ORAU Team **NIOSH Dose Reconstruction Project** Technical Basis Document for the Oak Ridge National Laboratory – Introduction	Document Number: ORAUT-TKBS-0012-1 Effective Date: 08/11/2004 Revision No.: 00 Controlled Copy No.: ________ Page 1 of 7
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ACRONYMS AND ABBREVIATIONS

CEF	Critical Experiments Facility
DOE	U. S. Department of Energy
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
IREP	Interactive RadioEpidemiological Program
keV	kilovolt-electron, 1,000 electron volts
MDA	minimum detectable activity
NIOSH	National Institute of Occupational Safety and Health
NTA	nuclear track emulsion, type A
ORAU	Oak Ridge Associated Universities
ORNL	Oak Ridge National Laboratory
RaLa	radioactive lanthanum
TBD	Technical Basis Document
U.S.C.	United States Code

1.0 INTRODUCTION

1.1 PURPOSE

Technical Basis Documents (TBDs) and Site Profile Documents are general working documents that provide guidance concerning the preparation of dose reconstructions at particular sites or categories of sites. They will be revised in the event additional relevant information is obtained about the affected site(s). These documents may be used to assist the National Institute for Occupational Safety and Health (NIOSH) in the completion of the individual work required for each dose reconstruction.

In this document the word "facility" is used as a general term for an area, building, or group of buildings that served a specific purpose at a site. It does not necessarily connote an "atomic weapons employer facility" or a "Department of Energy facility" as defined in the Energy Employees Occupational Illness Compensation Program Act of 2000 [42 U.S.C. Sections 7384l(5) and (12)].

This Site Profile represents a specific support mechanism documenting historical practices at the Oak Ridge National Laboratory (ORNL), also historically known as the X-10 site. Dose reconstructors can use this Site Profile in the evaluation of both internal and external dosimetry data for unmonitored and monitored workers. The document also serves as a supplement to, or substitute for, individual monitoring data. It provides technical basis information to be used to evaluate the total occupational radiation dose for ORNL workers. This dose results from exposure to external and internal radiation sources in ORNL facilities, to diagnostic occupationally required X-ray examinations, and to on-site environmental sources. In addition, this Site Profile addresses doses that could have occurred while the worker was not monitored, or dose that could otherwise have been missed.

1.2 SCOPE

Five TBDs comprise the ORNL Site Profile: Site Description, Occupational Medical Dose, Occupational Environmental Dose, Occupational Internal Dose, and Occupational External Dose.

The Site Description TBD (ORAUT-TKBS-0012-2) presents a brief description of the facilities and processes at ORNL since the early 1940s.

The Oak Ridge Graphite Reactor, which was to be a pilot plant for the larger plutonium production reactors at the Hanford site, achieved initial criticality on November 4, 1943. The Graphite Reactor served only briefly in its role as a pilot plant, and quickly became an essential tool for basic research and for radioisotope production. The Graphite Reactor was the first of many reactors to operate at the ORNL site as the Laboratory expanded its research into the use of nuclear reactors in a number of domains including energy, propulsion systems, materials research, and radioisotope production. In addition, ORNL operated the Critical Experiments Facility (CEF) at the Y-12 site from mid-1950 until 1987. The CEF supported experiments in design of various reactors at ORNL and elsewhere.

A large part of the activities and operations at ORNL has been research and development into chemical technologies for separation of materials from irradiated nuclear fuels and liquid waste streams. ORNL developed many of the solvent extraction processes adopted at the Nation's plutonium production facilities, and at one time the facility was a substantial provider of radioisotopes for industry and research. ORNL also produced stable isotopes using Calutrons at the Y-12 site. Isotope sales were eventually scaled back to only highly specialized materials, such as ^{252}Cf from the High Flux Isotope Reactor, which was separated and packaged in the Radiochemical Engineering Development Center. Between 1944 and 1956, the Radioactive Lanthanum (RaLa) program was carried out at ORNL to produce large quantities of ^{140}Ba/La for use in weapons dynamics studies at the Los Alamos National Laboratory. The RaLa program involved dissolving short-decay uranium fuel slugs irradiated in either the ORNL Graphite Reactor or the production reactors at the Hanford site.

ORNL has operated several accelerators including the 86-inch cyclotron at the Y-12 site, the Oak Ridge Isochronous Cyclotron, the Holifield Heavy Ion Research Facility, and the Oak Ridge Electron Linear Accelerator. Other smaller accelerators have also been used for such applications as dosimetry research and waste assay research.

Waste handling practices at ORNL evolved as the scope and duration of its mission expanded. Gaseous wastes were initially discharged via local stacks and vents before a centralized offgas treatment system began operating in 1950. Liquid wastes were originally handled using a system of tank farms and settling basins to treat wastes before discharge into White Oak Creek. More liquid waste treatment facilities were added over time. A number of trenches, burial grounds, and Solid Waste Storage Areas have been at ORNL for the disposal of solid wastes.

The Occupational Medical Dose TBD (ORAUT-TKBS-0012-3) provides information on doses workers received from X-rays that were required as a condition of employment. These X-rays were included in pre-employment screenings, annual physical exams, and termination exams. These X-ray exams were initially performed at the local hospital in Oak Ridge, where photofluorographic techniques appear to have been used. The Laboratory took over with its own X-ray equipment on October 3, 1947, and those examinations were conventional exposures. Oak Ridge Hospital, as it was originally known, became what is now known as Methodist Medical Center of Oak Ridge in 1959.

Chest X-rays have always been an element of employment-related physical examinations conducted by ORNL. However, the frequency of these exams and the workers who received them have varied. It appears that all workers have been required to have a chest X-ray as part of their preplacement examination. In addition, chest X-rays were performed annually and as part of termination examinations before 1963, though employees were allowed to waive these examinations in some cases. After 1963, the ORNL conducted routine chest X-rays only for preplacement exams and workers involved in respiratory protection programs, such as the asbestos program that began in 1976. The frequency of chest X-rays for workers in the asbestos program has varied over time. From 1976 to November of 1990, it was every 3 years. From November of 1990 to 2002, it depended on the worker's age: every 3 years for workers under 40, every 2 years for workers 40 to 49, and annually for workers over 49. In 2002 the frequency for asbestos workers changed again to annually for workers 45 and over.

From April 6, 1950, to September 23, 1953, lumbar spine X-rays were included in preplacement examinations for craft employees (such as pipe fitters, carpenters) to determine if they had pre-existing back problems. These X-rays were in addition to the chest X-ray included in the preplacement examination for other employees.

Both the X-ray equipment and the techniques used for X-rays covered by this TBD have changed over the years. These factors were taken into account in determining the dose that a worker would have received from an X-ray. When there was doubt about the technique used, assumptions were made to ensure the worker's dose was not underestimated. The parameters considered include the tube current and voltage, exposure time, filtration, source to skin distance, the view (posterior-anterior or lateral), and other factors that could affect the dose received by the worker.

Doses to the various organs exposed from the different X-ray examinations a worker could have received have been estimated and presented in tables for convenient reference by the dose reconstructors.

The Occupational Environmental Dose TBD (ORAUT-TKBS-0012-4) applies to workers who were not monitored for external or internal radiation exposure. Environmental dose is that which workers could have received while being outdoors on the ORNL site from inhalation of radioactive materials in the air, direct radiation from airborne releases, or direct radiation in the vicinity of process buildings and waste handling areas.

The Occupational Environmental Dose TBD provides a table of annual average airborne concentration and intake data for ^{131}I, tritium, and particulate mixed fission products. The concentration data are derived from a combination of conservative assumptions of airborne releases and dispersion and on-site air-monitoring data. Annual intakes reflect assumptions of continuous exposure for a period of 2,000 hours per year at a respiration rate of 1.2 cubic meters per hour. The intake values given for tritium include a multiplier of 1.5 to account for absorption through the skin.

In addition, the Occupational Environmental Dose TBD provides a table of annual average exposure rates for the ORNL site. These values are averages of exposure rates measured at a large number of locations in the main process areas. The measurements began early in the Laboratory's history and continued through 1984. They began as periodic measurements using portable instrumentation and evolved to continuous measurements with dosimeters. The values include contributions from the settling basin and process buildings where local exposure rates were much higher than ambient levels elsewhere. They do not include data from remote monitoring locations representing background levels, and thus should represent conservative estimates for an unmonitored individual moving about on the ORNL site.

The Occupational Internal Dosimetry TBD (ORAUT-TKBS-0012-5) discusses ORNL's *in vitro* and *in vivo* monitoring programs and facilities, including counting methods, minimum detectable activities (MDAs), and reporting practices. Environmental levels of uranium and ^{137}Cs are also discussed. For *in vitro* methods, MDAs were established by extracting information from a database of raw bioassay data compiled by ORNL. This database was queried for data from historical bioassay analyses including background counts, instrument efficiencies, chemical yields (recoveries), sample volumes, and aliquot volumes. The queries returned over 66,000 records spanning the period from 1947 through 1988. The records were screened to eliminate those that were incomplete or contained gross errors. The remaining records were used to calculate MDAs for individual analyses. The individual MDA data were then analyzed collectively for common analyses to establish representative values for a given analyte and period. MDAs are in terms of disintegrations per minute per 24-hour sample for both urine and fecal samples. The TBD provides a table of representative MDA values for specific analytes and periods for dose reconstructors to use in assessment for the period before 1989. It also includes a table of the annual average MDA values computed for specific analytes from the information obtained from the database. After 1989, ORNL computed MDAs for each *in vitro* sample analysis and reported them as part of the results. The TBD includes a table of typical MDAs for various analytes for the post-1989 period.

The TBD provides descriptions and MDAs for a number of the *in vivo* counting systems and geometries employed at ORNL. Plots of MDA versus chest wall thickness are provided for the ORNL germanium lung counter for ^{235}U, ^{238}U, ^{238}Pu, and ^{241}Am, and for the phoswich lung counter for ^{238}Pu and ^{241}Am. The MDA values cited in the Occupational Internal Dosimetry TBD were taken primarily from ORNL's own TBD for *in vivo* monitoring. Some values came from other ORNL reports.

The Occupational External Dosimetry TBD (ORAUT-TKBS-0012-6) describes ORNL's personnel monitoring methods and practices for the period from October 1943 to the present. It covers the various dosimeters used at ORNL, worker badging practices, dosimeter exchange frequencies, dose quantities and algorithms, dosimeter calibration practices, and reporting and administrative practices. The TBD contains detailed information on mixed neutron/photon radiation fields present in several ORNL facilities. Photon and neutron energy groups to be assumed when entering worker dose histories into the IREP program are given. Neutron energy spectra are discussed vis-à-vis the 500-keV response threshold for nuclear track emulsion, type A (NTA) film. Neutron-to-photon dose ratios are provided for use in cases where neutron monitoring could have been inadequate, such as the use of NTA film for monitoring in low-energy fields. The TBD provides limits of detection to be assumed for beta-gamma and neutron dosimetry for estimating missed dose. Adjustments to reported dose values for input into the IREP program are discussed, such as the use of exposure-to-organ-dose conversion factors for deep dose values for the period before DOE Laboratory Accreditation Program accreditation, adjustment of open window dose values for different calibration practices, and adjustment of neutron dose values for different neutron quality factors used in different eras.