Draft

SC&A'S ISSUES MATRIX FOR THE LAWRENCE BERKELEY NATIONAL LABORATORY SITE PROFILE TECHNICAL BASIS DOCUMENT

Prepared by

S. Cohen & Associates
1608 Spring Hill Road, Suite 400
Vienna, Virginia 22182

Saliant, Inc.
5579 Catholic Church Road
Jefferson, Maryland 21755

January 2012

Disclaimer

This document is made available in accordance with the unanimous desire of the Advisory Board on Radiation and Worker Health (ABRWH) to maintain all possible openness in its deliberations. However, the ABRWH and its contractor, SC&A, caution the reader that at the time of its release, this report is pre-decisional and has not been reviewed by the Board for factual accuracy or applicability within the requirements of 42 CFR 82. This implies that once reviewed by the ABRWH, the Board's position may differ from the report's conclusions. Thus, the reader should be cautioned that this report is for information only and that premature interpretations regarding its conclusions are unwarranted.

Lawrence Berkeley National Laboratory Site Profile Issues Matrix

This matrix contains a list of the issues SC&A has identified in the Lawrence Berkeley National Laboratory (LBNL) site profile technical base document, ORAUT-TKBS-0049 (ORAUT 2007 and ORAUT 2010). As of January 2012, SC&A has not performed a complete re-evaluation of the site profile issues in view of the recent Rev. 02 edition of ORAUT-TKBS-0049 (ORAUT 2010). A special exposure cohort (SEC) presently exists for the LBNL for the period August 13, 1942, through December 31, 1961.

This site profile issues matrix is based on preliminary assessments of the following:

- The LBNL site profile technical base document (TBD), ORAUT-TKBS-0049, Rev. 01, April 2, 2007 (ORAUT 2007)
- The LBNL Petition SEC-00160, December 18, 2009 (NIOSH 2009)
- The NIOSH SEC Evaluation Report dated January 20, 2010 (NIOSH 2010)
- SC&A's January 22, 2010, review of LBNL site profile ORAUT-TKBS-0049, Rev. 01, April 2, 2007 (SC&A 2010)
- The LBNL site profile TBD ORAUT-TKBS-0049, Rev. 02, May 10, 2010 (ORAUT 2010)

Issue 1: Inadequate Documentation of Historical Operations and Sources of Radiological Exposures
SC&A Finding: This review found that the site profile provides an inadequate overview of LBNL historical operations and the primary radiological exposure sources and conditions. The document lacks sufficient detail and analysis to provide comprehensive guidance to dose reconstructors. The period covered is large, as it is for several of the other DOE sites; however, the TBD failed to fully address the exposure implications of radiation sources to the degree necessary to allow a comprehensive assignment of historical doses, including missed doses. Specific operations and facilities are not discussed in sufficient detail. Examples of the lack of significant detail and information are the lack of coverage of the National Tritium Labeling Facility (NTLF) and the accelerator program at LBNL.
SC&A's January 2012 update: The tables and information concerning this issue appear to be similar in Rev. 02 of the 2010 TBD as they were in Rev. 01 of the 2007 TBD; *however, Attachment A was added to Rev. 02, which contains some historical information that SC&A will need to evaluate concerning this issue.*
NIOSH Response:
SC&A Reply:
Work Group Actions:
Board Action:

Issue 2: Insufficient Information for Internal Dose Reconstruction, Especially during the Early Years
SC&A Finding: There is insufficient information on bioassay monitoring before 1961, and the information on air sampling and building activities is not sufficient to calculate the workers' dose due to internal exposures. Workers were potentially exposed to a diversity of radionuclides at LBNL, and the TBD is incomplete in relation to the periods of time and quantities of radionuclides that were handled in the different areas. Table 5-4 of the TBD lists minimum detectable activities (MDAs) for in-vitro measurements, but is incomplete with regard to the totality of radionuclides that were handled at LBNL and their MDAs. The information on MDAs on the various periods is incomplete, posing a problem with the calculation of missed doses. Gross alpha, beta, and gamma analyses are reported as being used for the entire site operation, including the present time. The TBD does not discuss the fact that many radionuclides present at LBNL would not have been detected by gross measurements, or at least detected with low recoveries and resulting high minimum detectable concentrations (MDCs). In addition, the use of gross measurements results in an indeterminate MDC for a specific radionuclide.
SC&A's January 2012 update: SEC-00160 negates the pre-1962 bioassay concerns; *however, the remaining issues are still pertinent.*
NIOSH Response:
SC&A Reply:
Work Group Actions:
Board Action:

Issue 3: Special Forms of Tritium and Plutonium not Addressed by NIOSH
SC&A Finding: NIOSH fails to identify in the site profile that metal tritides and organically bound tritium (OBT) are included in the materials used at the site and that tritium was used extensively at LBNL, in particular at the NTLF, Building 75. There is very little discussion about tritium exposures in the internal dose section (Section 5.0) of the site profile. During the interviews, health physicists stated that it was possible that highly oxidized/high-fired forms of actinides were handled at the site. They stated that the most likely source of exposure to these forms would have been related to the production of sealed sources and targets that were made for use at LBNL and other national laboratories. It is possible that NIOSH is addressing this issue for plutonium exposures at LBNL; however, the site profile does not address high-fired forms of other actinides (thorium, uranium, etc.).
SC&A's January 2012 update: A section on OBT, SMTs, and Super S plutonium was added to Rev. 02 of the 2010 TBD; *therefore, SC&A will need to re-evaluate this issue in view of the revised TBD.*
NIOSH Response:
SC&A Reply:
Work Group Meeting:
Board Action:

Issue 4: External and Internal Data Legacy, Completeness, and Accuracy not Addressed
SC&A Finding: The changes in external and internal data record systems over the years (legacy) have not been addressed; neither have the completeness nor accuracy of the data used in dose reconstruction been addressed in the TBD. During the site visit by SC&A, it was determined that the bioassay database does not contain all bioassay data for all workers; therefore, it appears that the database may be incomplete. In addition, bioassay submittals were delinquent by at least 1 year in some file records. This delay could increase the minimum detectable doses significantly, especially for soluble and short-effective half-life nuclides. In Tables 5-1 through 5-5 of the TBD, NIOSH listed many in-vitro and in-vivo bioassay methods, along with information on frequency of sampling. Given the great number of radionuclides that could have resulted in internal exposures at LBNL, it is apparent that many of these are short-lived, relative to the bioassay frequency. During the site interviews, it appeared that work conducted at the Donner Laboratory and other laboratories at the University of California – Berkeley campus was not monitored and/or controlled as stringently as at other LBNL facilities. NIOSH should investigate whether or not the internal dose information (bioassay and air sampling data) for the work at these laboratories is adequate to reconstruct doses at these locations.
SC&A's January 2012 update: The tables and information concerning this issue appear to be similar in Rev. 02 of the 2010 TBD as they were in Rev. 01 of the 2007 TBD; *therefore, the issue is still pertinent.*
NIOSH Response:
SC&A Reply:
Work Group Action:
Board Action:

Issue 5: Insufficient Justification for Selection of IREP Energy Range Fractions for Photon Exposures
SC&A Finding: In Table 6-2 of the TBD, beta and photon doses are assigned to energy ranges according to the radioactive materials used in individual buildings at LBNL. For Buildings 51 and 71, a single photon energy distribution is given, and 10% of the measured dose is assigned to the 30–250 keV range and 90% assigned to >250 keV. It appears that this photon energy distribution is being applied to the entire history of accelerator use at LBNL. It is questionable that this energy distribution is appropriate in all situations and timeframes. In the early years, it is much more likely that technicians and others would be exposed to low-energy emitters shortly after a machine was powered off, or even during operation. This was presumably less likely as energies and risks grew larger and commensurate standards and protective practices evolved. Regardless of the precise fraction that should be assigned, the choice of less than 100% to the 30–250 keV category should only be made where there is supporting evidence. As it stands, the selection of a 10% fraction is not claimant favorable and not buttressed by the inclusion of supporting evidence. Although the other buildings have been assigned factors greater than 10% for the more claimant-favorable 30–250 keV photon energy range, the fact that the accelerator buildings have been assigned a single low factor creates doubt on the validity and process by which the other factors were determined for the remainder of the site.
SC&A's January 2012 update: The data and information relative to this issue in Section 6 of Rev. 02 of the 2010 TBD appear to be similar to that in Section 6 of Rev. 01 of the 2007 TBD; *therefore, this issue is still pertinent.*
NIOSH Response:
SC&A Reply:
Work Group Actions:
Board Action:

Issue 6: Insufficiency of Neutron Dosimetry Treatment

NTA Film Energy Threshold Determination: As has been the case in a number of site profiles prepared by NIOSH, there is an inconsistent approach to the energy cut-off for the NTA neutron dosimeter. Callout "c." in Table 6.5 references NIOSH 2002 as listing the NTA lower energy threshold at 500 keV. Yet attribution number 47 discusses 800 keV as the threshold, and this is used as the basis for this TBD. Other sources list 1,000 keV as the threshold for NTA response. The assumption that NTA film responds down to 500 keV is not justified by the technical data and is not claimant favorable.

Failure to Adjust Recorded Doses to Correct for Lack of Response of NTA and CR-39 in the Intermediate and Thermal Neutron Energy Range: Table 6.6 of the TBD, "Adjustments to Recorded Dose," defines the corrections for photon and neutron dosimeters to adjust the measured quantity. However, no adjustment is indicated for the failure of NTA film to respond to intermediate energy neutrons. As presented, a significant part of the spectrum is inappropriately monitored and uncorrected.

There is virtually no discussion of the potential for neutron fields throughout this historical facility. Given that LBNL was a world leader in accelerator development, and given the leading-edge high energies developed by the machines, it is likely that there was the potential for unanticipated radiation fields and possible neutron exposures across a range of energies, especially in the early decades.

There is a remarkable silence as to thermal or slow neutron exposure in the site profile document. A search of the "O" drive revealed only a single document that mentioned slow or thermal neutrons. Clearly, there was the potential for exposure to slow neutrons, as slow neutron electroscopes were in use in 1956 and readings were documented for several individuals.

It is unclear from the TBD how and when albedo TLD data were merged with CR-39 results. The gap in neutron response from above the cadmium cutoff to the lower energy threshold for CR-39 (also not mentioned, but assumed to be around 150 keV) is not discussed. NIOSH should evaluate the neutron program and determine how missed intermediate energy neutron dose should be determined for this period, as well as intermediate and thermal energy neutrons for the NTA and pre-NTA years.

Selection of Minimum Detectable Dose for CR-39 Dosimeters: Table 6-1 of the TBD shows that the MDL for CR-39 is 10 mrem, with no attribution provided. The Los Alamos TBD shows an MDL for CR-39 of 20 mrem. The current commercial service available from Landauer, Inc., also shows an MDL of 20 mrem. It is likely that the MDL for CR-39 is higher than 10, and more likely around 20 mrem. This number is important and it is likely to be amplified to take account of missed dose not only due to exposure below the detection limit (DL), but also to estimate dose due to lower energy neutrons that would have been missed entirely due to the inability of CR-39 to detect lower-energy neutrons.

Use of Neutron-Gamma Ratios for Situations Where Neutron Data are Lacking - Seeming Inconsistency Between the Environmental and External Dose Sections: Table 4.1 of the Environmental Occupational Dose section (Section 4.0) of the TBD contains estimates of annual environmental dose throughout the history of the facility. The values provided are totals of neutron and photon exposure. The Environmental Dose section utilizes a ≥70% factor and the External Dose section utilizes a 42% factor. This significant difference in the average site-wide neutron-to-photon ratio is surprising. It is possible that the environmental dose includes more sky shine and other factors; however, this issue needs to be addressed and the large difference explained. This section on the determination of missed and missing neutron exposure needs a thorough review. Both the source terms and the dosimeter response specifications need to be addressed.
SC&A's January 2012 update: Section 6 of Rev. 02 of the 2010 TBD has been mostly revised from Section 6 of Rev. 01 of the 2007 TBD; *therefore,* (1) *SC&A will need to re-evaluate this issue in view of the revised TBD,* and (2) *the issues listed above that were not covered in the revised TBD are still pertinent.*
NIOSH Response:
SC&A Reply:
Work Group Actions:
Board Action:

Issue 7: Failure to Justify the Shallow Dose: Deep Dose Assumption
SC&A Finding: The TBD provides guidance on the dose to be assigned in the "early" years (pre-1979) for which there is no record of beta exposure. In the general case, there is an assumption that a factor of three for the ratio of shallow to deep dose is reasonable and claimant favorable. However, LBNL had a broad mandate. In most cases, the site description does not provide sufficient detail as to the quantities, forms, and methods under which these materials were handled. What is known is that the levels of protection in the 1940s, 1950s, and 1960s were far from what would be considered good practice today. There is no mention of head and eye dose or non-uniform whole-body irradiation in the site profile. Typically, workers handling beta emitters and those performing maintenance inside accelerators can be exposed to significant non-uniform fields. Likewise, there is no mention in the TBD of potential skin and clothing contamination and resultant exposure. It is unclear from the TBD if workers were exposed to significant shallow dose, with possibly little deep dose to be used as an indicator. Possible activities that may have been conducted include fume hood operations, maintenance of accelerators, ventilation and plumbing systems, waste disposal operations, and spill cleanup. The lists of nuclides are extensive and include beta emitters, including some pure beta and low-energy x-ray emitters. For some personnel, the 3:1 ratio may not be claimant favorable. NIOSH should identify the workers who could have received exposure from these beta or low-energy x-ray emitters, or provide an alternative method of estimating the shallow dose in a claimant-favorable manner.
SC&A's January 2012 update: The data and information relative to this issue in Section 6 of Rev. 02 of the 2010 TBD appear to be similar to that in Section 6 of Rev. 01 of the 2007 TBD; *therefore, this issue is still pertinent.*
NIOSH Response:
SC&A Reply:
Work Group Actions:
Board Action:

Issue 8: Uncertainty in Beta-Gamma Dosimeter Response to Radiation Types and Energies

The Use of Early Electroscope Data Needs Greater Definition: Page 39 of the TBD describes the use of electroscope data as follows:

> *… Exposure data were recorded by film badges and thermoluminescent dosimeters (TLDs). Early exposure records also provided electroscope (or at times, electrometer or E was used) results, which supplemented the results measured by film. Dose reconstructors should use the electroscope results in a qualitative manner because no data were found on the calibration or energy response of these devices; they should use the film or TLD results to estimate the actual exposure or the electroscope reading if no corresponding dosimeter reading exists.*

A search of the "O" drive found that, anecdotally at least, there were significant problems with electroscopes. A study performed November 23, 1953, by Jim Bennett (Bennett 1953) showed that readings from the three electroscopes tested were widely divergent from the film that was exposed with them. Two gave a 10% response compared with the film, and the third was off scale. No details are provided as to the energy of the gamma source used for the exposure. However, the memo provides a cautionary statement as to using electroscope data, even in a qualitative manner.

Dosimeter Response to Very High Energy Photons and Charged Particles: LBNL was a pioneer in the development of high energy physics (HEP) and in the search for exotic particles. The film and electroscopes in use in the early decades will likely not have been calibrated for energies above 1 or 2 MeV. NIOSH should evaluate the dosimetry and potential for exposure to radiation at energies above that commonly produced by radioisotopes. The detectors will have responded to some degree, but the correction factor size and sign are unknown and not mentioned in the TBD. The response of the detector element or film, for example, will depend greatly on the composition of the holder and filters.

SC&A's January 2012 update: The data and information relative to this issue in Section 6 of Rev. 02 of the 2010 TBD appear to be similar to that in Section 6 of Rev. 01 of the 2007 TBD; *therefore, this issue is still pertinent.*

NIOSH Response:

SC&A Reply:

Work Group Actions:

Board Action:

Issue 9: X-ray Exposures are Uncertain
SC&A Finding: Table 3-1 lists the entrance skin exposure (ESE) doses used for the posterior/anterior (PA) chest exam. It states that until 1975, all dose estimates are defaulted to those provided in the TBD (ORAUT 2007). There is no information identified as being available on x-ray equipment that was used prior to 1975. Depending on how one views this information, there is no indication that this default is claimant favorable for the years 1942 through 1975. NIOSH needs to better describe what measures were taken to determine what types of equipment were used. For example: • Where did workers get exams between the years 1942–1975? • Were medical records available and do they indicate if x-rays were taken? • Were workers sent to alternate locations for exams and were those records researched? • Did NIOSH research address the potential use of PFGs to screen workers up through 1960? The TBD should be expanded in its discussion of the medical dose to address the issues indicated in the above questions in order to be considered complete.
SC&A's January 2012 update: Section 3 of Rev. 02 of the 2010 TBD has been mostly revised from Section 3 of Rev. 01 of the 2007 TBD; *therefore, SC&A will need to re-evaluate this issue in view of the revised TBD.*
NIOSH Response:
SC&A Reply:
Work Group Actions:
Board Action:

Issue 10: Uncertainty of Calculating Doses Prior to 1961
SC&A Finding: There is no information on how NIOSH is planning to reconstruct doses before 1961. In the TBD (ORAUT 2007): • Table 5-1 lists the in-vitro types of bioassay, the periods, and the frequencies of monitoring. It does not contain any information that might be applicable to calculate doses for exposures before 1961. • Table 5-4 lists the MDAs for various analysis results. The only pre-1961 information available is the MDA for gross alpha, and gross beta is for 1957–1961. • Table 5.8 contains only one reference to exposures before 1961. • Looking at the files for LBNL in the NIOSH OCAS Claims Tracking System (NOCTS), 24 claimants received compensation. Those were probably the most exposed workers, and 18 of the 24 claimants started working before 1961. There is only one bioassay record before 1961; a uranium urinalysis done in 1958. • Looking at the 99 claimant files for LBNL who did not receive compensation, 31 started working before 1961. There is only one bioassay record before 1961; a C-14 breath analysis performed after an incident in 1959. There is insufficient information related to bioassay monitoring before 1961 in the TBD.
SC&A's January 2012 update: SEC-00160 negates pre-1962 bioassay concerns; *therefore, this is no longer an issue.*
NIOSH Response:
SC&A Reply:
Work Group Actions:
Board Action:

Issue 11: Inadequacy of Bioassay Analyses Presentation
SC&A Finding: There was a diversity of radionuclides at LBNL. The Occupational Internal Dose section of the TBD (ORAUT 2007) specifies that, "from 1960 to 1996, both in vitro and in vivo monitoring records and associated interpretations exist." In Table 5.4, MDAs are listed for gross alpha for isotopes of thorium, plutonium, curium, actinium, and neptunium. The same method and MDA are listed for Cf-252 from 1965–1995. There is a remark specifying that, "method descriptions note that uranium, radium, and polonium are not detected by this method (Author unknown, no date)." Table 5.8, "Radionuclides and fraction activity by facility," is incomplete and difficult to use, in relation to discrimination between exposures during the various periods of time the rooms were used in the installation. Tables 5.1, 5.2, and 5.4 describing in-vitro bioassay programs, methods, and MDAs are incomplete and do not give enough information on internal dose calculations for LBNL employees. Table 5.8 is also incomplete and difficult to use, in relation to discrimination between exposures during the various periods of time and the rooms used in the installation.
SC&A's January 2012 update: Although some of the table identification numbers have changed in Section 5 of Rev. 02 of the 2010 TBD compared to those in Section 5 of Rev. 01 of the 2007 TBD, there appear to be no significant changes concerning this issue; *therefore, this issue is still pertinent.*
NIOSH Response:
SC&A Reply:
Work Group Actions:
Board Action:

Issue 12: Failure to Provide Sufficient Guidance for Unmonitored Workers
SC&A Finding: The TBD fails to provide guidance on how to calculate doses to workers without a complete description of the monitoring programs (Table 5.1), and on how to assign monitoring results to specific radionuclides and compounds. The TBD admits that, for many of the radionuclides, there is no specific information on the compounds with which they may have been associated. Insufficient guidance is provided on estimating internal doses for unmonitored workers. The information on bioassay programs is incomplete, as well as the list of radionuclides and compounds handled at the facility during the different time periods and in different locations. The TBD suggests that unmonitored workers should be assessed using coworker data and the tolerance levels, if there is evidence that they worked with uncontained radioactive materials; otherwise, environmental data should be used. This suggestion cannot be followed using the information available in the TBD. NIOSH should revise the site profile document to provide information sufficient for proper dose reconstruction, particularly for unmonitored workers.
SC&A's January 2012 update: The data and information relative to this issue in Section 5 of Rev. 02 of the 2010 TBD appear to be similar to that in Section 5 of Rev. 01 of the 2007 TBD; *therefore, this issue is still pertinent.*
NIOSH Response:
SC&A Reply:
Work Group Actions:
Board Action:

Issue 13: Inadequate Coverage of Occupational Environmental Dose
SC&A Finding: Section 4.0 of the TBD (ORAUT 2007), Occupational Environmental Dose, is incomplete and should be revised to provide a more comprehensive description of the historical environmental dose to workers at LBNL. The deficiencies and omissions are such that inadequate guidance is provided for dose reconstructors. NIOSH assumes that the gamma and neutron environmental exposure is primarily from accelerators and, thus, using the maximum measured value from the onsite and fence-line monitors for a given year would be claimant favorable. NIOSH fails to discuss the possible exposure of unmonitored workers from irradiators. In particular, the Co-60 irradiator housed in Building 74 may have been capable of higher doses at locations at distances less than those to the site perimeter or onsite monitoring locations (LBNL 1995a). Table 4-2, "Maximum site-wide annual median intakes (Bq/yr) via inhalation," contains the NIOSH best estimates of annual intakes. Except for tritium and C-14, the values in the table are based on gross alpha and beta measured values from the site environmental program. While this may be a conservative assumption relative to the effective dose equivalent (EDE), this may not be claimant favorable for specific organ doses. For example, for exposure to I-131, where the committed dose equivalent per unit intake for the thyroid is almost two orders of magnitude greater than for Sr-90, the dose to the thyroid would be grossly underestimated. Given the wide range of radioisotopes used at LBNL, NIOSH should present a more claimant-favorable approach to dose reconstruction for radionuclides whose intakes were determined from gross alpha and beta measurements.
SC&A's January 2012 update: The data and information relative to this issue in Section 4 of Rev. 02 of the 2010 TBD appear to be similar to that in Section 4 of Rev. 01 of the 2007 TBD; *therefore, this issue is still pertinent.*
NIOSH Response:
SC&A Reply:
Work Group Actions:
Board Action:

References:

Bennett, J., 1953. Memorandum on "Film Badge Testing," Lawrence Berkeley Laboratory, Berkeley, California. December 2, 1953.

LBNL 1995. *Lawrence Berkeley National Laboratory - 1994 Site Environmental Report*, LBL-27170 (1995 rev.), University of California, Berkeley, California, May 1995.

NIOSH 2002. *Technical Basis Document - External Dose Reconstruction Implementation Guideline*, OCAS-IG-001, Rev. 1, National Institute for Occupational Safety and Health, Office of Compensation Analysis and Support, Cincinnati, Ohio. August, 2002.

NIOSH 2009. *SEC-00160 – Petition for All employees who worked in any area at the Lawrence Berkeley National Laboratory from August 13, 1942 through December 31, 1961*. National Institute for Occupational Safety and Health, Office of Compensation Analysis and Support, Cincinnati, Ohio. December 18, 2009.

NIOSH 2010. *SEC Petition Evaluation Report, Petition SEC-00160*, Rev. 0. National Institute for Occupational Safety and Health, Office of Compensation Analysis and Support, Cincinnati, Ohio. January 20, 2010.

ORAUT 2007. *Technical Basis Document for the Lawrence Berkeley National Laboratory*, ORAUT-TKBS-0049, Rev. 01, Oak Ridge Associated Universities Team, Cincinnati, Ohio. April 2, 2007.

ORAUT 2010. *Technical Basis Document for the Lawrence Berkeley National Laboratory*, ORAUT-TKBS-0049, Rev. 02, Oak Ridge Associated Universities Team, Cincinnati, Ohio. May 10, 2010.

SC&A 2010. *Review of the NIOSH Site Profile for the Lawrence Berkeley National Laboratory*, ORAUT-TKBS-0049, Rev. 01, 2007. SCA-TR-TASK1-0002, January 22, 2010.