although the Occupational External Dose TBD (Widner 2004) has not formally undergone revision, some of the methodologies to be implemented in the revision have been passed onto the dose reconstructors.

A large number of skin cancers are compensable. There are few situations were extremity dose reconstructions are necessary.

The revision of TBDs from other sites may affect the revisions made to the LANL TBDs. For example, changes in the SRS TBD (Scalsky 2005), will impact those in the LANL TBD.

External Monitoring

In the 1940s and 1950s, if individuals were working directly with radioactive material, a film badge was issued. The external monitoring program covered the individuals who received the dose. The LANL badging criteria was comprehensive enough to cover those exposed, as well as those who were not exposed. Support workers would have been included in the badged population. NIOSH/ORAU uses the recorded dose in dose reconstructions including cases where ionization chambers were used as dosimeters.

In the 1940s, film was not well known for its effectiveness in monitoring radiation exposure. The reactors at LANL were used for critical mass determinations and neutron sources, and later testing of various reactor designs. The first film badges at LANL were used in the reactors. Monitoring was added for those individuals involved in refining and concentrating product. The detection limit of 10 mrem was not conceivable until around 1953. Prior to this time, radiation safety personnel were looking for beta burn type affects to determine high exposures. LANL was not able to measure extremity dose prior to 1952.

Nuclear Track Plates were used at LANL starting in about 1948. The function of these plates was to make physics measurements. In about 1949, the Nuclear Track Plates were attached to the badge. This system provided a crude process by which to measure exposure. Doses assigned from this monitoring system were recorded in the dose of record regardless of the quality of the measurement.

Individuals working with neutron sources (PuBe, PoBe, etc.) and accelerator operations personnel were the first set of individuals monitored. Initially, reactor workers were not monitored for neutron exposure.

Finger print changes were used to monitor large beta exposures prior to 1951. In 1951, the use of finger ridge impressions was discontinued because it was determined that they were not a good indicator of radiation exposure. Skin dose is assigned by the methodology outlined in OTIB-0017 (Merwin 2005).

Neutron Dose

The revisions to the TBD use neutron-to-photon ratios rather than NTP and NTA results to determine neutron dose. This methodology is currently built into the dose reconstruction process. Both a median and a 95% value are available for application by the dose reconstructor. The neutron-to-photon ratios determined from 1979–2000 will be used to reconstruct neutron dose back to 1942. NIOSH/ORAU feel the neutron-to-photon ratios provide the best data available. At the moment, there is some uncertainty in how to verify that the 1979–2000 data is representative of the early years. The photon measurements also represent the best available technology at the time. There were a lot of studies conducted on these badges, and the lab had a good idea of how these badges responded.

For the LANSCE facility, a combination of data from TLDs and NTA film data is available. The dose reconstructor would combine the results from both dosimeters to obtain the dose. After 1979, this would be used in lieu of the neutron-to-photon ratios.

Neutron correction factors were applied by LANL at the time of badge processing, and are reflected in the dosimetry records.

Uncertainty Factor

The ±8% uncertainty factor for the Model 7776 and 8823 dosimeters comes from DOELAP studies of the badge systems. Additional uncertainty is built into the dose reconstruction beyond the ±8% uncertainty factor.

Tritium Dose

The tritium dose was determined from bioassay data, but is included with external dosimetry. Individual dose components (e.g., tritium, neutron, photon) are available in the dosimetry records.

Co-worker Dose

Specific co-worker dose procedures for dose reconstruction are determined by Task 5. Co-worker doses are under evaluation and will be ready by about May 2006 for LANL. There are generic methods covered OTIB-0020 (Merwin 2004 - external) and OTIB-0019 (Brackett 2004 - bioassay).

Records

Senator Udall's office is currently involved in an investigation of the accuracy of medical records. His office has contacted NIOSH about the medical records stored at the Los Alamos hospital. NIOSH is currently trying to determine how the absence of these records will affect dose reconstruction.

It appears that pocket ionization chamber (PIC) data was not extracted from medical records to dosimetry notebooks, files, or databases, but further confirmation of this should be obtained from LANL. If the PIC data were available, it is noted that these dosimeters were fragile and prone to discharge upon impact and represent unreliable data for dose reconstruction.

Incidents

The dose record provided by Los Alamos includes documentation on doses received from criticality accidents, as well as other incidents. In the case of a criticality accident, the site would have performed a special analysis that would be considered in the dose reconstruction. There is no specific methodology developed for handling the criticality accidents, as there was with the Y-12 TBD (Ijaz and Adler 2004). Dose reconstructors have not seen cases involving major incidents like this to date.

The five volumes of information on the dosimetry program (the Bible) talk about external dosimetry limits, but do not necessarily discuss criticality specifications. The Criticality Safety group was a part of the Criticality Experiment group. Although they worked collaboratively, the Criticality Safety requirements were generated by Criticality Safety and not Radiological Control.

In-Vivo Detection of Na-24

The initial in-vivo counter (Humco) was not able to distinguish between radionuclides. When the NaI detectors were put into service, they would have been able to detect Na-24 if it were present. There were no significant measurements associated with Na-24 activation.

Shortly after the SL-1 Accident in Idaho, LANL developed a Personal Neutron Activation Dosimeter (PNAD) with various foils. This was for the purposes of measuring exposure in an accident situation. There were no accidents following their implementation that required these dosimeters to be read.

Offsite Exposure

Individuals involved in radiological activities at other sites (e.g., NTS) were assigned a badge at that site. The results were returned to the site. The record bears out this statement. NIOSH/ORAU is also making records requests for LANL employees from Nevada. The inclusion of the dose in LANL records, and the separate consideration of dose records from Nevada in the dose reconstruction process may result in a double assignment of dose.

SEC Petition

There was an SEC petition submitted for LANL; however it did not qualify.

There were no further discussions related to Questions #4, #6–#13, #15–#21, and #23–#27 listed in Attachment 3, *Responses to SC&A Questions for LANL Site Profile Document – Occupational External Dose*, ORAUT-TKBS-0010-4. The written responses and discussions covered under other questions were adequate to answer these questions.

SC&A Comments

Page 67 of TBD-6 (Widner 2005) lists the uncertainty factors as 8% for the Model 7776 and 8823 Dosimeters. This is for a very specific DOELAP neutron energy exposure, and not an indication of the dosimeter's ability to measure neutron doses to within 8% in the overall working environment at LANL. Limitation of these dosimeters to different neutron energy spectra is discussed in TBD-6, and is one of the reasons for changing from the Model 7776 to the 8823. To provide a clearer concept of what these dosimeters were capable of, TBD-6 needs to indicate the narrow energy range that the 8% uncertain covers, or better yet, list a more realistic, wider energy range with a corresponding larger percentage of uncertain (i.e., 20% for 10 keV to 14 MeV, or what ever is appropriate for these dosimeters).

Action Items for NIOSH/ORAU

(1) Provide a list of planned changes to the Occupational External Dose TBD

(2) Provide a list of documents recently received from LANL

(3) Provide further substantiation for the switch from neutron dosimeters to neutron-to-photon ratios

(4) Provide access to the following document along, with addition documentation collected to date about critical mass studies and measurements involving the first attempts to temporarily create a critical mass of fissile material.

Hacker, B. *The Dragon's Tail: Radiation Safety in the Manhattan Project, 1942–1946*, University of California Press (1987), p. 69.

Action Items for SC&A

(1) Provide NIOSH with a list of Action Items from the conference call.

(2) Provide a summary of the conference call discussion.

(3) Clarify the question on sub-criticality experiments and indicate how this might affect the dose reconstruction process

(4) Provide questions regarding the use of neutron-to-photon ratios and the data supporting this approach

(5) Review OTIB-0017 (Merwin 2005) as a procedure for assigning skin dose at LANL

ATTACHMENT 5: SUPPLEMENTAL RESPONSES TO ACTION ITEMS FROM CONFERENCE CALLS

During the conference call several action items were assigned to both SC&A and the NIOSH/ORAU team. The response to these action items has been compiled below.

Action Items Response for NIOSH/ORAU

During the course of the conference call, it became apparent that significant changes were under consideration for the LANL site profile, and that the revision to the site profile was pending the release of the SC&A site profile review. The NIOSH/ORAU team has provided a list of the proposed planned changes to the site profile to inform both SC&A and the Advisory Board of their plans.

Site description summary

(1) Provide an updated response to General Question #3 regarding dose received at test sites – (Refer to the attached file Attachment "Proposed Changes-LANL-TBD2006").

(2) Elaborate on the use of TIBs in dose reconstructions for LANL claims – (Refer to the attached file Attachment C "Input from Task 5 for LANL")

(3) Make the following reference cited in the TBD responses available to SC&A: U.S. Department of Energy, 1991, *Tiger Team Assessment of the Los Alamos National Laboratory, September 23–November, 8, 1991*, Office of Environment, Safety and Health. This report is available on the ORAUCOC terminal server/SRDB.

Occupational Medical Dose TBD Conference Call Summary

(1) Provide access to the records referenced in the responses to the Medical TBD questions – (Refer to the attached file Attachment C "Input from Task 5 for LANL")

(2) NIOSH/ORAU will provide clarification on when PFG dose is applied by dose reconstructors – (Refer to the attached file Attachment C "Input from Task 5 for LANL")

Occupational Internal Dose

(1) Explanation of when the dose reconstructor uses OTIB-0018 versus OTIB-0002 – (Refer to the attached file Attachment C "Input from Task 5 for LANL")

(2) The location of the LANL Database containing bioassay for the LANL population – (Refer to the attached file Attachment C "Input from Task 5 for LANL")

Occupational External Dose

(1) Provide input from Jack Fix on the effectiveness of the early photon badges at LANL – awaiting reply from Jack Fix

(2) Provide further substantiation for the switch from neutron dosimeters to neutron-to-photon ratios – (Refer to the attached file Attachment A "Proposed Changes-LANL-TBD2006").

(3) Provide pertinent sections of the following document along with additional documentation collected to date regarding subcriticality experiments.

Hacker, B. 1987. *The Dragon's Tail: Radiation Safety in the Manhattan Project, 1942–1946*, University of California Press, pg. 69.

This book provides an overview of early radiation safety issues encountered at LANL and at other MED sites, but does not offer new details that could be used for a site profile document, specifically the LANL site profile. No further response is planned regarding this book.

The NIOSH/ORAU team indicated during the conference call that 9 nine additional boxes of LANL documents were received from LANL by the LAHDRA project. These documents may or may not be applicable to or useful for the site profile revision. The NIOSH/ORAU team has provided a complete list of documents (NIOSH Attachment B) found in these boxes.

The complete list has not been provided in this review as it contains 5,198 entries. The documents contained in these boxes are currently under review by NIOSH/ORAU but have not been uploaded to the Site Research Database to date. Some of these documents include additional H-Division reports, process descriptions, operations logbooks, material balance sheets, environmental monitoring information, Health Physics monitoring data, health hazard summaries, and correspondence and technical reports from the H-Division.

NIOSH Attachment A
Proposed Changes to be Made to Los Alamos TBDs Intro and Section 2, Site Description

(1) Changes will be made to the Introduction section of the site profile document as necessary to reflect changes in other site profile sections.

(2) Addendum to the ORAU/NIOSH Response to SC&A General Question 3: The following statement is an addendum to the ORAU/NIOSH initial response and supersedes the prior response: All dosimetry results for LANL workers visiting other sites where dosimetry was provided by the host sites were sent to LANL and became part of a worker's exposure history file. This practice was confirmed by Dr. James N.P. Lawrence and John Voltin during the March 2006 conference calls with ORAU/NIOSH project members and SC&A reviewers. Dr. Lawrence was a LANL health physicist who started his employment there in 1951 and retired in the early 1990s. John Voltin is a health physicist currently employed at LANL.

(3) The error on page 29 of Section 2 will be corrected and the value will be changed to 0.04 R/day.

(4) Will update Reference section to include a list of available LANL H-Division reports.

Proposed Changes to be Made to Los Alamos TBD Section 3, Occupational Medical Dose

No revisions to Section 3 are currently planned due to a lack of new reference material. NIOSH is currently reviewing other medical records located at the Los Alamos Hospital that may contain relevant information for this section. If these efforts lead to the discovery of useful information, then ORAU/NIOSH will notify SC&A of any planned revisions to this TBD.

Proposed Changes to be Made to Los Alamos TBD Section 4, Occupational Environmental Dose

Errors were identified through Verification and Validation efforts in three tables of the TBD. These errors are attributed to data transcription issues. The necessary corrections have been made to Tables 4-2, 4-10, and 4-15 (Refer to revised tables below). The corrected information is highlighted in red.

The impact of the changes led to a lowering of estimated intakes, particularly for H-3 at TA-3. In no case is there a significant increase in intake.

Table 4-2. Estimated annual average intakes of Am-241, H-3, I-131, Pu-239, Th-232, U-234, MFP, and P/VAP for TA-3 (Bq/yr)[a]

Year	^{241}Am	^{3}H[b]	^{131}I	^{239}Pu	^{232}Th	^{234}U	MFP[c]	P/VAP[d]
1971		2.7E+04	1.3E+02	2.5E-02		2.3E-02		
1972	2.8E-03	4.4E+03	5.8E+01	1.2E-02		6.9E-03		
1973	6.2E-04	4.7E+03	7.4E+01	1.2E-02	3.0E-03	1.4E-02	2.5E+00	
1974				2.9E-01		3.9E-02	6.7E-02	
1975		6.4E+03		8.2E-02		3.8E-02	3.6E-02	
1976				7.7E-03		7.1E-02	8.1E-02	
1977		1.2E+05		6.5E-03		6.6E-02	9.4E-02	
1978		2.9E+04		1.1E-02		3.6E-02	7.9E-02	
1979		8.8E+05	8.9E-01	2.1E-01		5.1E-02	9.2E-02	
1980		1.3E+03	1.4E+00	1.4E-01		3.0E-02	8.3E-02	
1981		2.6E+05	8.3E-01	7.7E-03		4.6E-02	3.4E-02	
1982		5.7E+05	9.2E-01	1.5E-02		6.3E-02	1.5E-02	
1983		6.7E+05	2.7E-01	1.7E-02		3.5E-02	3.3E-03	
1984		5.2E+05	5.9E-02	2.2E-02		4.2E-02	8.1E-03	
1985		6.2E+05	1.7E-02	3.8E-02		6.7E-02	6.8E-03	
1986		3.6E+05	1.6E-02	3.8E-02		1.2E-01	9.4E-03	
1987		2.5E+05		1.3E-02		1.7E-01	4.2E-03	
1988		2.4E+06		1.0E-02		9.8E-02	5.8E-03	
1989		8.5E+04		7.6E-03		7.1E-02	7.5E-03	
1990		1.5E+05		4.2E-03		3.8E-02	7.6E-03	

Table 4-2. Estimated annual average intakes of Am-241, H-3, I-131, Pu-239, Th-232, U-234, MFP, and P/VAP for TA-3 (Bq/yr)[a]

Year	^{241}Am	^{3}H[b]	^{131}I	^{239}Pu	^{232}Th	^{234}U	MFP[c]	P/VAP[d]
1991	1.3E-04	2.0E+03		1.1E-04		8.2E-03	2.8E-03	
1992	2.8E-04	3.6E+03		2.2E-04		3.2E-03	1.6E-03	
1993	1.7E-03	7.1E+02		4.9E-03		1.3E-03	1.2E-03	
1994	5.2E-04	2.7E+02		2.8E-04		3.3E-03	7.5E-03	
1995	1.3E-03	8.0E+02		2.6E-04		1.8E-03	1.8E-01	4.4E+02
1996	1.3E-04	1.7E+02		2.4E-04	3.2E-05	2.1E-03		
1997	2.2E-04	4.8E+02		2.4E-04	7.4E-05	1.5E-03		
1998	3.1E-04	3.6E+02		3.6E-05	8.2E-05	1.3E-03		3.1E+00
1999	2.0E-04	3.6E+02		2.4E-04	4.3E-05	1.7E-03		
2000	0.0E+00	3.2E+02		2.3E-04	2.5E-05	2.7E-03		
2001	0.0E+00	4.1E+02		5.3E-05	2.7E-05	2.4E-03		
2002	1.5E-04[e]	3.4E+02		1.6E-04	5.0E-05	1.9E-03		
2003	1.5E-04[e]	3.9E+02		1.6E-04	5.0E-05	1.9E-03		

a. Calculated from estimated air concentrations in Table 4C-3, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.
c. MFP = mixed fission products; claimant favorable to assume all is ^{90}Sr.
d. P/VAP = Particulate/vapor activation products; claimant favorable to assume all is ^{68}Ge, Class W.
e. Estimated from average of corresponding values for 1997–2001.

Table 4-10. Estimated annual average intakes of Am-241, H-3, I-131, Pu-239, U-234, and MFP for TA-21 (Bq/yr)[a]

Year	^{241}Am	^{3}H[b]	^{131}I	^{239}Pu	^{234}U	MFP[c]
1971	5.7E-04[d]	1.1E+04		2.6E-03	1.1E-02	
1972	5.7E-04[d]	2.0E+04[e]		7.5E-03	9.6E-03	
1973	5.7E-04[d]	2.0E+04		2.0E-03	1.4E-02	2.0E-04
1974	5.7E-04[d]	2.0E+04[e]		2.1E-03	6.9E-03	5.7E-04
1975	5.7E-04[d]	8.5E+03		1.6E-03	4.3E-03	2.8E-04
1976	5.7E-04[d]	5.3E+03		6.7E-04	5.8E-03	1.1E-04
1977	5.7E-04[d]	6.9E+03		1.9E-03	1.3E-02	6.4E-04
1978	6.6E-06	6.9E+03[e]		2.0E-03	1.3E-02	2.0E-04
1979	3.7E-06	5.1E+02		5.4E-04	1.1E-02	9.1E-05
1980	1.2E-05	1.5E+03		2.8E-03	9.9E-03	8.2E-04
1981	5.7E-06	7.5E+02		4.1E-04	5.0E-03	5.5E-04
1982	6.8E-06	2.1E+03		5.3E-04	1.3E-02	8.5E-05
1983	1.9E-05	2.7E+03		8.0E-05	4.3E-03	1.6E-04
1984	5.7E-04[d]	1.2E+03		1.3E-04	8.9E-03	6.1E-05
1985	5.7E-04[d]	2.1E+03		3.6E-05	5.8E-03	7.1E-05
1986	5.7E-04[d]	2.2E+03		1.2E-04	4.8E-03	6.3E-05
1987	5.7E-04[d]	6.9E+03		9.8E-05	4.8E-03	3.7E-05
1988	5.7E-04[d]	5.3E+03		7.1E-05	7.2E-03	3.0E-05
1989	5.7E-04[d]	2.2E+03		1.2E-04	1.1E-02	6.1E-06
1990	5.7E-04[d]	1.7E+03		2.0E-04	6.7E-03	2.5E-06
1991	0.0E+00	1.1E+03		1.7E-04	7.5E-03	5.9E-06
1992	2.4E-04	1.2E+03	8.9E+01	2.2E-04	3.3E-03	4.7E-06
1993	3.2E-04	5.6E+02		4.4E-04	2.4E-03	2.0E-06
1994	5.7E-04	4.5E+02		5.9E-04	2.5E-03	9.8E-06
1995	5.5E-04	1.1E+03		1.1E-03	2.8E-03	

Table 4-10. Estimated annual average intakes of Am-241, H-3, I-131, Pu-239, U-234, and MFP for TA-21 (Bq/yr)[a]

Year	^{241}Am	^{3}H[b]	^{131}I	^{239}Pu	^{234}U	MFP[c]
1996	3.7E-04	4.1E+02		1.5E-03	2.2E-02	
1997	3.8E-04	6.3E+02		1.5E-03	1.9E-03	
1998	5.0E-04	1.5E+03		2.3E-03	1.4E-03	
1999	2.6E-04	8.2E+02		3.1E-04	1.9E-03	
2000	8.3E-05	9.7E+02		3.3E-04	1.8E-03	
2001	0.0E+00	9.6E+02		3.3E-04	2.3E-03	
2002	2.4E-04[f]	9.8E+02[f]		9.5E-04[f]	1.9E-03[f]	
2003	2.4E-04[f]	9.8E+02[f]		9.5E-04[f]	1.9E-03[f]	

a. Calculated from estimated air concentrations in Table 4C-12, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. ^{3}H intake multiplied by 1.5 to account for submersion dose.
c. MFP = mixed fission products; claimant favorable to assume all is ^{90}Sr.
d. Assumed to be the highest value of all years for which data are available.
e. Assumed to be the highest value of the two adjacent years.
f. Estimated from average of corresponding values for 1997–2001.

Table 4-15. Estimated annual average intakes of H-3, Pu-239, and U-234 for TA-41 (Bq/yr)[a]

Year	^{3}H[b]	^{239}Pu	^{234}U
1971	9.4E+04	3.7E-03	
1972	3.2E+04	2.1E-03	
1973	1.7E+04	3.0E-04	
1974-1978			
1979	4.2E+04		
1980	1.2E+05		
1981	3.7E+04		
1982	3.8E+04		
1983	2.9E+05		
1984	1.4E+06		
1985	3.7E+05		
1986	3.9E+05		
1987	1.4E+05		
1988	5.1E+05		
1989	3.4E+06		
1990	1.3E+06		
1991	1.1E+06		
1992	8.6E+04		
1993	1.4E+05	2.0E-06	
1994	5.0E+04	3.9E-06	
1995	2.3E+04	3.0E-06	1.8E-06
1996	3.2E+04		
1997	1.2E+04		
1998	1.1E+04		
1999	3.8E+03		
2000	1.8E+03		
2001	1.6E+05		
2002	3.7E+04[c]		
2003	3.7E+04[c]		

a. Calculated from estimated air concentrations in Table 4C-17, assuming an inhalation rate of 2,400 m^3/yr (and multiplying by 3.7×10^{-2} Bq/pCi); blanks indicate no data are available for those years.
b. Estimated from average of corresponding values for 1997–2001.
c. ^{3}H intake multiplied by 1.5 to account for submersion dose.

No other revisions to Section 4 are currently planned due to a lack of qualified data before 1971. Revisions to this TBD are possible in the future as release estimates for pre-1971 are refined under the LAHDRA project efforts.

Proposed Changes to be Made to Los Alamos TBD Section 5, Occupational Internal Dose

(1) Will add discussion on the format and content of the new LANL Bioassay Data base which was finalized in November 2005 and includes units, MDA values, and supporting information (e.g., sampling date, volume, and interpretation of results).

(2) Will add descriptions of Delayed Neutron Activation Analysis (DNAA) and associated practices used by LANL for estimating uranium in bioassay samples and interpretation of data presented in the new LANL Bioassay Database for U-238 and U-235 when both

results are listed for a sample. Uranium results had not been supplied to NIOSH before the TBD was published and therefore descriptions of uranium analysis were not included in the document. The issues have been researched and the information communicated to the dose reconstructors. How to use results for uranium DNAA (presently referred to as UNAA at LANL) will be incorporated into the TBD document.

(3) Will add clarification on MDA values used for the early years based on information provided by Margo Clark's paper in 2005 on the history of the Bioassay program.

(4) Will add inventory values for Barium-140/Lanthanum-140 and strontium-90 in the RaLa shots; hypothetical overestimates of missed intakes will be derived for workers with presumptive cancers potentially exposed during the RaLa project years.

(5) Will add clarification of bioassay protocol for Zia workers based on discussions with Jim Lawrence, who directed the bioassay program from 1951 through 1992. Clarification will include discussions of the bioassay protocol and protocols used for restricting Zia workers' access to material handling areas.

(6) Will add clarification on the availability of 'special nuclide' bioassay information. No bioassay results for special nuclides will be available in the new database. Information on nuclides other than plutonium, americium, tritium, uranium, and polonium in-vitro bioassay and fission/activation product whole-body counts and uranium, americium, and plutonium lung counts will be the only data generally provided for a claimant. The results of any other bioassay that may have been performed for other nuclides will only be available upon request.

(7) Will remove statements regarding missing 1951 uranium bioassay data. Originally documents from the 1990s indicated that the notebook was missing. However, review of the new database indicates that bioassay results are present for 1951.

(8) Will develop a list of organs and the fission products that produce the highest potential dose to those organs. This is useful in assigning potential missed dose when whole-body count results are below MDA levels. This can be done on an individual basis, but this type of list will assist the dose reconstructor to determine the most claimant-favorable assignment more quickly. Estimates of missed intakes may be provided based on air sample results if additional results are available, and if necessary. The calculated co-worker internal dose may be determined to be adequate for mixed fission products.

(9) Documented intake incidences that have been identified since the TBD was released will be added.

(10) Revised TBD will include general editing for enhancement and readability of the document.

(11) Will remove the word "not" on page 30 concerning iodine at OWR.

(12) The internal co-worker doses are expected to be published soon. These doses will be reviewed. Following the review, the extent to which the TBD will need to be modified to fill in any gaps will be determined at that time.

Proposed Changes to be Made to Los Alamos TBD Section 6, Occupational External Dose

(1) Will add text regarding the definition of "facility" to the Section 6.1 Introduction.

(2) Will change the photon energy group percentages for Accelerator Operations in Table 6-14 and Table 6E-7 based on comments from Task 5 and OCAS personnel. Will eliminate discrepancy between Tables 6-14 and 6E-7 and add guidance concerning attribution of "shallow" dose to <30 keV photons and >15 keV electrons.

(3) Will clarify the adjustment factors to be applied to reported photon doses (Table 6E-3) and the time periods and conditions under which they should be applied.

(4) Will change the recommended distributions for neutron-to-photon ratio from uniform distributions to distributions characterized by medians and 95^{th} percentile values, and add a distribution for plutonium facilities that handled Pu-238.

(5) Will correct the definition of RBE, which currently yields 1/RBE.

(6) Will, if so directed by ORAU Task 5/NIOSH, add a discussion concerning the representativeness of neutron-to-photon ratio distributions derived from 1979–2000 data to operations in years before 1979, and/or provide justification for use of those distributions to estimate neutron exposures when neutron monitoring was not performed, unreliable, or highly uncertain.

(7) If so directed by ORAU Task 5/NIOSH, will remove the $\pm$8% uncertainty factors for the 7776 and 8823 TLDs, or add an indication that the uncertainty factors provided in Table 6E-4 are not the factors ultimately used in dose reconstruction.

(8) If clarification is provided concerning what information is desired, will add a discussion of external dose monitoring practices applied to workers involved in critical assembly experimentation and/or criticality incidents, and/or information regarding radiation fields that would have been expected from those activities.

(9) Will review referenced recent revisions to the SRS TBD and, if applicable, propose revisions to the LANL TBD that are warranted.

NIOSH Attachment C
Additional Detail from Task 5 on Los Alamos National Laboratory
SC&A Questions
(Don Stewart)

Site Description Summary, Item 4.

As SC&A points out, the use of technical information bulletins in LANL dose reconstructions is case-specific, and they are applied for a variety of reasons. The best resource for a given claim is of course the dose reconstruction report, which will cite each technical information bulletin used; however, for the sake of assisting resolution of the question, the following highlights are provided.

- Some technical information bulletins apply guidance to all dose reconstructions equally, such as ORAUT-OTIB-0005, 'Internal Dosimetry Organ, External Dosimetry Organ, and IREP Model Selection by ICD-9 Code,' which lists current guidance over which cancer model, assumed internal organ for dose reconstruction, and assumed organ for external dose reconstruction are to be applied to any given ICD-9 code;
- Some technical information bulletins apply to all cancers in a certain class, the most-used example being ORAUT-OTIB-0017, 'Interpretation of Dosimetry Data for Assignment of Shallow Dose,' which is used to apply the current best assumptions for estimating skin dose from dosimeter records;
- Some technical information bulletins were created especially to address gaps or updates to information in site technical basis documents (e.g. technical information bulletin ORAUT-OTIB-0027, 'Supplementary External Dose Information for Rocky Flats Plant'), or incorporation of additional information published elsewhere (e.g., ORAUT-OTIB-0050, 'Use of Rocky Flats Neutron Dose Reconstruction Project Data in Dose Reconstructions'). Currently, there are no technical information bulletins in these categories for Los Alamos National Laboratory.
- Co-worker doses, when available, are applied in accordance with guiding technical information bulletins ORAUT-OTIB-0020 'Use of Co-Worker Dosimetry Data for External Dose Assignment,' and specific doses are provided in specific technical information bulletins for each site. No co-worker doses are currently published in technical information bulletins for Los Alamos National Laboratory.
- Other TIBs guide dose reconstructors to perform specific tasks, such as wound modeling, calculating tritium doses from tritium bioassay results, etc. Many of these would be applicable to LANL in specific cases, as indicated in individual dose reconstruction reports.
- Internal dose overestimates are available in ORAUT-OTIB-0014, 'Assignment of Environmental Doses for Employees Not Exposed to Airborne Radionuclides in the Workplace,' ORAUT-OTIB-0018, 'Internal Dose Overestimate for Facilities with Air Sampling Programs,' and ORAUT-OTIB-0002, 'Maximum Internal Dose Estimates for Certain DOE Complex Claims.'

Occupational Medical Dose, Item 3.

Records referenced in the responses referenced in the responses to the Medical TBD questions include the technical basis document itself, other cited references, and the reproduction of a table discussing application of occupational medical x-ray doses in a dose reconstruction guideline for the LANL site. Since this is a convenience document that summarizes the technical basis document, the technical basis document itself remains the best record in this case.

Occupational Medical Dose, Item 4.

Dose reconstructors assume all routine annual occupational medical x-rays through the year 1956 are photofluorographic exams. In light of this standard overestimating assumption, no decision is called for in this case by the dose reconstructor as to whether a given exam was photofluorographic or not, prior to 1957.

Occupational Internal Dose, Item 3.

- ORAUT-OTIB-0018, 'Internal Dose Overestimate for Facilities with Air Sampling Programs,' and ORAUT-OTIB-0002, 'Maximum Internal Dose Estimates for Certain DOE Complex Claims,' both provide overestimated internal dose estimates as delimited by the use limitations in each document. Dose reconstructors have the option to use them when applicable, and may even apply them in cases where they are not strictly applicable according to the use limitations, if this application is sufficiently justified based on case data and the justification for the application is documented in the dose reconstruction report (this is rare);
- Typically, OTIB-0002 is applied for individuals with no internal dose monitoring or dose monitoring with zero or negligible results; OTIB-0002 is also limited to non-systemic organs per its list of applicable organs. Systemic organs are included in the applicability of OTIB-0018.
- The selection of TIB-0018 is typically reserved for claims where individuals are more likely to have been exposed to airborne radioactivity on a routine basis. It presupposes a continuous exposure (over an occupational year) to airborne radioactivity at the control criterion, which is, as most operational health physicists will agree, an overestimating assumption due to the fact that typical exposures at or above the control criterion are short with respect to an occupational year.
- Due to its higher internal doses, OTIB-0018 is typically used when an individual is suspected to have been exposed to unmonitored intakes based on work category, information in the interview record, or other case-specific data.
- It should be noted that the utility of the internal dose overestimate from this OTIB-0018 is limited for systemic organs, as the allowable air concentrations and the resultant doses to systemic organs are often large, precluding their use for completing a non-compensable claim.

- Both OTIB-0002 and OTIB-0018 may be used only for non-compensable cases at the Los Alamos National Laboratory.

Action Items Response Summary for SC&A

SC&A's summary of the conference call is documented in Attachment 4. Included in this summary are the action items from each of the conference calls held. This summary was shared with the NIOSH/ORAU Team on May 7, 2006, to obtain their feedback on the factual accuracy. Comments received have been integrated.

SC&A provided questions related to the use of neutron-to-photon ratios and the data used to support this approach. The original TBD makes use of the neutron dosimetry results, whereas the planned revision will apply neutron-to-photon ratios. This marks a significant changed in approach that is not reflected in ORAUT-TKBS-0010-6, Rev. 0. The NIOSH/ORAU Team referred SC&A to ORAUT-OTIB-0017 as the approach to be used for assigning skin dose. If assigned by the Advisory Board, SC&A will conduct a formal review of the OTIB.

ATTACHMENT 6: LANL-SPONSORED ATMOSPHERIC AND UNDERWATER TESTING

Table A6-1: Los Alamos National Laboratory Sponsored Atmospheric Weapons Tests, Underwater Weapons Tests, and Special Projects

Test	Operation	Date	Location	Type	Purpose
Trinity		7/16/1945	Alamagordo, New Mexico	Atmospheric	Weapons Related
Able	Crossroads	6/30/1946	Bikini Island	Airdrop	Weapons Effects
Baker	Crossroads	7/24/1946	Bikini Island	Underwater	Weapons Effects
X-ray	Sandstone	4/14/1948	Enewetak	Tower	Weapons Related
Yoke	Sandstone	4/30/1948	Enewetak	Tower	Weapons Related
Zebra	Sandstone	5/14/1948	Enewetak	Tower	Weapons Related
Able	Ranger	1/27/1951	Nevada Test Site	Airdrop	Weapons Related
Baker	Ranger	1/28/1951	Nevada Test Site	Airdrop	Weapons Related
Easy	Ranger	2/1/1951	Nevada Test Site	Airdrop	Weapons Related
Baker-2	Ranger	2/2/1951	Nevada Test Site	Airdrop	Weapons Related
Fox	Ranger	2/6/1951	Nevada Test Site	Airdrop	Weapons Related
Dog	Greenhouse	4/7/1951	Enewetak	Tower	Weapons Related
Easy	Greenhouse	4/20/1951	Enewetak	Tower	Weapons Related
George	Greenhouse	5/8/1951	Enewetak	Tower	Weapons Related
Item	Greenhouse	5/24/1951	Enewetak	Tower	Weapons Related
Able	Buster	10/22/1951	Nevada Test Site	Tower	Weapons Related
Baker	Buster	10/28/1951	Nevada Test Site	Airdrop	Weapons Related
Charlie	Buster	10/30/1951	Nevada Test Site	Airdrop	Weapons Related
Dog	Buster	11/1/1951	Nevada Test Site	Airdrop	Weapons Related
Easy	Buster	11/5/1951	Nevada Test Site	Airdrop	Weapons Related
Sugar	Jangle	11/19/1951	Nevada Test Site	Surface	Weapons Effects
Uncle	Jangle	11/29/1951	Nevada Test Site	Crater	Weapons Effects
Able	Tumbler-Snapper	4/1/1952	Nevada Test Site	Airdrop	Weapons Effects
Baker	Tumbler-Snapper	4/15/1952	Nevada Test Site	Airdrop	Weapons Effects
Charlie	Tumbler-Snapper	4/22/1952	Nevada Test Site	Airdrop	Weapons Related
Dog	Tumbler-Snapper	5/1/1952	Nevada Test Site	Airdrop	Weapons Related

Table A6-1: Los Alamos National Laboratory Sponsored Atmospheric Weapons Tests, Underwater Weapons Tests, and Special Projects (continued)

Test	Operation	Date	Location	Type	Purpose
Easy	Tumbler-Snapper	5/7/1952	Nevada Test Site	Tower	Weapons Related
Fox	Tumbler-Snapper	5/25/1952	Nevada Test Site	Tower	Weapons Related
George	Tumbler-Snapper	6/1/1952	Nevada Test Site	Tower	Weapons Related
How	Tumbler-Snapper	6/5/1952	Nevada Test Site	Tower	Weapons Related
Mike	Ivy	10/31/1952	Enewetak	Surface	Weapons Related
King	Ivy	11/15/1952	Enewetak	Airdrop	Weapons Related
Annie	Upshot-Knothole	3/17/1953	Nevada Test Site	Tower	Weapons Related
Nancy	Upshot-Knothole	3/24/1953	Nevada Test Site	Tower	Weapons Related
Dixie	Upshot-Knothole	4/6/1953	Nevada Test Site	Airdrop	Weapons Related
Badger	Upshot-Knothole	4/18/1953	Nevada Test Site	Tower	Weapons Related
Encore	Upshot-Knothole	5/8/1953	Nevada Test Site	Airdrop	Weapons Effects
Harry	Upshot-Knothole	5/19/1953	Nevada Test Site	Tower	Weapons Related
Grable	Upshot-Knothole	5/25/1953	Nevada Test Site	Airburst	Weapons Related
Climax	Upshot-Knothole	6/4/1953	Nevada Test Site	Airdrop	Weapons Related
Bravo	Castle	2/28/1954	Nevada Test Site	Surface	Weapons Related
Union	Castle	4/25/1954	Nevada Test Site	Barge	Weapons Related
Yankee	Castle	5/4/1954	Nevada Test Site	Barge	Weapons Related
Nectar	Castle	5/13/1954	Enewetak	Barge	Weapons Related
Wasp	Teapot	2/18/1955	Nevada Test Site	Airdrop	Weapons Effects
Moth	Teapot	2/22/1955	Nevada Test Site	Tower	Weapons Related
Hornet	Teapot	3/12/1955	Nevada Test Site	Tower	Weapons Related
Bee	Teapot	3/22/1955	Nevada Test Site	Tower	Weapons Related
Ess	Teapot	3/23/1955	Nevada Test Site	Crater	Weapons Effects
Apple-1	Teapot	3/29/1955	Nevada Test Site	Tower	Weapons Related
Wasp Prime	Teapot	3/29/1955	Nevada Test Site	Airdrop	Weapons Related
HA	Teapot	4/6/1955	Nevada Test Site	Airdrop	Weapons Effects
MET	Teapot	4/15/1955	Nevada Test Site	Tower	Weapons Effects
Apple-2	Teapot	5/5/1955	Nevada Test Site	Tower	Weapons Related
Wigwam	Wigwam	5/14/1955	Pacific	Underwater	Weapons Effects
Zucchini	Teapot	5/15/1955	Nevada Test Site	Tower	Weapons Related
No.1	Project 56	11/1/1955	Nevada Test Site	Surface	

Table A6-1: Los Alamos National Laboratory Sponsored Atmospheric Weapons Tests, Underwater Weapons Tests, and Special Projects (continued)

Test	Operation	Date	Location	Type	Purpose
No. 2, Plutonium dispersal	Project 56	11/3/1955	Nevada Test Site	Surface	
No. 3, Plutonium dispersal	Project 56	11/5/1955	Nevada Test Site	Surface	
No. 4, Plutonium dispersal	Project 56	1/18/1956	Nevada Test Site	Surface	
Romeo	Castle	3/26/1956	Nevada Test Site	Barge	Weapons Related
Lacrosse	Redwing	5/4/1956	Enewetak	Surface	Weapons Related
Cherokee	Redwing	5/20/1956	Bikini Island	Airdrop	Weapons Related
Erie	Redwing	5/30/1956	Enewetak	Tower	Weapons Related
Franklin	Plumbbob	6/2/1956	Nevada Test Site	Tower	Weapons Related
Seminole	Redwing	6/6/1956	Enewetak	Surface	Weapons Related
Flathead	Redwing	6/11/1956	Bikini Island	Barge	Weapons Related
Blackfoot	Redwing	6/11/1956	Enewetak	Tower	Weapons Related
Osage	Redwing	6/16/1956	Enewetak	Airdrop	Weapons Related
Dakota	Redwing	6/25/1956	Bikini Island	Barge	Weapons Related
Navajo	Redwing	7/10/1956	Bikini Island	Barge	Weapons Related
Huron	Redwing	7/21/1956	Enewetak	Barge	Weapons Related
No.1, Plutonium dispersal	Project 57	4/24/1957	NAFR	Surface	
Boltzmann	Plumbbob	5/28/1957	Nevada Test Site	Tower	Weapons Related
Priscilla	Plumbbob	6/24/1957	Nevada Test Site	Balloon	Weapons Related
Coulomb-A	Plumbbob	7/1/1957	Nevada Test Site	Surface	Safety Experiment
John	Plumbbob	7/19/1957	Nevada Test Site	Rocket	Weapons Effects
Kepler	Plumbbob	7/24/1957	Nevada Test Site	Tower	Weapons Related
Pascal-A	Plumbbob	7/26/1957	Nevada Test Site	Balloon	Safety Experiment
Stokes	Plumbbob	8/7/1957	Nevada Test Site	Shaft	Weapons Related
Doppler	Plumbbob	8/23/1957	Nevada Test Site	Balloon	Weapons Related
Pascal-B	Plumbbob	8/27/1957	Nevada Test Site	Shaft	Weapons Related
Franklin Prime	Plumbbob	8/30/1957	Nevada Test Site	Balloon	Weapons Related
Galileo	Plumbbob	9/2/1957	Nevada Test Site	Tower	Weapons Related
Coulomb-B	Plumbbob	9/6/1957	Nevada Test Site	Surface	Safety Experiment
Laplace	Plumbbob	9/8/1957	Nevada Test Site	Balloon	Weapons Related
Fizeau	Plumbbob	9/14/1957	Nevada Test Site	Tower	Weapons Related
Newton	Plumbbob	9/16/1957	Nevada Test Site	Balloon	Weapons Related

Table A6-1: Los Alamos National Laboratory Sponsored Atmospheric Weapons Tests, Underwater Weapons Tests, and Special Projects (continued)

Test	Operation	Date	Location	Type	Purpose
Pascal-C	Project 58	12/6/1957	Nevada Test Site	Shaft	Safety Experiment
Coulomb-C	Project 58	12/9/1957	Nevada Test Site	Surface	Safety Experiment
Yucca	Hardtack 1	4/28/1958	Pacific	Balloon	Weapons Effect
Cactus	Hardtack 1	5/5/1958	Enewetak	Barge	Weapons Related
Butternut	Hardtack 1	5/11/1958	Enewetak	Barge	Weapons Related
Koa	Hardtack 1	5/12/1958	Enewetak	Surface	Weapons Related
Wahoo	Hardtack 1	5/16/1958	Enewetak	Underwater	Weapons Effect
Holly	Hardtack 1	5/20/1958	Enewetak	Barge	Weapons Related
Yellowwood	Hardtack 1	5/26/1958	Enewetak	Barge	Weapons Related
Magnolia	Hardtack 1	5/26/1958	Enewetak	Barge	Weapons Related
Tobacco	Hardtack 1	5/30/1958	Enewetak	Barge	Weapons Related
Rose	Hardtack 1	6/2/1958	Enewetak	Barge	Weapons Related
Umbrella	Hardtack 1	6/8/1958	Enewetak	Underwater	Weapons Effect
Walnut	Hardtack 1	6/14/1958	Enewetak	Barge	Weapons Related
Linden	Hardtack 1	6/18/1958	Enewetak	Barge	Weapons Related
Elder	Hardtack 1	6/27/1958	Enewetak	Barge	Weapons Related
Sequoia	Hardtack 1	7/1/1958	Enewetak	Barge	Weapons Related
Scaevola	Hardtack 1	7/14/1958	Enewetak	Barge	Safety Experiment
Pisonia	Hardtack 1	7/22/1958	Enewetak	Barge	Weapons Related
Teak	Hardtack 1	8/1/1958	Johnston Island Area	Rocket	Weapons Effect
Orange	Hardtack 1	8/12/1958	Johnston Island Area	Rocket	Weapons Effect
Argus I	Argus	8/27/1958	South Atlantic	Rocket	Weapons Effect
Argus II	Argus	8/30/1958	South Atlantic	Rocket	Weapons Effect
Argus III	Argus	9/6/1958	South Atlantic	Rocket	Weapons Effect
Eddy	Hardtack II	9/19/1958	Nevada Test Site	Balloon	Weapons Related
Mora	Hardtack II	9/29/1958	Nevada Test Site	Balloon	Weapons Related
Quay	Hardtack II	10/10/1958	Nevada Test Site	Tower	Weapons Related
Lea	Hardtack II	10/13/1958	Nevada Test Site	Balloon	Weapons Related
Dona Ana	Hardtack II	10/16/1958	Nevada Test Site	Balloon	Weapons Related
Rio Arriba	Hardtack II	10/18/1958	Nevada Test Site	Tower	Weapons Related
Socorro	Hardtack II	10/22/1958	Nevada Test Site	Ballon	Weapons Related

Table A6-1: Los Alamos National Laboratory Sponsored Atmospheric Weapons Tests, Underwater Weapons Tests, and Special Projects (continued)

Test	Operation	Date	Location	Type	Purpose
Oberon	Hardtack II	10/22/1958	Nevada Test Site	Tower	Safety Experiment
Catron	Hardtack II	10/24/1958	Nevada Test Site	Tower	Safety Experiment
De Baca	Hardtack II	10/26/1958	Nevada Test Site	Balloon	Weapons Related
Santa Fe	Hardtack II	10/30/1958	Nevada Test Site	Balloon	Weapons Related
Adobe	Nougat	4/25/1962	Christmas Island Area	Airdrop	Weapons Related
Aztec	Nougat	4/26/1962	Christmas Island Area	Airdrop	Weapons Related
Questa	Nougat	5/4/1962	Christmas Island Area	Airdrop	Weapons Related
Mesilla	Nougat	5/9/1962	Christmas Island Area	Airdrop	Weapons Related
Swordfish	Nougat	5/11/1962	Pacific	Underwater	Weapons Effects
Encino	Nougat	5/12/1962	Christmas Island Area	Airdrop	Weapons Related
Nambe	Nougat	5/25/1962	Christmas Island Area	Airdrop	Weapons Related
Alma	Nougat	6/8/1962	Christmas Island Area	Airdrop	Weapons Related
Yeso	Nougat	6/10/1962	Christmas Island Area	Airdrop	Weapons Related
Rinconada	Nougat	6/15/1962	Christmas Island Area	Airdrop	Weapons Related
Dulce	Nougat	6/17/1962	Christmas Island Area	Airdrop	Weapons Related
Dulce	Nougat	6/17/1962	Christmas Island Area	Airdrop	Weapons Related
Otowi	Nougat	6/22/1962	Christmas Island Area	Airdrop	Weapons Related
Otowi	Nougat	6/22/1962	Christmas Island Area	Airdrop	Weapons Related
Starfish Prime	Storax	7/9/1962	Johnston Island Area	Rocket	Weapons Effect
Sunset	Storax	7/10/1962	Christmas Island Area	Airdrop	Weapons Related
Small Boy	Storax	7/14/1962	Nevada Test Site	Tower	Weapons Effect
Little Feller	Storax	7/17/1962	Nevada Test Site	Surface	Weapons Effect
Chama	Storax	10/18/1962	Johnston Island Area	Airdrop	Weapons Related
Checkmate	Storax	10/20/1962	Johnston Island Area	Rocket	Weapons Effect
Bluegill 3 prime	Storax	10/26/1962	Johnston Island Area	Rocket	Weapons Effect
Kingfish	Storax	11/1/1962	Johnston Island Area	Rocket	Weapons Effect
Tightrope	Storax	11/4/1962	Johnston Island Area	Rocket	Weapons Effect

* Data has been compiled from *United States Nuclear Tests, July 1945 through September 1992* (DOE/NV 2000).

ATTACHMENT 7: SUMMARY DOSE RECONSTRUCTION ASSUMPTIONS AND CONSISTENCY OF ASSUMPTIONS WITH OTHER SITE PROFILES

The default site profile assumptions and methodologies for Los Alamos National Laboratory (LANL) are summarized below and were compared to those of other site profiles reviewed to date or in current review. LANL developed many of the initial procedures used at other DOE facilities to support the weapons program. Periodically, LANL served as a backup to other DOE sites, such as Rocky Flats Plant and Hanford. LANL is the only remaining U.S. pit production facility since the shutdown of Rocky Flats and the Plutonium Finishing Plant Hanford. Site profiles completed to date by the SC&A team include Bethlehem Steel, Mallinckrodt Chemical Works (MCW), Iowa Army Ammunition Plant (IAAP), Hanford, the Savannah River Site (SRS), the Y-12 National Security Complex (Y-12 Plant), Idaho National Engineering and Environmental Laboratory (INEEL), the Nevada Test Site (NTS), and the Rocky Flats Plant (RFP). Additional site profiles in the process of review are Oak Ridge National Laboratory (ORNL), the Mound Plant (Mound), and Fernald (FMPC). LANL had multiple missions that overlapped with a number of other sites in the DOE complex, such as weapons research, the heat source program, reactor research, assembly and disassembly operations, and tritium operations, to name a few.

To ascertain the differences in assumptions between what assumptions are used for the LANL site profile versus other site profiles, the assumptions from each LANL TBD must first be understood. The core assumptions for each TBD have been outlined below.

Dose Reconstruction Assumptions for Occupational Medical Dose

There was a limited amount of site-specific data related to x-ray equipment and techniques in the TBD. Information provided in ORAUT-TKBS-0010-3, Table 3-1 (Johnson 2004, pg. 5) indicates that x-ray frequency through the operating period ranged from semi-annually to every five years. Claimant-specific information is provided to NIOSH by LANL, and is used to supplement the frequencies listed in ORAUT-TKBS-0010-3, Table 3-1 (Johnson 2004, pg. 5). The basis for the LANL occupational medical exposure site profile (Johnson 2004) is ORAUT-OTIB-0006, *Technical Information Bulletin: Dose Reconstruction from Occupationally Related Diagnostic X-ray Procedures*, Revision 2 (Kathren 2003). In the absence of site-specific data, the LANL site profile relied on values provided in this document for occupational medical exposure.

The default values for Occupational Medical Dose are the same as those used in other site profiles, as noted on the following pages of the Occupational Medical Dose TBD (Johnson 2004).

- Exam included posterior-anterior (PA) and lateral (LAT) views.
- Dose conversion factors assume minimum collimation for calculating the organ dose for Type I x-ray equipment (pg. 6).

- Organ doses from lateral chest x-rays estimated by multiplying the PA Entrance Skin Exposure (ESE) by a factor of 2.5 (pg. 6).
- Dose Conversion Factors (DCFs) outlined in ICRP Publication 34 (ICRP 1982) to assign organ dose (pg. 6).
- Source-to-image distance assumed was 72 inches (pg. 7).
- No air gaps between the patient and the film (pg. 8)
- Single phase x-ray units except the three phase Type V unit (pg. 8)
- Chest thickness for PA chest x-rays is 24 cm and lateral chest x-rays is 36 cm (pg. 7)
- Added filtration of 2.5 mm for Type I x-rays (pg. 13)
- Skin dose calculated using a backscatter factor of 1.35 or 1.4 based on NCRP 102 (NCRP 1989) (pg. 21)
- Dose conversion factor for the thyroid from Anterior-Posterior (AP) c-spine x-rays corrected for depth by 0.2 (pg. 15)
- Analogue organs used for the organs listed in IREP but not in International Commission on Radiation Protection (ICRP) Publication 34 (ICRP 1982, pg. 11)
- Type II examinations from 1964 to 1976 required interpolation of all listed DCFs, to estimate the DCF for the HVL of 7.2 mm Al that was found in available data. ICRP 34 (ICRP 1982) contains DCFs for (half value layers (HVLs) up to 4.0 mm Al. (pg. 9)
- Type II examinations from 1977 to 1984, Type IV and Type V equipment assumed an HVL of 3.5. For Type III equipment an HVL of 3.0 was used.
- PFG assumptions based on the methodology in ORAUT-OTIB-0006, Revision 2 (Kathren 2003).
- Uncertainty for x-ray procedures is 30% (pg. 17).

For guidance on lumbar spine exams, the LANL site profile (Johnson 2004) based its assumptions on *Radiation Doses in Diagnostic X-ray Procedures* (Lincoln and Gupton 1958) Lumbar spine x-ray dose has been integrated into the latest revision of ORAUT-OTIB-0006, Revision 3, PC-1 (Kathren and Shockley 2005). This information should be integrated into subsequent revisions of the LANL TBD.

Dose Reconstruction Assumptions for Occupational Environmental Dose

ORAUT-TKBS-0010-4 (Cehn and McDowell-Boyer 2004) describes the default assumptions for occupational environmental dose at LANL. Supplemental information based on recent data review efforts by the NIOSH/ORAU team are provided in Attachment 5 of this report. Occupational environmental dose included internal exposures from onsite atmospheric radionuclide concentrations, and external exposure from submersion and ambient radiation. Values derived for occupational environmental dose were based on environmental measurements (i.e., air monitoring data) and emission rates. Other assumptions made with respect to environmental dose from the Occupational Internal Dose TBD (Cehn and McDowell-Boyer 2004) include:

- Environmental measurement data reflect air concentrations from nearby as well as more distant sources of emission (pg. 8).
- Emission estimates are used in the absence of measurement data (pg. 8).
- Radionuclides of concern were defined as those that resulted in 1 mrem 50-year effective dose or 10 mrem to the highest exposed organs (pg. 11).
- For radionuclide screening, a 1.7 m^3/hour inhalation rate over a 2000-hour work year was assumed (pg. 11).
- The radionuclides of concern for environmental dose were tritium, I-131, Th-232, U-234, U-238, Pu-238, Pu-239, mixed fission products (MFPs) and particulate and vapor activation products (P/VAP) (pg. 11).
- Where monitoring data were available, the average air concentrations over all stations in the TAs were used (pg. 12).
- For years and locations where data were not available, an estimate based on the source emission rate and the air concentration data for available years was made (pg. 12).
- Ratios between plutonium air concentration and releases in TA-3 and TA-21 were derived, and these ratios were applied to effluents from other TAs to obtain an air concentration (pg. 12).
- Pu-239 and Pu-239 specific data were summed and reported in the TBD as Pu-239 (pg. 13).
- The specific activity for uranium is based on 0.02% U-234, 2.96% U-235, and 97.02% U-238. All uranium was assumed to be U-234 (pg. 13).
- All mixed fission products were assumed to be Sr-90 (pg. 13).
- All P/VAP were assumed to be Ge-68, Class W (pg. 13).
- For post-1970 intakes, the average air concentrations were used to estimate an annual intake based on a breathing rate of 2,400 m^3/yr and 2,000 work hours per year (pg. 14).
- Where the location of the worker could not be determined, the site-wide maximum estimated intake was assumed (pg. 14).
- All particles are considered respirable (pg. 14).
- The most claimant-favorable solubility is assumed (pg. 14).
- Site-wide maximum and GM values were calculated based on results from TA-3, TA-18, TA-53, and TA-54. Dose is based on 2080-hours per year (pg. 15).
- A resuspension factor of 1E-9/meter is applied for soil resuspension calculations (pg. 15).
- When the worker location is unknown, the site-wide maximum ambient radiation dose is assigned (pg. 18).

- The off-site dose for Los Alamos town site (TA-0) was applied to LANL workers in TA-0, TA-2, TA-21, TA-35, TA-41, TA-43, TA-48, TA-53, TA-60, and TA-61 during the period of testing. The distance to the receptor is 2.9 kilometers (pg. 18).
- Average airborne concentrations for Ar-41 in TA-2 were calculated for 1967 forward. The source and receptor were assumed to be at the same level (pg. 19).
- From the noble gas concentrations, the resulting average annual dose was calculated based on exposure for 2,000 hours/year (pg. 19).
- O-15 was used to estimate skin dose from emissions by TA-53, and Ar-42 was used to estimate the whole-body dose. The average airborne concentration was determined, and an average dose calculated based on 2,000 hours/year. A ground level release was assumed (pg. 20).

Dose Reconstruction Assumptions for Occupational Internal Dose

ORAUT-TKBS-0010-5 (Argall 2004) describes the default assumptions for occupational internal dose at LANL. The assumptions were derived from historical records relating to the in-vivo, the in-vitro, and the air monitoring programs.

Assumptions related to in-vitro analysis in the Occupational Internal Dose TBD (Argall 2004) include:

- Assume the plutonium compound to be plutonium oxide unless otherwise indicated (pg. 13).
- Urine data marked as invalid in the database can be used at the discretion of the dose reconstructor (pg. 69).
- Use the date of intake provided by LANL if it is available. If no intake date is indicated, use current models and best judgment in determining the intake date for acute intakes (pg. 83).
- The isotopic mixture for thorium under a best-fit scenario should be based on professional judgment. In the case of a maximizing approach, assume Th-230. The absorption class (M or S) should be selected based on the expected compound or matrix (pg. 33).
- Assume weapons-grade plutonium (6%), or prior to 1957 (3%). For maximizing intakes, assume fuel-grade plutonium (12%) at 10-years old. For intakes since 1996, assume fuel-grade plutonium (12%) at 20-years old (pg. 20).
- If the results from the thermal ionization mass spectrometry (TIMs) analysis are used for dose assessment, Pu-240 must be accounted for in the calculations (pg. 18).
- Pulmonary absorption types are assumed based on the work location or material composition where they are known (pg. 20).

- Tritiated water (HTO) is assumed where specific information is not available on chemical form or work location. In the case of HRL and IBF Buildings, the predominant form of tritium is organically bound tritium (OBT) (pg. 23).
- Specific guidance for assessment of OBT and special metal tritides (SMT) doses is provided in OCAS-TIB-002 (OCAS 2003, pp. 23–24).
- The isotopic composition for uranium is defaulted to the values in the Integrated Modules for Bioassay Analysis IMBA NIOSH Phase I database USDOE Version 1.0.42, Table 5-11 (depleted uranium), or Table 5-12 (enriched uranium) (pp. 25–26).
- The default absorption for uranium is Type M (pg. 26).
- Background uranium is subtracted from uranium bioassay results (pg. 29).
- Any gross beta activity should be considered an occupational intake (pg. 30).
- Strontium dose is only calculated when bioassay results are available (pg. 31).
- Missed dose for polonium is assessed only if there is polonium bioassay data, or there is an indication of exposure from the claimant interview. Dose should only be assessed for those years when polonium bioassay was available (pg. 31).
- Individual specific polonium baseline values in urine and feces are subtracted from later results (pg. 32).

Other assumptions discussed in the LANL Occupational Internal Dose TBD (Argall 2004) related to in-vivo counting include:

- Detection of Cs-137 in a whole-body count should be considered occupational exposure if other fission or activation products are detected, or if fission products, activation products, or radiostrontium are detected in the urine (pg. 37).
- All fission and activation products, excluding Cs-137, identified in a whole-body or lung count should be considered unless there is a reason for invalidating dose documented in the record (pg. 37).
- If the record indicates that Cs-137 is from a non-occupational source, the dose should be disregarded (pg. 37).
- If Cs-137 is detected in the whole-body count, and the values are below the mean body burdens from fallout derived by the NCRP (NCRP 1987), Cs-137 is assumed to be from fallout (pg. 37).
- In-vivo results and detection limits should be used only to bound intakes determined from in-vitro counting for americium, plutonium, and uranium. These results are not used as the primary source of determination of intake or missed dose (pg. 38).
- The standard deviation assumed for whole-body counts is 0.3 times the minimum detectable activity (MDA) or reporting level, and for chest counts is 0.5 times the MDA. For results greater than 3 times the MDA, assume a standard deviation of 0.1 times the result (pg. 41).

- Am-241 observed in lung counts years after the intake are considered in-growth from Pu-241 or from the Am-241 in the initial plutonium mixture (pg. 20).
- Plutonium mixtures should not be inferred from americium results, and the absence of americium should not preclude the calculation of dose from americium contribution to the mixture. If Am-241 is a part of a mixture, the absorption type is assumed to be the same as the plutonium for that mixture (pg. 22).
- The calculation of missed americium dose is based on sensitivities listed in Table 5-8 of the TBD (pg. 23).

Air Monitoring Data

- Average airborne concentrations by location and year were calculated from general air samples or averages obtained directly from LANL reports (pg. 42).
- Maximum and average airborne concentrations can be used to establish boundary conditions for chronic intakes below the instrument detection levels (pg. 42).
- Potential missed dose from radionuclides other than plutonium and americium are determined based on contamination levels, tolerance and maximum allowable concentration (MAC) air concentration levels, and airborne concentration of significant radionuclides (pg. 51).
- For individuals with no early bioassay data for plutonium, uranium, and polonium, but bioassay data from later years, the later bioassay data can be used to back-calculate an internal dose (pg. 51).

Average or maximum air concentration data is used to assess intakes for polonium, uranium, and plutonium missed dose in 1943–1946. A geometric standard deviation (GSD) of 5 is assumed for a hypothetical intake (pg. 51).

Dose Reconstruction Assumptions for Occupational External Dose

The LANL Occupational External Dose TBD ORAUT-TKBS-0010-6 (Widner 2005) describes the default assumptions for occupational external dose at LANL. The dose assignments were based on pocket dosimeter, film badge, neutron track plate, track-etch dosimetry, and thermoluminescent dosimeter results. The current Occupational External Dose TBD (Widner 2005) states that it does not address reconstruction of skin dose.

Assumptions related to beta/gamma exposure include (Widner 2005):

- Beta and photon energy distributions are determined by area (pp. 69–70).
- The default beta and photon energies for input into IREP are > 15 keV beta and 20–250 keV photon (pp. 69–70).
- 100% AP geometry is assumed for all workers (pg. 49).

- For operations from 1949, nonpenetrating dose was attributed to beta dose. Nonpenetrating dose equals the skin dose minus the sum of the deep dose, neutron dose, and tritium dose (pg. 70).
- For operations prior to 1949, the beta dose is calculated by multiplying the recorded deep dose by 1.008. This ratio was derived from median annual shallow-to-deep dose ratios for 1949 through 1958. Only values where the deep dose was greater than 50 mrem were considered in the analysis. This method applies to reactor operations, uranium production, accelerator operations, waste handling, radioactive lanthanum sources, and calibration facilities (pg. 70).
- Low-energy photon exposures are considered pertinent to TA-1 (D-Building), TA-21, TA-55 and TA-3 (pg. 69).
- For plutonium processing and production facilities, low-energy photon exposures are evaluated. Before 1949, 100% of the photon dose is attributed to the 30–250 keV energy range, and an additional dose of 1.86 times the photon dose is attributed to the <30 keV energy range. The low-energy photon dose is in addition to the recorded photon dose. For 1949 and after, the nonpenetrating dose should be attributed to the <30 keV energy range to account for low energy photons (pg. 69).
- Missed dose is based on the minimum detectable level/2 times the exchange frequency (pg. 68).
- Missed beta/photon dose is entered as a lognormal distribution with a GSD of 1.52 (pg. 68).
- Uncertainty factors for reported LANL doses are provided based on characterization of dosimeters by site personnel and the DOELAP analysis. Uncertainties for beta/photon dose range from 14%–30%, and for neutron dose range from 8%–50%. The actual value is based on the dosimeter type (pg. 67).
- Adjustment factors for photon doses are recommended for plutonium areas from 1949–1962 and 1973–1979. Adjustment factors for photon exposures >200 keV are recommended for the brass-cadmium badges from September 1961–October 1964 (pg. 67).
- Mean, median, and 95% gamma doses were calculated by year for all dosimeter results that were equal to or exceeded 50 mrem. The median dose is assigned to unmonitored workers for each year of employment (pp. 65–66).

Assumptions related to neutron exposure include (Widner 2005):

- The main work areas where there was a potential for neutron exposures include D-Building (TA-1), DP West (TA-21), DP East (TA-21), TA-55, Omega Site (TA-2), TA-53, Criticality Laboratory (TA-2, TA-18), and the CMR Building (TA-3). Assume the plutonium compound to be plutonium oxide unless otherwise indicated (pg. 36).
- ICRP 60 (ICRP 1991) neutron correction factors were determined for plutonium production facilities (TA-1, TA-21 and TA-55), the LAMPF (TA-53), reactor operations

(TA-2, TA-35, TA-52), criticality experiments (TA-2, TA-18), and actinide chemistry and metallurgy research (pg. 92).

- Assume 100% fission spectrum neutrons (0.1 to 1 MeV) for LANL reactors (pg. 43).
- The neutron spectrum at the Chemical and Metallurgy Research (CMR) facility is assumed to be similar to that of the plutonium facilities, but with a slightly higher fraction of 2 to 20 MeV neutrons (pg. 43).
- Missed neutron doses prior to 1979 are based on the application of a neutron-to-photon ratio for each work area to the photon dose (pg. 49).
- The recommended neutron-to-photon ratios are determined for plutonium facilities, criticality experiments, and other operations. The neutron-to-photon ratios were determined from dosimeter values in 1979–2004 with deep and neutron doses greater than or equal to 50 mrem (pg. 35).
- Work location records are used to determine whether an individual worked in an area with neutrons and what the appropriate energy distribution of neutrons was. If no neutron dose was assigned to the worker or co-workers for several months, the assumption is that the person was not exposed to neutrons and is, therefore, not assigned a missed neutron dose (pg. 71).

Inconsistencies within the LANL Site Profile

There is some confusion on when to calculate dose based on photofluorography (PFG) parameters. The Occupational Medical Dose TBD (Johnson 2004) indicates that PFG should be assumed prior to 1957, when no specification of x-ray type is available (pg. 6). Furthermore, it indicates that all exams after 1956 are assumed to be chest radiographs (pg. 6). Later the TBD (Johnson 2004) states that PFG should be used prior to 1964 when no information on the type of exam is available (pg. 10). OTIB-0006 Revision 3 (Kathren and Shockley 2005) also lists 1964 as the year of the last documented PFG. The direction on when to apply PFG should be clarified as it appears to be inconsistent with the document.

The Occupational External Dose TBD (Widner 2005) states that it does not address skin exposure, yet it provides detailed guidance on how to determine non-penetrating and low-energy photon doses. These data seem to be providing a methodology to assess skin exposure in spite of the statement made in the Occupational External Dose TBD (Widner 2005). This inconsistency should be corrected.

Am-241, H-3, I-131, Pu-239, Th-232, U-234, MFPs (i.e., Sr-90), and P/VAPs (i.e., Ge-68) were considered for the site-wide maximum exposures, which are applied when work location is unknown. Ambient external dose as well as dose external dose from Ar-41 was considered. External dose from Ar-41 was specific to TA-2. Be-7, P-32, As-72, Br-76, Rb-88, Cs-137, Cs-138, La-140, Ir-191, Hg-203, and Th-234 were considered; however, the dose contributions were <10E-5 Sv/year so this dose was neglected. Other radionuclides, such as Po-210, I-125 Xe-133, Kr-85, Ra-226, Np-237, C-11, N-13, I-133, I-135, and U-233, were not considered even in the screening assessment, yet they were mentioned in the LANL Site Description (Buddenbaum 2004).

Inconsistencies Between Site Profiles

There is variation among site profiles related to the standard chest thickness and whether an adjustment factor is applied. As mentioned above, the thicknesses assumed for LANL were 24 cm and 36 cm for PA chest x-rays and lateral chest x-rays, respectively. The SRS TBD (Scalsky 2005) and INEEL TBD assumes a chest thickness of 26 cm and 34 cm for PA chest x-rays and lateral chest x-rays, respectively. OTIB-0006 Revision 2 and Revision 3 both indicate that the average worker chest size is 22–24 cm (Kathren and Shockley 2005). The OTIB recommends that adjustments be applied for larger individuals with chest thicknesses of 25–27 cm and > 27 cm chest thickness, resulting in an increase in dose by a factor of 1.5 and 2.0, respectively. In the absence of site-specific data, consistent default assumptions are warranted. The LANL site profile should reference the most current version of ORAUT-OTIB-0006 when using this document in dose reconstruction.

The NIOSH/ORAU team has recognized that there should be a consideration of exposure by receptor points. The application of multiple receptor points is consistent with the approach in the Hanford, SRS, and Idaho National Engineering and Environmental Laboratory (INEEL) TBDs. The LANL TBD (Cehn and McDowell-Boyer 2004) relies on environmental air sampling data as well as applying the χ/Q methodology to determine the annual average air concentrations. The Hanford TBD applied the puff advection model (Savignac 2003), while the SRS applied the Gaussian model (Scalsky 2005). The assumptions made with respect to ventilation rate and exposure time are consistent with other site profiles. Models used within the different environmental TBDs are not consistent; nor is an explanation provided for why one applies certain models at one DOE site, but not at another.

Dose from the resuspension of contaminated soil has been given minimal attention in the current version of the Environmental Dose TBD (Cehn and McDowell-Boyer 2004), but is currently under investigation by the NIOSH/ORAU team. Soil resuspension dose is considered in relation to environmental exposure at both the Rocky Flats Plant (McDowell-Boyer and Little 2004) and the Savannah River Site (Scalsky 2005). The inclusion of dose from resuspension of soil is appropriate for LANL given the numerous weapons test shots the laboratory conducted, especially in the early years of operations (Buddenbaum 2004, pp. 12–16).

The Iowa Army Ammunition Plant TBD (Leonowich et al. 2005) specifically deals with hydroshots from both an environmental and internal dose perspective. Although the environmental TBD recognizes the potential exposures from the radioactive lanthanum test shots conducted at Bayo Canyon, it does not appear to address potential exposures from other testing sites including TA-4, TA-5, TA-7 (Gomez Ranch Site), TA-8 (Anchor Site West), TA-12, TA-13 (P Site), TA-14 (Q Site), TA-20 (Sandia Canyon Site), TA-27 (Gamma Site), TA-40 (Detonator Firing Site), TA-67 (Pajarito Site), and TA-68 (Water Canyon Site). Consideration should be given to all test sites as the radionuclides of concern vary. At IAAP, clean-up operations presented exposure hazards to fine as well as visible pieces of radioactive material. Since LANL has similar operations, this is likely the case at the laboratory.

There is mention of Ra-226 and radon in Table 5A-10 (pg. 70) of the LANL internal dose TBD, although there was no discussion included for potential internal dose from radon. Radon was specifically addressed in the Mallinckrodt Chemical Workers (MCW) and Fernald TBDs, where K-65 residues with high concentrations of Ra-226 were handled; yet the LANL TBD (Argall 2004) fails to consider radon exposure from the cooking off of sources or leaking of radium sources in TA-1. The impact of radon on dose reconstruction should be evaluated, particularly for the earlier years.

During the Y-12 Special Exposure Cohort petition review, considerable attention was given to radionuclides generated by the ORNL Isotopes Production Group and potential exposures to Y-12 workers from these activities. Similar operations were conducted at LANL at the accelerators. The TBD (Argall 2004) does not include a discussion on accelerator-produced radionuclides, radionuclides produced during early experiments, and medical radionuclide production. Depending on the quantities and types of radioactive material produced, this may affect internal dose.

The LANL Occupational Internal Dose TBD (Argall 2004) simply refers the dose reconstructor to the specific guidance provided in OCAS-TIB-002 (OCAS 2003), when the dose records indicate an exposure to organically bound tritium (OBT) and metal tritides (MTs). The Mound Internal Dosimetry TBD (Millard 2004), in Section 5.3.1.1 Metal Tritides, states that a lung clearance class of S should be assumed for all metal tritides other than lithium. The SRS Internal Dosimetry TBD and associated TIBs fail to treat the topic of dose reconstruction from exposure to organically bound tritium and metal tritides. Consideration should be given to identifying those facilities with special tritium compounds and developing a common methodology to assign dose from the compounds.

There has been no consideration of ingestion dose for LANL workers. The Bethlehem Steel and the Mallinckrodt Chemical Works (MCW) TBDs included ingestion as a potential route of internal dose. This may particularly be appropriate at LANL in the early years when, as the TBD indicates, conditions were deplorable. Although engineering controls were implemented over time, internal contamination from incidents, reused personal protective equipment, and deposition on food and beverages in areas where eating was allowed may have led to ingestion.

The Hanford, SRS, and other site profiles discount the use of NTA film as an adequate measure of neutron dose yet the LANL site profile appears to use NTA film results for monitored workers. The LANL Occupational External Dose TBD (Widner 2005) applies an area-specific neutron energy distribution for years after 1978. For years prior to 1980, the annual photon dose is multiplied by a neutron-to-photon ratio to obtain the neutron dose. The TBD (Widner 2005) has derived three neutron-to-photon ratios for the plutonium facilities, criticality experiments (> 50 m distant), and other operations. The SRS Occupational External Dosimetry TBD distinguishes neutron energies and neutron-to-photon ratios for reactors, fuel fabrication, plutonium production, and radionuclide production and calibration (Scalsky 2005). The INEEL Occupational External Dose TBD (Rohrig 2004) considers the reactors, the processing plant, waste handling operations, calibration sources, and uranium handling. Neutron energy spectra and neutron-to-photon ratios for Pu-238 and Pu-239 operations are segregated at SRS (Scalsky 2005). The categories used in the LANL TBD (Widner 2005) lack the detailed analyses seen in site profiles from other sites. Further evaluation of neutron-to-photon ratios should include more specific categories including neutron sources (RaBe, Cf, etc.), accelerators, early subcriticality experiments, initiator development and neutron spectra from alternate fissile materials. NIOSH/ORAU has proposed to include a Pu-238 specific neutron-to-photon ratio in the next revision.

The Occupational External Dose TBDs for Y-12 (Murray 2003), SRS (Scalsky 2005), and Hanford (Scalsky 2003) base their default exposure geometry on the compensability or non-compensability of the claim. The MCW (Westbrook 2005) and RFP (Furman and Lopez 2004) Occupational External Dose TBDs base default exposure geometries on job titles. Both the LANL TBD (Johnson 2004) and the INEEL (Rohrig 2004) Occupational External Dose TBDs default to 100% Anterior-Posterior (AP) exposure. Further evaluation of exposure geometry for photon and neutron exposure should be evaluated for LANL workers to determine if 100% AP geometry is appropriate for all LANL workers, or whether methods employed at other facilities are more appropriate.

In general, the Integrated RadioEpidemiology Program (IREP) input criteria for Radiation Rate, Radiation Type, and Dose Distribution Type are the same for LANL as for other site profiles. Maximizing internal dose is assigned with the use of ORAUT-OTIB-0018, *Internal Dose Overestimates for Facilities with Air Sampling Programs*, or ORAUT-OTIB-0002, *Technical Information Bulletin: Maximum Internal Dose Estimates for Certain DOE Complex Claims*. The application of these OTIBs for the assignment of dose is consistent with other site profiles. External dose assumptions were consistent with those used in other site profiles. The default energies for beta, photon, and neutron exposure were >15 keV, 30–250 keV, and 0.1–2.0 MeV, respectively. The missed external dose is calculated using the MDL/2 calculation times the number of monitoring periods, and is entered as a lognormal distribution with a GSD of 1.52. This is consistent with other site profiles.

ATTACHMENT 8: SITE EXPERT COMMENTS ON THE LANL SITE PROFILE

Several comments were provided by individuals interviewed, which related directly to the LANL Site Profile documents. These comments are provided as a separate attachment from the site expert interview summaries. The information provided below was from interviews and hardcopy documentation from Dr. Ken Silver of Eastern Tennessee State University and current employees at Los Alamos National Laboratory.

Comments from Dr. Ken Silver

Dr. Silver submitted *Review and Critique of the Draft NIOSH Site Profile Document for Los Alamos National Laboratory* to the NIOSH Office of Compensation, Analysis and Support, Extensive on September 19, 2005. This document provides a detailed critique of the LANL site profile; however, to date NIOSH has not formally responded to Dr. Silver's comments on the site profile. As a result of the issues identified in Dr. Silver's document, SC&A held a conference call with Dr. Silver on November 1, 2005 to get some clarification on the issues raised in his review, and on additional concerns he had with the content of the LANL site profile.

Dr. Silver discussed the following issues as his primary areas of concern regarding the NIOSH Los Alamos National Laboratory site profile.

- NIOSH had access to a number of LANL documents, and simply repackaged the documents in their site profile. These technical report documents have not undergone external peer review. They documented the "official story" and did not include input from workers who experienced the program firsthand.

- NIOSH/ORAU is having difficulty retrieving necessary data from LANL according to chapter five of the Occupational Internal Dose TBD (Argall 2004). As of June 2005, ORAU personnel indicated that bioassay data would be forthcoming from LANL within a few weeks. The current status of this is unknown. The data being provided may not be the raw data, but may include LANL adjustments.

- Workers have had difficulty establishing their employment at LANL. Early in the EEOICPA process, even some of the Construction unions were of little assistance to the workers in proving employment.

- There is a need to have more insight into the data available to NIOSH prior to making any decisions on dose reconstruction.

- The average worker doesn't have confidence that the dosimeters were properly measuring dose.

- There was reportedly "purging" of dosimetry records for Zia workers. Purportedly, this was related to lawyers' concerns at the time the Zia contract changed.

- 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 "technical report number. Many times these collective doses were lower than those reported to DOE (Silver 2005, pg. 42)

- NIOSH stated that periodic progress reports were issued until 1960. Some are publicly available through 1964. Workers indicated that reports were issued beyond 1964. There may be security reasons why reports are not being provided by LANL. Or there may be an effort to conceal information about environmental and workplace exposures to fission products. For example, they may be withholding reports on the Rover tests, Experimental Breeder Reactors, and fuel elements brought back for post mortem studies.

- A comprehensive list of incidents is absent from the site profile. Based on the many issues with the bioassay program cited in the Tiger Team report, one cannot assume the bioassay results will capture uptakes from incidents. For example, there were issues with who was monitored, how samples were collected, and how samples were handled.

- TA-21 Decontamination and Decommissioning (D&D) personnel were not required to wear respirators. The Occupational Environmental Dose TBD (Cehn and McDowell-Boyer 2004) cites a LANL technical report which claims all workers wore respirators.

- There was a gap noted in the Occupational Environmental Dose TBD (Cehn and McDowell-Boyer 2004) for exposure from ambient airborne releases prior to 1970. Dr. Silver does not have environmental air monitoring data from this era; however, there are technical reports available for years after about 1959. Another issue related to environmental exposure is the problem with workers tracking contamination home. This was of particular concern on a 1960–1961 underground hydronuclear test.

- There has been an SEC petition filed by State Representative Harriet Ruiz. The petition issues center around the unavailability of medical records for LANL employees and the potential impact these records have on dose reconstruction.

- Dr. Silver has suggested to the Construction Trades that they file a Freedom of Information Act (FOIA) request for a "Vaughn index" of NIOSH holdings on LANL for the records not yet publicly available. The Waste Disposal Facility (Area G, TA-54) may be the subject for a future petition based on the 92 different radionuclides handled in that area and issues with instruments.

- Previous worker interviews indicate that LANL was aware of the disparity between the radiation protection procedures and what actually occurred in the field. Documentation to this effect has not been located yet.

- Communication with claimants indicates that the existing LANL site profile is used as a basis for denial.

Dr. Silver recommended that SC&A consider the following questions during the course of the review.

- How did NIOSH address geometry questions such as Electromechanical Technicians sitting on magnets and other equipment at accelerators?

- What bioassay programs were implemented for workers?

- Has there been a comparison between the quantities of material processed and the availability of bioassay? How did NIOSH address exposure to radionuclides available in smaller quantities?

- How are gaps with pre-1970 environmental data addressed in dose reconstructions?

- Have sample claims been reviewed to evaluate partial body exposures (e.g., Electromechanical Technicians) and individuals handling core samples with potential neutron exposure?

- Why is there a discrepancy in collective dose between the LANL reports and the annual reports submitted to DOE?

- Have egress procedures and spread of contamination to non-radiological areas been reviewed, including offsite?

- Why is it so difficult to establish employment at LANL?

- What is the quality of the data provided to NIOSH?

Several follow-up discussions were held with Dr. Silver during the course of the review to identify potential sources of information on the above topics. Dr. Silver recommended several sources of information pertinent to dose reconstruction and the historical radiation protection program.

- Appendices to the Tiger Team report on microfiche – supplement to the report which may provide further information.

- Institutional History Document in 3 volumes – helpful in determining the structure of the Radiation Protection Program through time.

- Information on Human Radiation Experiments for the 1940s and 1950s also contained information on measurement of occupational exposures. Because the human experiments ended after the 1950s, information on occupational exposures in the 1960s and 1970s is not available in the public domain. Harry Schulte and Harry Jordan wrote journal articles on worker and environmental exposures.

- LA-6848-MS, Author Margaret Rogers

- Zia worker study (Galke et al. 1992)
- Article on the Medical Health Surveillance program by Brian S. Schwartz (see American Journal of Industrial Medicine)
- University of New Mexico Zimmerman Library – Copies of FOIA requests maintained here (along with CDC LAHDRA documents).

Dr. Silver recommended several site experts to SC&A that he felt would provide valuable information on LANL operations and safety. These individuals included personnel from RadCon, dosimetry, the accelerators, waste management, D&D, Construction Trades, and outside individuals who have conducted research related to LANL.

Comments on the Occupational Environmental Dose TBD

There were several improvements recommended by LANL staff related to the NIOSH Occupational Environmental Dose TBD (Cehn and McDowell-Boyer 2004)

- As the early releases were likely more significant, retrieval of early environmental monitoring data would be beneficial (1940s, 1950s). Less is known about this period of time than other periods.
- The data from the annual Environmental Surveillance Reports need to be considered in context. Often, the data are measured close to a source of radiation or contamination and do not represent the exposure to a general worker onsite.
- The maximum environmental air sampling data has been assumed as the most appropriate number for dose reconstruction by NIOSH without consideration of air monitor position or restricted access to areas. It is incorrect and misleading to use these data for all site personnel. For example, there is a sampler adjacent to tritium disposal shaft. The ambient air sampling levels is high because of the location.
- There is no explanation of where the data in Table 4A-1 (Cehn and McDowell-Boyer 2004) was obtained. LANL and Center for Disease Control and Prevention (CDC) contractor personnel are currently working to locate data from the 1940s for TA-1.
- There was a contamination problem with environmental air samples from the Second Quarter of 1995. The data is qualified in LA-13210-ENV, *Environmental Surveillance at Los Alamos During 1995* (LANL 1996, pg. 85). The NIOSH Occupational Environmental Dose TBD (Cehn and McDowell-Boyer 2004) did not take this into account.
- Table 4B-1 (Cehn and McDowell-Boyer 2004) lists the Estimated Maximum Effective Dose for 1967 from Th-232 as 8.3E2 Sv/year. The Estimated Maximum Effective dose

for 1950 from U-234 is 3.3E-1 Sv/year. These doses are excessive and there is no justification for them.

- In Table 4C-12 (Cehn and McDowell-Boyer 2004), the estimated decrease from 1970 to 1971 is a factor of 200. This suggests the earlier values are overestimated by a factor of 200. This discontinuity needs to be further investigated.

- The list of references in the NIOSH Occupational Environmental Dose TBD (Cehn and McDowell-Boyer 2004) is short compared to the thousands of relevant references (i.e., memos, progress reports) available through LANL. There are reports from 1958–1971. The reports for earlier years are more sporadic.

- The environmental monitoring group at LANL provided documentation to NIOSH, but was not provided an opportunity to comment on the NIOSH TBD after it was final. HSR-12 and HSR-4 had an opportunity to comment on portions of the Occupational Environmental Dose TBD (Cehn and McDowell-Boyer 2004).

- The Occupational Environmental Dose TBD (Cehn and McDowell-Boyer 2004) does not include information from the EPA regarding the Cerro Grande Fire. LANL workers requested that this information be included in the site profile for LANL.

There was a concern expressed by environmental monitoring staff that the use of overestimates of environmental doses in the NIOSH dose reconstruction process undermines the best estimate values derived using reasonable assumptions by LANL.

Comments from Other Site Experts

- Site experts in general felt the Site Description TBD (Buddenbaum 2004) presented a good history of the site operations. In particular, the TA-18 description was “pretty good.”

- The NIOSH/ORAU team interviewed several of the Radiological Control staff at LANL, including members of the Dose Assessment, External Dosimetry, and current and former Medical staff. Questions were related to the dosimetry and medical programs. Although the NIOSH/ORAU team held worker outreach meetings, there was not focused effort to interview personnel outside the HSR group.

- LANL staff recognized the incompleteness of the incident file provided in the NIOSH Site Description incident list, which seems to be a very small and arbitrary subset of the recorded incidents. There were incidents missing which resulted in intakes or overexposure. For example, the NIOSH incident list did not include the March 2000 event involving a group of workers from PF4 who received internal uptakes of Pu-238. The negative pressure was not operating. As a result, a radiological control technician (RCT) crawled under the glove box. While there, the swage lock fitting blew out. There were no incidents listed after 1978, when in fact they did occur. There were also some apparent gaps in the NIOSH Internal Dosimetry (Argall 2004) incident list. The incidents in these lists can easily be cross-checked against hardcopy incident files and/or the Incident Database. In fact, the Dose Assessment Team indicated that the total number of exposures at the laboratory was much larger than the NIOSH incident lists.

- Some Dose Assessment team members expressed their concern with the legal and political nature of the NIOSH dose reconstruction program versus its scientific basis.

During the dose reconstruction process for EEOICPA, records of officers traveling to other DOE sites were not included as a part of the LANL record and were not requested by LANL-DOE for submission to NIOSH. A true dosimetry reading is unlikely for LANL employees traveling off-site to other DOE facilities.