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ADVISORY BOARD ON RADIATION AND WORKER HEALTH

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

A REVIEW OF NIOSH'S PROGRAM EVALUATION REPORT DCAS-PER-047, "GRAND JUNCTION OPERATIONS OFFICE"

Contract No. 211-2014-58081
SCA-TR-PR2015-0093, Revision 1

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February 2015

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S. COHEN & ASSOCIATES: ***Technical Support for the Advisory Board on Radiation & Worker Health Review of NIOSH Dose Reconstruction Program***	Document No. SCA-TR-PR2015-0093, Revision 1 Effective Date: Draft – February 10, 2015
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Project Manager: _____ Date: _____ John Stiver, MS, CHP	Reviewer: John Stiver

Record of Revisions

Revision Number	Effective Date	Description of Revision
0 (Draft)	01/27/2015	Initial issue
1 (Draft)	02/10/2015	Added observation to Section 3.0. Requested additional data from NIOSH to adequately assess GJOO photon and neutron doses, and radon exposure, which resulted in the rewriting of Sections 4.1 and 4.2.3. Changed and eliminated some Exhibits in Attachment B and renamed the attachment accordingly. Moved two Exhibits from Attachment B to Attachment C. Some minor formatting and typographical issues addressed.

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ABBREVIATIONS AND ACRONYMS

Advisory Board or Board	Advisory Board on Radiation and Worker Health
AEC	Atomic Energy Commission
AP	anterior-posterior
Bq/g	becquerels per gram
CEP	Controls for Environmental Pollution
CFR	*Code of Federal Regulations*
DAC	derived air concentration
DCAS	Division of Compensation Analysis and Support
D&D	decontamination and decommissioning
d/yr	day per year
DCF	dose conversion factor
DOE	(U.S.) Department of Energy
DR	dose reconstruction
EEOICPA	Energy Employees Occupational Illness Compensation Program Act
GJOO	Grand Junction Operations Office
GJRAP	Grand Junction Remedial Action Program
GM	geometric mean
GSD	geometric standard deviation
hr/d	hours per day
HT	target organ
ICRP	International Commission on Radiological Protection
IG	Implementation Guide
INL	Idaho National Laboratory
IREP	Interactive RadioEpidemiological Program
keV	kilo electron volt
Ln	lognormal
LOD	limit of detection
$\mu Ci/m^3$	microcurie per cubic meter
µCi/mg	microcurie per milligram
µCI/ml	microcurie per milliliter
µCI/yr	microcurie per year
m	meter

m^3/hr	cubic meter per hour
MeV	million electron volts
mg	milligram
mg/m^3	milligrams per cubic meter
mg/yr	millgram per year
MPC	maximum permissible concentration
mrem	millirem
NIOSH	National Institute for Occupational Safety and Health
NURE	National Uranium Resource Evaluation
OCAS	Office of Compensation Analysis and Support
ORAUT	Oak Ridge Associated Universities Team
pCi/l	picocurie per liter
pCi/mg	picocurie per milligram
PEP	Program Evaluation Plan
PER	Program Evaluation Report
POC	probability of causation
Qtr	quarter
R	Roentgen
rem	roentgen equivalent man
REMS	Radiation Exposure Monitoring System
SC&A	S. Cohen and Associates (SC&A, Inc.)
SEC	Special Exposure Cohort
SNL	Sandia National Laboratory
SRDB	Site Research Database
TBD	technical basis document
TIB	technical information bulletin
TLD	thermoluminescent dosimeter
U	uranium
UMTRA	Uranium Mill Tailing Remedial Action
U_3O_8	uranium oxide
WL	working level
WLM	working level month
yr	year

1.0 STATEMENT OF PURPOSE

To support dose reconstruction (DR), the National Institute for Occupational Safety and Health (NIOSH) and the Oak Ridge Associated Universities Team (ORAUT) have assembled a large body of guidance documents, workbooks, computer codes, and tools. In recognition of the fact that all of these supporting elements in DR may be subject to revisions, provisions exist for evaluating the effect of such programmatic revisions on the outcome of previously completed DRs. Such revisions may be prompted by document revisions due to new information, misinterpretation of guidance, changes in policy, and/or programmatic improvements.

The process for evaluating potential impacts of programmatic changes on previously completed DRs has been proceduralized in OCAS-PR-008, *Preparation of Program Evaluation Reports and Program Evaluation Plans* (OCAS 2006), Revision 2, dated December 6, 2006. This procedure describes the format and methodology to be employed in preparing a Program Evaluation Report (PER) and a Program Evaluation Plan (PEP).

A PER provides a critical evaluation of the effect(s) that a given issue/programmatic change may have on previously completed DRs. This includes a qualitative and quantitative assessment of potential impacts. Most important in this assessment is the potential impact(s) on the Probability of Causation (POC) of previously completed DRs with POCs of <50%.

During a teleconference by the Advisory Board's Procedures Review Subcommittee meeting on August 28, 2014, SC&A was tasked by the Board to conduct reviews of two PERs. Included among the PERs is DCAS-PER-047*, Grand Junction Operations Office* (DCAS 2014). In conducting a PER review, SC&A is committed to perform the following five subtasks, each of which is discussed in this report:

Subtask 1: Assess NIOSH's evaluation/characterization of the "issue" and its potential impacts on DR. Our assessment intends to ensure that the "issue" was fully understood and characterized in the PER.

Subtask 2: Assess NIOSH's specific methods for corrective action. In instances where the PER involves a technical issue that is supported by document(s) [e.g., white papers, technical information bulletins (TIBs), procedures] that have not yet been subjected to a formal SC&A review, Subtask 2 will include a review of the scientific basis and/or sources of information to ensure the credibility of the corrective action and its consistency with current/consensus science. Conversely, if such technical documentation has been formalized and previously subjected to a review by SC&A, Subtask 2 will simply provide a brief summary/conclusion of this review process.

Subtask 3: Evaluate the PER's stated **approach** for identifying the universe of potentially affected DRs, and assess the **criteria** by which a subset of potentially affected DRs was selected for re-evaluation. The second step may have important implications in instances where the universe of previously denied DRs is very large and, for reasons of practicality, NIOSH's re-evaluation is confined to a subset of DRs that, based on their scientific

judgment, have the potential to be significantly affected by the PER. In behalf of Subtask 3, SC&A will also evaluate the timeliness for the completion of the PER.

Subtask 4: Conduct audits of DRs affected by the PER under review. The number of DRs selected for audit for a given PER will vary. (It is assumed that the selection of the DRs and the total number of DR audits per PER will be made by the Advisory Board.)

Subtask 5: Prepare a written report that contains the results of DR audits under Subtask 4, along with our review conclusions.

2.0 RELEVANT BACKGROUND INFORMATION

2.1 OVERVIEW OF FACILITY HISTORY

Between 1943 and 1946, the Manhattan Engineering District acquired the Grand Junction site in order to concentrate U_3O_8 from "green sludge" considered a byproduct of vanadium production. Subsequently in 1947, the U.S. Atomic Energy Commission (AEC) established a domestic uranium procurement program that was responsible for the receipt, sampling, and analysis of uranium (and vanadium) concentrates purchased from domestic ore processing operations until 1974.

From 1974 to 1984, the Grand Junction Operations Office (GJOO) supported the National Uranium Resource Evaluation (NURE) Program in the preparation of samples prior to analytical analysis. Sample preparation activities, which included crushing, sizing, and blending, posed the greatest potential for internal exposure.

Other activities included cleanup activities under the Uranium Mill Tailing Remedial Action (UMTRA) program starting in 1978, and the Grand Junction Remedial Action Program (GJRAP) involving 600 vicinity **offsite** properties from 1972 to 1988. However, offsite soil samples were prepared and analyzed in onsite facilities. By 2001, remediation that included onsite buildings had been completed and the facility had been approved for unrestricted use, but remains under the (U.S.) Department of Energy's (DOE's) purview to this day.

2.2 LIMITATIONS PERTAINING TO MONITORING DATA FOR GJOO WORKERS AND THE INCLUSION IN THE SEC

On April 29, 2011, the Secretary of Health and Human Services designated a Special Exposure Cohort (SEC) for workers at the GJOO (NIOSH 2011). The SEC designation was based on the following deficiencies/limitations:

- NIOSH determined that there are insufficient personnel monitoring, workplace monitoring, or source term data to estimate **unmonitored external exposures** for the period March 23, 1943, through December 31, 1959.

- NIOSH determined that there are insufficient information/data to reconstruct internal doses from all potential sources (inclusive of radon) during the period from March 23, 1943, through January 31, 1975.

Although NIOSH concluded that it is not possible to reconstruct all radiation doses for employees who worked at the GJOO during the period from March 23, 1943, through January 31, 1975, NIOSH nevertheless intends to use any available/credible internal and external monitoring data for DRs of individuals who do not qualify for inclusion in the SEC.

3.0 SUBTASK 1: IDENTIFY THE CIRCUMSTANCES THAT NECESSITATED THE NEED FOR DCAS-PER-047

No Technical Basis Document (TBD) has been developed for DRs of workers at the GJOO; however, a "template" had been developed for guidance to assess exposures in behalf of claims. During NIOSH's evaluation of the GJOO SEC petition, a substantial body of new information was discovered with the potential for significant impacts on previously completed DRs. The availability of new data for DR required the original template to be revised on September 5, 2012, and the subsequent issuance of DCAS-PER-047 on March 26, 2014, in order to evaluate the effect of these revisions on previous DRs.

Among additional data requiring revisions to the GJOO template were the following:

- External dosimetry data for years between 1982 and 1998 containing 15,000 records with gamma and beta results and a limited number of neutron exposures.
- Source term data for modeling neutron exposures.
- Surrogate exposure data for assigning annual gamma and beta doses to unmonitored workers.
- Air sampling data that included radon measurements.

SC&A's Comments

Among programmatic revisions that may impact the outcome of previously completed DRs and mandate the need for a PER, none is more justifiable than the discovery of new/site-specific information with the potential of significantly raising estimates of radiation exposures/doses.

Based on the acquisition of new data for the GJOO facility as provided in the revised GJOO template, SC&A concurs with the issuance of DCAS-PER-047, and there are **no findings**.

A central component for SC&A's review of DCAS-PER-047 is a critical assessment of the **revised GJOO template**. Templates (inclusive of the GJOO template), however, are **not** posted/available on the NIOSH website and can only be retrieved in **conjunction** with a completed Dose Reconstruction Report for a claimant who worked at the GJOO facility.

Observation #1. For facilities with no TBD and for which a "template" has been developed, such a template should be made available to SC&A on the NIOSH website without having to obtain a GJOO claimant's Dose Reconstruction Report (containing Privacy Act information/data that are not the focus of the review).

4.0 SUBTASK 2: ASSESS NIOSH'S SPECIFIC METHODS FOR CORRECTIVE ACTION

In instances where the PER involves technical issues that are supported by a document that has been formalized, Subtask 2 will provide a brief summary of said document.

As stated in Section 3.0, the discovery of new data prompted NIOSH to revise/edit the **original template** issued on September 5, 2012, as the principal guidance document for the DR of GJOO claims. As a convenience to the reader, excerpts of the revised template for GJOO are enclosed herein as Attachment A in a modified form in which Tables are numerically identified.

4.1 AN OVERVIEW OF THE GJOO "REVISED TEMPLATE" FOR EXTERNAL EXPOSURES

SC&A critically reviewed both the old and the revised templates and assessed the changes introduced. Summarized below are key changes, which reflect newly discovered data that are site-specific, as well as other data that NIOSH employed as surrogate values, along with comments/findings by SC&A.

4.1.1 Additional External Dose Data

NIOSH discovered a data report provided by the Idaho National Laboratory (INL), which contained more than 15,000 records of external monitoring data of GJOO workers for the period **1982** to **1998**. These records identify gamma (penetrating) doses and the **contribution** of the beta dose to the skin. Records also include a limited number of workers who were assessed for neutron exposures in the early years, but whose numbers increased in later years.

SC&A's Comments. SC&A briefly reviewed the collated exposure data cited in the ORAUT's *Grand Junction Operations Office Dosimetry Spreadsheet, 1986–2007* (ORAUT undated) and verified dates, the number of available records, reported exposures for gamma (penetrating dose), beta (non-penetrating dose), and the very limited number of neutron measurements. The overwhelming gamma and beta exposures were recorded as zero (0) values and suggest low exposures for the operational and decontamination and decommissioning (D&D) periods between 1982 and 1998.

4.1.2 Changes to the Assignment of External Dose for Unmonitored Workers for Years 1960 through 2009

Although NIOSH assumed that all radiation workers at GJOO had been monitored, NIOSH also concluded that there were questions about the availability and completeness of these records.

Deep Dose

To address these concerns, NIOSH derived **annual deep doses** for the years 1960 through 2009 in behalf of three categories of workers by means of surrogate data that represent ". . . maximum values from the **DOE Annual Report** summaries or the 95th percentile value from the **REM**

database" (See Table 1 of Attachment A) [Emphasis added]. A review of Attachment A, however, provides **no** reference(s) or databases, which served as the source for values shown in Table 1 of Attachment A.

SC&A's Comments/Findings

In an attempt to verify "unmonitored gamma doses" cited in Table 1 of the revised GJOO template (see Attachment A), SC&A compared these values to values cited by NIOSH, as given in Exhibit B-1 of Attachment B. For illustration, the following data for 1985 should be compared.

GJOO Template Data. Table 1 of Attachment A identifies a deep dose of 0.090 rem to be assigned for 1985 to a GJOO worker classified as Operator/Laborer. In behalf of Table 1, the GJOO template provides the following explanation/guidance for the assignment of doses for unmonitored workers:

> ***Deep Dose***
> *The maximum values from the DOE annual report summary or the* ***95th percentile value from the REMS database*** *has been applied as a* ***single exchange*** *with missed dose applied to all other exchanges. This value was used to determine dose for the unmonitored "Operator/Laborer Dose" category as summarized in the table below.* [Emphasis added.]

For the year 1985, dosimeters were exchanged quarterly (i.e., four times per year) and the LOD value was 20 mrem. Thus, the 95th percentile recommended annual dose of 90 mrem represents the following components.

$$90 \text{ mrem} = (95^{th} \text{ percentile of neared doses}) + (3 \times \text{LOD}/2)$$
$$= 60 \text{ mrem} + 30 \text{ mrem}$$

Data Shown in Exhibit B-1. Exhibit B-2 represents data cited in Section 6.2 of the NIOSH *SEC Petition Evaluation, Report Petition SEC-00175* (NIOSH 2011) that was issued January 11, 2011. The following reported photon exposures (i.e., deep dose) correspond to the year 1985:

No. of Individuals	Average Dose (mrem)	Maximum Dose (mrem)	GM (mrem)	GSD	95th Percentile Dose (mrem)
118	126.91	8,500	55.07	1.7	132.18

Thus, for the 118 individuals with measurable doses in 1985, the 95th percentile dose was 132.12 mrem, which does **not** include the aforementioned three missed doses that would raise the dose to a total of **162.18 mrem** for 1985.

The dose of 162 mrem is 72 mrem higher than the 90 mrem dose cited in Table 1 of the GJOO template. Based on this discrepancy (which is shared with all other years), SC&A in its first draft report issued on January 27, 2015, cautiously classified this as a "**conditional finding**."

SC&A was requested to contact NIOSH in order to resolve this discrepancy in behalf of Conditional Finding #1, as well as Conditional Findings #4 and #6. In response to SC&A's request for information that would explain the observed discrepancy, NIOSH provided the Excel spreadsheet "JGOO Photon.xlsx," which provided dosimetry data for all years (1960–2009).

For illustration and comparison to data shown above, SC&A selected spreadsheet data for photon doses monitored at GJOO in 1985 (see Exhibit B-2 and Exhibit B-3).

Exhibit B-2 cites annual dosimeter data for **118 workers** who had a measurable dose in 1985, as identified in Column C. It must be noted, however, that dose values in Column C are **not** real doses, but represent **midpoint dose values** of a distribution published in DOE reports (see Exhibit C-1 of Attachment C). Thus, in 1985, there was 1 person with a dosimeter reading between 8–9 rem, 5 persons with dosimeter readings between 100–250 mrem, and 112 persons with "measureable [sic] doses" between 0–100 mrem.

Exhibit B-3 cites annual dosimeter data for **528 GJOO workers** with measurable and **non-**measurable doses in 1985. Thus, Exhibit B-3 includes all data cited in Exhibit B-2 plus a total of **410 workers with non-measurable dosimeter data** whose assigned 1985 exposures are limited to four missed doses, or 40 mrem.

Table 1 summarizes derived doses representing Table 1 of the revised GJOO template (see Attachment A), and Exhibit B-1, Exhibit B-2, and Exhibit B-3 in Attachment B.

Table 1. 95th Percentile Dose for Unmonitored GJOO Workers for 1985

Reference (Source)	No. of Individuals	95th Percentile Dose (rem)
Table 1[a]		0.090
Exhibit B-1[b]	118	0.162[e]
Exhibit B-2[c]	118	0.163
Exhibit B-3[d]	528	0.090

[a] From Table 1 of the GJOO revised template.
[b] From Section 6.2, Table 6-4, of SEC Petition Evaluation Report, Petition SEC-00175.
[c] From spreadsheet GJOO Photon.xlsx: worker data with **measurable** dosimeter response for 1985.
[d] From spreadsheet GJOO Photon.xlsx: worker data with measurable and **non-**measurable dosimeter responses for 1985.
[e] Includes missed dose of 30 mrem.

A comparison of doses identifies the fact that the recommended 95th percentile dose of 0.090 rem in Table 1 of the GJOO revised template was defined by data representing Exhibit B-3, which includes 410 workers with **non-measurable** doses among the 528 total workers for 1985.

Conversely, Exhibit B-1 (which represents data cited in the GJOO SEC Petition Evaluation Report) identifies the 95th percentile dose of 0.162 rem that corresponds to data that are restricted to the 118 GJOO workers with measurable doses.

Based on these data, SC&A recommends that this discrepancy be resolved in favor of higher doses that **exclude** data representing workers with **non**-measurable doses for the following reasons:

- Operators/laborers are traditionally regarded by NIOSH as the most highly exposed group among monitored workers and the inclusion of a majority fraction of workers with **non**-measurable exposures is inconsistent with the concept.

- Secondly, there is inconsistency between data previously cited in the GJOO SEC Evaluation Report issued in January 2011 and the revised GJOO template issued in September 2012.

- Lastly, there is inconsistency within Table 1 of the revised GJOO template regarding the methodology for deriving ". . . **maximum values** from the DOE annual report summary [versus] the 95th percentile value from the REMS database." [Emphasis added.]

  "Maximum values" from the DOE annual reports as used for years 1960–1984 are based on the highest dose equivalent range to which even a **single** GJOO worker belonged. As an **extreme example**, had this protocol been extended to include the year 1985, Exhibit B-1 shows a maximum individual with exposure of 8,500 mrem. Thus, this value would have been assigned as the 95th percentile dose to unmonitored workers, which is nearly 100 times higher than the 90 mrem value recommended in Table 1 of the GJOO template.

  A second factor that precludes a common methodology for all years is the fact that prior to 1974, there was no separation between measurable and non-measurable dosimeter doses between 0–1 rem (see Exhibit C-2 of Attachment C). For this reason, exposures cited in Table 1 of the GJOO revised template identify the identical dose of 1.500 rem for all years 1960–1974. This value includes 1 rem of dose based on limitations that define the methodology for aggregating doses during these years, and 0.500 rem for 25 missed doses.

  The use of two very different approaches for deriving assigned doses to unmonitored workers is evident by the more than 10-fold change in dose between years pre- and post-1985.

Finding #1. Dose estimates defined in Table 1 of the revised GJOO template are not only inconsistent with data cited in the Petition Evaluation Report for SEC-00175, but are inappropriately derived. SC&A recommends the exclusion of non-measurable data for deriving the 95th percentile value for Operators/Laborers, and proportional adjustments for Supervisors and Administrative personnel for the years 1985 through 2009.

Shallow Dose

For the assignment of a shallow dose for unmonitored workers, NIOSH recommends a beta-to-gamma ratio of 1.5 for all years (i.e., 1960–2009).

SC&A's Comments

SC&A reviewed the 95th percentile beta-to-photon doses cited in REMS (see Exhibits B-1 and B-4 in Attachment B) and concluded that the beta-to-gamma ratio of 1.5 selected by NIOSH was appropriate and claimant favorable.

Neutron Dose

Due to the limited availability of neutron exposure data prior to 1985, REMS neutron data for the years 1986–2009 were analyzed to obtain the 95th and 50th percentiles. These values were assigned to "geologists" and "all others," respectively, on the assumption that pre-1985 exposures were similar to post-1985 exposures.

SC&A's Comments/Findings

SC&A reviewed neutron exposures cited in REMS for years 1985 through 2009 (see Exhibit B-5 in Attachment B) as a basis for assigning neutron doses, as given in Table 2 of the revised template (see Attachment A). Table 2 of the template identifies neutron doses of 0.123 rem and 0.031 rem as the 95th and 50th percentile values, respectively, for pre-1981 years, as well as for years 1981–1985.

Based on neutron data cited in the Petition Evaluation Report for Petition SEC-00175 and reproduced herein as Exhibit B-5 in Attachment B, SC&A was uncertain how NIOSH used these data to derive neutron doses cited in Table 2 of the revised GJOO template. In response to a request for additional information, SC&A received neutron data from NIOSH that are enclosed herein as Exhibit B-6 in Attachment B.

Exhibit B-6 identified individual neutron doses for select years that include 1986–1992, 1996–1999, and 2003–2004. For example, for 1986, there were six dosimeter readings that represented the following: average neutron dose of 94.17 mrem; a maximum dose of 181 mrem; a GM dose of 79.21 mrem; and a 95th percentile dose of 207.01 mrem. These values match values for 1986 data shown in Exhibit B-5 and, therefore, reflect data representing data presented by NIOSH in the GJOO SEC Petition Evaluation Report.

As shown in Exhibit B-6, NIOSH converted all 66 dosimeter values to their lognormal (Ln) values, yielding a Ln(Total) value of 227.65. When divided by 66, the mean Ln value of 3.450 yields a GM dose of 31.48 mrem with a GSD of 2.2944 and the following 95th percentile dose:

$$\begin{aligned} 95^{th}\text{ Percentile Dose} &= (31.48)\,(2.2944)^{1.645}\text{ mrem} \\ &= (31.48)\,(3.919)\text{ mrem} \\ &= 123\text{ mrem} \end{aligned}$$

The derived values of 0.031 and 0.123 rem from data shown in Exhibit B-6 match the values of 0.031 and 0.123 rem cited in Table 2 of the revised GJOO template (see Attachment A).

While SC&A was able to match dosimeter data in Exhibit B-6 with neutron doses recommended in Table 2 of the GJOO template, SC&A questions the inclusion of data that involve dosimeter values that are well below LOD values.

Footnotes *c* and *d* of Table 2 of the GJOO revised template identify that, for neutron dosimeters, the LOD of 40 mrem is assumed. Inspection of Exhibit B-6 shows that a total of 40 dosimeters registered doses less than 40 mrem and 15 registered doses below LOD/2.

SC&A recalculated the GM dose and the 95th percentile dose for the 26 dosimeter values with ≥ 40 mrem values. Using this restrictive dataset, SC&A derived the GM dose of 67.85 mrem and the 95th percentile dose of 158.62 mrem (see Exhibit B-7 in Attachment B).

Not surprisingly, both of these values are significantly higher than the corresponding neutron values of 31 mrem and 123 mrem cited in Table 2 of the GJOO revised template.

Finding #2. SC&A recommends the exclusion of neutron dosimeter values below the LOD value of 40 mrem for deriving GM and 95th percentile neutron doses for unmonitored GJOO personnel for all years prior to 1985.

4.1.3 Occupational Medical Dose

The assignment of medical exposures applies to two time periods; (1) 1943 through 1946, and (2) 1962 through 1969. For all other years, x-rays were taken **offsite** and are, therefore, not included for DR. For the assignment/derivation of organ dose(s), the revised template provides the following guidance:

> *A **pre-employment, annual,** and **post-employment anterior-posterior (AP) chest and AP pelvis** X-ray should be assumed for **each year** during the operational period prior to 1947. Between 1962 and 1969, a **pre-employment, annual,** and **post-employments chest X-ray** is assumed. However, since the view type is not known and the X-rays were done by a portable X-ray machine, all views should be considered (anterior-posterior, posterior-anterior, and photofluorographic).* [Emphasis added.]

SC&A's Comments/Findings

Guidance for assigning occupational medical dose as currently stated in the template appears misleading and is assumedly incorrect. For example, for the years 1943 through 1946, the following guidance is given:

> *. . . A pre-employment, annual, and post-employment **anterior-posterior** (AP) chest and AP pelvis X-ray should be assumed for **each year** during the operational period prior to 1947.* [Emphasis added.]

Taken literally/verbatim, this would imply the assignment of six x-rays per year, and for an employment period of 1943–1946, a total of 24 medical x-rays could be assigned. Obviously, this guidance is incorrect and needs to be properly phrased (i.e., remove words 'each year.')

Observation #2. Current guidance for the assignment of medical x-rays is ambiguous and requires clarification/editing.

4.2 AN OVERVIEW OF THE GJOO FACILITY'S "REVISED TEMPLATE" FOR INTERNAL EXPOSURES

4.2.1 Bioassay Monitoring Data

Although there is no comprehensive bioassay database for the GJOO site, there are, nevertheless, limited/incomplete data during the SEC period (i.e., 1943–1975). For post-1975 years, the template provides the following additional information.

> *. . . **No** bioassay samples have been captured for the period from February 1975 (the end of the SEC period) until 1984. . . . The samples [i.e., urine and fecal] collected for the post-1975 period were for both off-site and on-site work. Therefore, for a given worker, the samples might **not** be for work that is covered by EEOICPA* [42 U.S.C. §§ 7384 *et seq.*]. [Emphasis added.]

SC&A's Comments

As previously stated in the template, when bioassay data are available during the SEC period (i.e., prior to 1975), they may, in fact, be used for a partial DR under select conditions (e.g., employment of less than 250 days or a member of the SEC class with a second, but non-presumptive, cancer).

For post-1975 periods, bioassay data are either unavailable or are compromised by the inability to segregate offsite from onsite exposures. For said reasons, estimates of internal exposures were derived/modeled from air monitoring data, as discussed below.

4.2.2 Air Monitoring Data

Prior to 1989, air samples **generally** lacked information regarding location. However, in 1986, time-weighted exposures for the first quarter were calculated in terms of maximum permissible concentration (MPC)-hours for individuals performing grinding operations of uranium mill tailings in the sample preparation laboratory. The exposure in MPC-hours was documented for the highest-exposed individual.

Additionally, the revised GJOO template references the following other data for dose modeling/ reconstruction:

(1) Among air samples recovered in the sample preparation area was a 1980 sample that was identified as "the most concentrated sample containing 0.0046 mg/m^3 of uranium."

(2) Five hundred and sixty-nine air sample measurements were recovered for on-site D&D work, including both general area and breathing zone samples. . . . These samples can be used to assign doses to D&D workers and others (supervisors, etc.) if individual bioassay results are not available.

SC&A's Comments and Findings

In behalf of air monitoring data, NIOSH provided the reference ORAUT 1981 for the most concentrated air sample containing 0.0046 mg of uranium, and the reference ORAUT 1986 for the exposure in MPC-hours for the highest exposed sample preparation worker in 1986. SC&A reviewed these documents and verified values stated therein. However, no reference is provided that identifies the source/document for the ". . . Five hundred and sixty-nine air sample measurements [that] were recovered for on-site D&D work . . ." that spans the period 1989–2009.

These **three** independent air sampling datasets were used by NIOSH for the development of inhalation and ingestion intake rates discussed in Section 4.2.3 below.

Finding #3. NIOSH provides neither the raw data nor a documented source for the 569 air sample measurements associated with D&D work for years 1989–2006.

4.2.3 Modeled Doses for Internally Exposed Unmonitored Individuals

Sample Preparation. For the post-1975 SEC period, unmonitored internal exposures for workers engaged in **sample preparation** were modeled for two time periods—1975 to 1984, and 1985 to 2003—and for four different worker categories engaged in **sample preparations**. For the **first period** (i.e., 1975–1984), all modeled doses were based on the highest-recorded air sample value of 0.0046 mg/m^3 of **uranium ore** taken in the Sample Plant in July 1980.

For the second period (i.e., 1985–2003), intake values were based on time-weighted MPC-hr exposure to the highest exposed individual. The assigned MPC-hr exposure was conservatively assumed to represent thorium-230 (which has the most restrictive MPC value).

Decontamination and Decommissioning. Internal exposures due to inhalation and ingestion of airborne contaminants among D&D workers for the period 1989–2006 were based on the 95th percentile value of 569 air samples representing both **general area** and **breathing zone** samples.

Modeled estimates of inhalation and ingestion rates for unmonitored worker groups are cited in Table 4 of Attachment A. Provided below is SC&A's attempt to match a sample set of values reported in Table 4 of the revised template.

SC&A's Comments and Findings

A standard element of SC&A's audit is to verify key sources of data/information, as well as the associated methods used by NIOSH to derive intake estimates, such as those cited in Table 4 of Attachment A.

- Assessment of Intake Rates during Ore Sample Preparation (1975–1984). Intake estimates were based on the "highest air concentration" sample containing 0.0046 mg/m^3 of uranium.

For the highest exposed worker (i.e., operator), SC&A derived the following annual intakes:

Total U-234, -235, -238 inhaled per year (mg/yr):
(0.0046 mg/m^3)(1.2 m^3/hr)(8 hr/d)(250 d/yr) = 11.04 mg/yr

Total U inhaled per year (µCi/yr):
(11.04 mg/yr)(6.83E-04 µCi/mg) = 7.54E-03 µCi/yr

Total Th-230 and Ra-226 inhaled per year:
Based on activity fractions defined in Table 1 of Attachment A, SC&A calculates the following yearly intakes:

For Th-230 or Ra-226 = (Activity for U)(Activity fraction)
= (7.54E-03 µCi/yr)(0.249/0.502)
= 3.74E-03 µCi/yr

A comparison of values derived by SC&A to those cited in Table 4 of Attachment A shows that, for the Operator, the intake of uranium at 7.54E-03 µCi/yr matches the value of 7.57E-03 µCi/yr cited by NIOSH.

For both Th-230 and Ra-226, SC&A's derived yearly intake rate of 3.74E-03 is slightly less than **one-half** of NIOSH's derived value of 7.57E-3 µCi/yr.

Finding #4. In the derivation of intake rates for Ra-226 and Th-230, NIOSH failed to employ activity fractions cited in Table 3 of Attachment A.

- Assessment of Intake Rates during Tailing Sample Preparation (1985–2003)
Intake rates for this time period were based on MPC-hr data assigned to the highest exposed worker.

For the highest exposed worker (i.e., operator), SC&A calculates the following intakes that are based on the assigned value of 61 MPC-hrs/Qtr for Th-230:

- Annual Th-230 Exposure = (61 MPC-hr/Qtr)(4 Qtr/yr)
= 244 MPC-hrs/yr

- Annual Inhalation Th-230 = (244 MPC-hrs/yr)(MPC_{Th-230})
(for a breathing rate of 1.2 m^3/hr and the MPC value of 1×10^{-5} µCi/m^3)

Annual Inhalation Th-230 = (244 MPC-hr/yr)(1.2 m^3/hr)(1E-05 µCi/m^3
Annual Inhalation Th-230 = 2.928E-03 µCi/yr

- Annual Inhalation U-234, -235, -238 = (2.928E-03 µCi/yr)(Activity fraction)
= (2.928E-03 µCi/yr)(0.092/0.454)
= 0.593 µCi/yr

A comparison of values derived by SC&A to values cited in Table 2 of Attachment A show **essential equivalency.** (The slightly lower value derived by NIOSH assumes 2,000 work-hrs/yr (or 500 work-hrs/Qtr) versus the 2,080 work-hrs/yr (or 40 work-hrs/ week) defined in 10 CFR 20, Appendix B.)

There are **no findings** associated with the intake rates (inhalation and ingestion) assigned to workers engaged in sample preparation of **tailings** for years 1985–2003.

- Assessment of Intake Rates during D&D Activities for Years 1989–2006
  The revised template states that ". . . The 95th percentile of the lognormal analysis was used to determine the intake rates to be assigned."

  SC&A assumes that the "95th percentile of the lognormal analysis . . ." refers to the aforementioned 569 air sample measurements that NIOSH recovered for onsite D&D, which, however, were not referenced (see Finding #3 above).

  In the absence of data, SC&A is not able to assess/confirm assigned intakes during D&D activities cited in Table 2 of Attachment A.

Radon Exposures. The revised template states that:

> *. . . Radon in buildings was studied extensively in the D&D era (1989–2001) . . . including 300 daughter measurements taken in 1985 . . . In 1990, the site implemented and participated in the DOE radon study that included all occupied buildings on site at that time. The available radon measurements can be used to establish the dose from radon and decay products for February 1, 1975, to December 31, 2001. . . .* ***The table below provides the results of a lognormal analysis of the 1990 radon study.*** [Emphasis added.]

Based on these statements the revised template identifies radon concentrations/exposures for the following two time periods:

Years	Radon Concentration	WLM/yr
1975–1998	5.7 pCi/l	3.4E-01
1999–2001	1.6 pCi/l	9.6E-02

SC&A's Comments and Findings

In spite of several cited radon surveys/studies (including the "1990 radon study" as the source for deriving radon exposures cited above), the template does not identify these studies in its Reference List.

Upon request, NIOSH submitted the following additional information in support of the above-cited radon data:

- By 1975, the last drum of concentrated radium-containing material had been shipped offsite and it is assumed that radium contamination remained constant until remediation in 1997–1998.

- The 1990 radon study showed that only three buildings showed radon levels above 4 pCi/l, with the highest recorded level at **5.7 pCi/l**.

- Following remediation, radon levels were reduced to **1.6 pCi/l**.

- After 2001, radon levels were reduced to background levels.

In context with the additional information provided by NIOSH, SC&A concurs with radon exposure estimates cited in the revised GJOO template, and there are no findings.

5.0 SUBTASK 3: EVALUATE THE PER'S STATED APPROACH FOR IDENTIFYING THE UNIVERSE OF POTENTIALLY AFFECTED DRs

Given the extensive revision to the original template, NIOSH reviewed **all claims** (independent of the issue date of the revised template) to determine if the latest information (i.e., revised template) was used. Additionally, claims with **no** employment **after 1959** were not considered for re-evaluation, provided they met criteria needed for inclusion to the added SEC class(es).

These screening criteria identified a total of 24 claims requiring re-evaluation using guidance contained in the revised GJOO template. The re-evaluation of these 24 claims yielded the following POC values:

- The POC values for 22 claims remained below 45%.
- For one claim, the revised POC fell between 45% and 50% and required further evaluation, with 30 Interactive RadioEpidemiological Program (IREP) Input runs of 10,000 iterations each. The final POC, however, remained below 50%.
- For the single remaining claim, the revised POC exceeded 50%.

SC&A's Comments

SC&A's assessment of DCAS-PER-047 included a critical comparison between the original and revised GJOO templates. SC&A concurs with NIOSH that revisions were extensive and mandated a review of all previously completed claims that represented the original template and were exempt from inclusion in the SEC class.

There are no findings pertaining to the selection criteria used to identify claims potentially affected by PER-047 and the need for re-evaluation.

6.0 SUBTASK 4: CONDUCT AUDITS OF A SAMPLE SET OF DRs AFFECTED BY DCAS-PER-047

NIOSH identified a total of 24 **re-evaluated** DRs/claims, of which 22 claims yielded POCs below 45%, one claim resulted in a POC between 45% and 50%, and one claim exceeded 50%.

SC&A's assessment suggests that the impact of DCAS-PER-047 and the implementation of dose reconstruction under the revised template are likely to vary significantly among the 24 claims subject for selection and review by SC&A.

Most significantly impacted are claims with prolonged employment periods that (1) either post-date 1960 (when unmonitored external dose can be reconstructed) and/or post-date 1975 (when unmonitored internal and radon doses can be reconstructed); and (2) involve workers in the job category of operators/general laborers.

SC&A therefore recommends the selection of three (3) cases with significant employment periods as operators/laborers for the following three employment periods:

(1) Post-1960
(2) Post-1975 (sample preparation period)
(3) Post-1989 (or the D&D period)

7.0 REFERENCES

10 CFR 20, Appendix B. *Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage*; Final Rule, 56 FR 23409, May 21, 1991.

42 CFR 82, 2002. *Methods for Radiation Dose Reconstruction under the Energy Employees Occupational Illness Compensation Program Act of 2000*; Final Rule, Federal Register/Vol.67, No. 85/Thursday, May 2, 2002, p. 22314.

42 U.S.C. §§ 7384 *et seq., Energy Employees Occupational Illness Compensation Program Act of 2000*; as amended; OCAS web site.

DCAS 2014. *Grand Junction Operations Office*, Rev. 0, DCAS-PER-047, NIOSH's Division of Compensation Analysis and Support, Cincinnati, Ohio. March 26, 2014.

ICRP (International Commission on Radiological Protection) 1991. *1990 Recommendations of the International Commission on Radiological Protection*, Publication 60, Pergamon Press, Oxford, England.

NIOSH 2011. *SEC Petition Evaluation Report, Petition SEC-00175*, Rev. 0, Grand Junction Operation Office, January 12, 2011.

OCAS 2006. *Preparation of Program Evaluation Reports and Program Evaluation Plans*, OCAS-PR-008, Rev. 2, NIOSH's Office of Compensation Analysis and Support, Cincinnati, Ohio. December 6, 2006.

ORAUT 1981. *1980 Environmental Monitoring Report – U.S. Department of Energy Facilities, Grand Junction, Colorado, and Monticello, Utah* (Bendix Field Engineering Corporation, Grand Junction, Colorado, BFEC-1981-3, April 1981), Oak Ridge Associates Universities, Cincinnati, Ohio. SRDB Reference ID 90862.

ORAUT 1986. *Summary of MPC – Time Weighted Exposure for the First Quarter* (memorandum from B. Rothman to A.N. Tschaeche, Bendix Field Engineering Corporation, Grand Junction, Colorado, April 1, 1986), Oak Ridge Associates Universities, Cincinnati, Ohio. SRDB Reference ID 98100.

ORAUT (Undated). *Grand Junction Operations Office Dosimetry Spreadsheet, 1986-2007*, Oak Ridge Associates Universities, Cincinnati, Ohio. SRDB Reference ID 107374.

SEC 2011. *Special Exposure Cohort Designation for a Class of Employees from Grand Junction Operations Office, Grand Junction, Colorado*, Secretary of Health and Human Services. April 29, 2011.

U.S. DOE (Department of Energy) 1987. *Nineteenth Annual Report, Radiation Exposures for DOE and Doe Contractor Employees – 1986*, Office of Nuclear Safety, December 1987.

ATTACHMENT A: RELEVANT EXCERPTS FROM THE REVISED GJOO TEMPLATE

Dose Reconstruction Methodology

External Dose

Monitored Individuals

Exposure records are maintained at the Grand Junction office and in a database maintained by the Idaho National Laboratory (INL). A data report through the use of INL location codes was provided by INL that includes personnel believed to be associated with Grand Junction. This report has data between the years 1982 and 1998 and contains over 15,000 records, each with a gamma and beta result. There are also occasional neutron results in this spreadsheet. The persons listed in this report may include individuals involved in off-site remediation work. As a claimant-favorable assumption, all exposures listed in this report would be assumed to have occurred on site.

Dosimeter Dose

Deep Dose Pre-1981

Grand Junction used film badges prior to 1981. Limited film badge data are available for 1952 through 1959. Through 1959, the exchange rate for film badges was biweekly. No information is available on exchange rates between 1960 and 1980; therefore, it is assumed that a biweekly exchange is continued during this period. Penetrating doses should be applied as 100% 30–250 keV photons using acute exposure rate and exposure (R)-to-organ (HT) DCF values for the AP geometry in accordance with the External Dose Reconstruction Implementation Guideline. Reported and missed doses should be assigned in accordance with the guidance found in the *Technical Information Bulletin: A Standard Complex-Wide Methodology for Overestimating External Doses Measured with Film Badge Dosimeters*. The limits of detection are 0.04 rem for photons and 0.05 rem for electrons, respectively.

Deep Dose Post-1980

Grand Junction began using TLDs after 1980. The exchange frequency possibly varied from monthly to quarterly. Penetrating doses should be applied as 100% 30–250 keV photons using acute exposure rate and Deep Dose Equivalent [Hp(10)] DCF values for the AP geometry in accordance with the External Dose Reconstruction Implementation Guideline. Reported and missed doses should be assigned in accordance with the *Technical Information Bulletin: A Standard Complex-Wide Methodology for Overestimating External Doses Measured with Thermoluminescent Dosimeters*. The limit of detection is 0.020 rem for photons and electrons.

Shallow Dose

Shallow measured and missed doses based on the dosimetry records will be assessed per guidance found in the *Technical Information Bulletin: Interpretation of Dosimetry Data for Assignment of Shallow Dose*. Shallow dose will be assigned as an acute dose and 100% >15 keV electron energy range.

Attachment A: Relevant Excerpts from the Revised GJOO Template (continued)

Neutron Dose

Neutron doses should be applied as 100% 0.1–2.0 MeV neutrons with ICRP-60 weighting factors of 1.91 using chronic exposure rate and Deep Dose Equivalent [Hp,slab(10)] DCF values for the AP geometry in accordance with the External Dose Reconstruction Implementation Guideline. Exchange rates are assumed to be the same as photon doses. A neutron limit of detection of 0.040 rem for film badges and 0.020 for TLDs is assumed based on the known neutron detection limits for other major DOE sites, such as the Savannah River Site and Hanford.

Unmonitored Individuals

The Grand Junction Operations Office had a policy of monitoring all radiation workers. However, access to monitoring data is limited and it is unclear if what is reported is complete. Therefore, workers without dosimetry records should be given unmonitored dose (as described below).

Deep Dose

The maximum values from the DOE annual report summary or the 95th percentile value from the REMS database has been applied as a single exchange with missed dose applied to all other exchanges. This value was used to determine dose for the unmonitored "Operator/Laborer Dose" category as summarized in the table below.

Table 1. Unmonitored Gamma Dose

Year	Operator/Laborer Dose[a] (rem)	Supervisor Dose[b] (rem)	Administrative Dose[c] (rem)
1960	1.500	0.750	0.520
1961	1.500	0.750	0.520
1962	1.500	0.750	0.520
1963	1.500	0.750	0.520
1964	1.500	0.750	0.520
1965	1.500	0.750	0.520
1966	1.500	0.750	0.520
1967	1.500	0.750	0.520
1968	1.500	0.750	0.520
1969	1.500	0.750	0.520
1970	1.500	0.750	0.520
1971	1.500	0.750	0.520
1972	1.500	0.750	0.520
1973	1.500	0.750	0.520
1974	1.500	0.750	0.520
1975	1.250	0.625	0.520
1976	0.520	0.520	0.520
1977	1.000	0.520	0.520
1978	1.000	0.520	0.520

Attachment A: Relevant Excerpts from the Revised GJOO Template (continued)

Table 1. Unmonitored Gamma Dose (Continued)

Year	Operator/Laborer Dose[a] (rem)	Supervisor Dose[b] (rem)	Administrative Dose[c] (rem)
1979	1.250	0.625	0.520
1980	1.500	0.750	0.520
1981[d]	1.030	0.515	0.052
1982[d]	1.030	0.515	0.052
1983[d]	1.030	0.515	0.052
1984[d]	1.030	0.515	0.052
1985	0.090	0.045	0.040
1986	0.064	0.040	0.040
1987	0.088	0.044	0.040
1988	0.056	0.040	0.040
1989	0.081	0.040	0.040
1990	0.079	0.040	0.040
1991	0.055	0.040	0.040
1992	0.087	0.043	0.040
1993	0.046	0.040	0.040
1994	0.058	0.040	0.040
1995	0.046	0.040	0.040
1996	0.058	0.040	0.040
1997	0.046	0.040	0.040
1998	0.104	0.052	0.040
1999	0.045	0.040	0.040
2000	0.046	0.040	0.040
2001	0.044	0.040	0.040
2002	0.052	0.040	0.040
2003	0.061	0.040	0.040
2004	0.046	0.040	0.040
2005	0.045	0.040	0.040
2006	0.042	0.040	0.040
2007	0.044	0.040	0.040
2008	0.045	0.040	0.040
2009	0.072	0.040	0.040

a. For pre-1981, doses are based on maximum value from the DOE annual summaries. For post-1984, doses are based on the 95th percentile of the REMS data for badges with end dates in that year. Value applied as a single exchange with missed dose applied to all other exchanges.

b. Supervisor dose is assumed to be half of the Operator/Laborer dose or missed dose for all exchange frequencies.

c. Administrative dose is assumed to be one-tenth of the Supervisor dose or missed dose for all exchange frequencies.

d. Based on maximum recorded dose for adjacent years and missed dose based on current LODs and exchange frequency.

Attachment A: Relevant Excerpts from the Revised GJOO Template (continued)

Shallow Dose

Since no beta data were provided during this period, a beta-to-gamma ratio from 1950s 'era data was calculated to be 1.2. Using data reported by REMS for years after 1980, an average ratio was calculated to be 1.5 beta-to-gamma. As these later data include exposure from off-site remediation activities, the beta component may be expected to be high compared to on-site activities. However, the more claimant-favorable ratio of 1.5 should be used to bound shallow dose for all years between 1960 and 1980.

Neutron Dose

There are limited data for pre-1985 neutron exposures in individual claimant files. However, there are exposure data from REMS from 1985 through 2009, and there is no indication that the source term was any different prior to 1985. These data were analyzed to obtain the 95th and 50th percentiles, which are considered a bounding estimate for unmonitored neutron exposures.

Table 2. Neutron Doses

Job Category	Time Period	Measured Dose (rem)	Missed Dose (rem)	Total Dose (rem)
Geologist[a]	Pre-1981	00.123	0.500[c]	0.623
Geologist[a]	1981-1985	0.123	0.060[d]	0.183
All Other[b]	Pe-1981	0.031	0.500[c]	0.531
All Other[b]	1981-1985	0.031	0.060[d]	0.091

a. Based on 95th percentile
b. Based on 50th percentile
c. 0.500 rem = [(26-1)*(0.040/2)]
d. 0.060 rem = [(4-1)*(0.040/2)]

The number of workers that had potential to neutron exposures is limited due to the limited role of neutron sources at the Grand Junction Operations Office. Therefore, the 95th percentile should only apply to Geologist and the 50th percentile should apply to All Other job categories. After 1985, neutron dosimetry records are assumed to be complete based on a review of GJOO records. Therefore, no unmonitored dose is assigned after 1985.

As stated, all unmonitored doses are considered as bounding estimates and are applied as constant values in IREP.

Medical Dose

From 1943 through 1946, annual chest X-rays were taken of all employees, primarily anterior-to-posterior views. For the years 1947 through 1992, X-rays were taken off site at the site doctor's office or the Community Hospital in Grand Junction. However, for a short period between 1962 through 1969, an office of the U.S. Public Health Service brought a portable X-ray unit to the Grand Junction Office three or four times a year and stayed for about a week to X-ray employees.

Attachment A: Relevant Excerpts from the Revised GJOO Template (continued)

Even though some claimant files contain X-ray records, available records cannot be assumed to be complete. Information determined to be more claimant-favorable than the general guidance should be used. As an example, one claimant record indicates that several of the X-rays performed were "two views." This would indicate that two posterior-anterior views should be assigned. The locations for X-ray records for various time periods are documented.

A pre-employment, annual, and post-employment anterior-posterior (AP) chest and AP pelvis X-ray should be assumed for each year during the operational period prior to 1947. Between 1962 and 1969, a pre-employment, annual, and post-employment chest X-ray is assumed. However, since the view type is not known and the X-rays were done by a portable X-ray machine, all views should be considered (anterior-posterior, posterior-anterior, and photofluorographic). For all other years, X-ray dose is not applicable since they were performed off site at a noncovered facility. X-ray doses will be assigned in accordance with the Technical Information Bulletin: Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures.

Internal Dose

Dosimetry Data

There are over a hundred bioassay-related documents in the Site Research Database that have been captured for the GJOO site. However, there was no comprehensive bioassay database for the site. The samples can be divided into two periods. From 1945–1973, the vast majority of the samples were analyzed for total uranium in urine in terms of mg/liter. No bioassay samples have been captured for the period from February 1975 (the end of the SEC period) until 1984. There are samples in 1984, 1986, and from 1990 to 1998. These were urine and fecal samples which were generally analyzed by alpha spectroscopy. The samples were typically analyzed for uranium-234, -235, and -238, but often included thorium-230 and radium-226. The samples collected for the post-1975 period were for both off-site and on-site work. Therefore, for a given worker, the samples might not be for work that is covered by EEOICPA. For part of this period, there was a pre-job sampling program, and many of the samples were collected for this purpose. After 1990 or so, the practice was to collect pre-job samples but discard them after a period (about one year) if the worker had not been exposed to greater than 10% of a DAC or 40 DAC-hours. Data were sometimes re-sent by the contract laboratories due to re-analyzed samples, etc. Some sample collection dates are missing in the references. The actual period of D&D (decontamination and decommissioning) work began in 1988–1989 with the "extensive" decontamination of Buildings 33 and 35 and the start of the remediation of the outdoor tailings.

Thirty-six GJOO Rust employees and subcontractor employees were involved in non-intrusive radiological field assessment activities from approximately October 1993 through May 1994 at Sandia National Laboratories (SNL). These employees submitted a total of 186 samples for bioassay analysis to the SNL Internal Radiological Dosimetry Program while working at SNL. Ninety-eight of the 186 samples were analyzed by Controls for Environmental Pollution (CEP). The only other samples sent to CEP were some waste characterization samples, but the results failed quality assurance and were determined to be unusable contamination.

Attachment A: Relevant Excerpts from the Revised GJOO Template (continued)

Air Monitoring Data

After January 1975 and before the start of the D&D work in 1989, air samples are generally lacking in the references. As noted above, the most hazardous on-site work was probably at the sample preparation area. Five sets of samples were recovered for this area from July 1980 to June 2002. The 1980 environmental report noted that the principal environmental problem was the dust generated from grinding and crushing samples. Air sampling was performed in the Sample Plant during July 1980 while ore samples were being prepared. The most concentrated sample contained 0.0046 mg/m^3 of uranium. This is the maximum credible concentration of natural uranium since non-ore materials were processed most of the time. All but one of the July 1980 to June 2002 samples are spot measurements. However, time-weighted exposures for the first quarter of 1986 were calculated for individuals working in the sample preparation lab performing grinding of uranium mill tailings. These samples were taken for comparison to the allowable maximum permissible concentration exposure (MPC-hours). These are the most reliable data for sample preparation activities on tailings samples since they were collected over an entire quarter. The exposure in MPC-hours was documented for the highest-exposed worker.

Five hundred and sixty-nine air sample measurements were recovered for on-site D&D work, including both general area and breathing zone samples. These samples indicate that air concentrations were well-controlled during these activities (generally less than 10% of the DAC or action level in use). These samples can be used to assign doses to D&D workers and others (supervisors, etc.) if individual bioassay results are not available.

Source Terms

All of the significant exposures were to uranium and its decay products. Yellowcake was sampled and stored on site during the uranium procurement program. Buildings that had been used as the sampling plants and buildings that were used as indoor storage were likely contaminated with yellowcake. Uranium ore was brought on site for processing in the pilot plants, and some was buried with tailings on site. During the NURE program, most of the material prepared for sampling was not ore, but occasionally ore samples were processed. Tailings were present in outdoor areas, but also potentially in former pilot plant buildings. After 1984, the main work of the sampling plant and analytical chemistry was processing of soil samples contaminated with tailings. Unless a worker's job is very well described, it will not be possible to determine whether the primary exposure was to yellowcake, ore, or tailings. Therefore, the most claimant-favorable activity fractions should be used in the dose reconstruction.

As mentioned above, some small quantities of unsealed radioactive materials were handled that were not part of the uranium series (for example, plutonium, americium, and tritium).

Attachment A: Relevant Excerpts from the Revised GJOO Template (continued)

These were part of waste treatability studies, bioassay measurements for others, etc. GJOO also possessed a few tritium-containing Zetatron tubes (small neutron generators). Documentation indicates that surveys and, in some cases, precautionary bioassays were performed. In addition, the Analytical Chemistry Laboratory used liquid or solid reference materials in concentrations of a few tens of microcuries per milliliter (μCi/ml) or becquerels per gram (Bq/g). Intakes of any of these materials appear to have been unlikely to unmonitored personnel.

Activity Fractions
The contamination remaining from yellowcake procurement and storage was essentially uranium. Only a small fraction of the thorium-230 and radium-226 present in ore was carried through to the yellowcake. The fractions varied with time and the processes used in the mills. After the end of the SEC period, exposures to yellowcake contamination without ore and tailings cannot be ruled out. Therefore, it is recommended that dose reconstructors choose the more favorable option between ore and tailings.

During the NURE program, most of the material sampled was not ore. If an ore sample was being processed, the dust would have only contained between 0.15 percent and 0.3 percent uranium oxide. During the period with the highest workload and particulate concentrations, ventilation was necessary to protect workers against the non-radioactive constituents of the samples, such as silica dust. The small amounts of uranium in the dust were present in their natural isotopic abundances.

The mixture of the radioisotopes present in the tailings varied, depending on the composition of the ore, when the ore was milled, and what process was used. An assumption is made that 90 percent of the uranium was recovered and that all of the thorium-230 and radium-226 remained in the tailings. The table below was constructed assuming that uranium-238, uranium-234, thorium-230, and radium-226 are in equilibrium in ore and that the uranium-235 activity is 2% of the uranium-234/-238 activity. The total activity fractions in the table can be used to assign intakes when only a total activity is reported for a sample. After 1975, air samples were generally counted using a proportional counter which could discriminate between alpha and beta counts. The gross alpha counts obtained were then compared to a conservative MPC or DAC value.

Table 3. Relative Activity and Total Activity Fractions in Ore and Tailings

Nuclide	Relative Activity in Ore	Removed by Milling	Relative Activity in Tailings	Total Activity Fractions	
				Ore	Tailings
U-234/235/238	2.02	90%	2.02	0.502	0.092
Th-230	1	0%	1	0.249	0.454
Ra-226	1	0%	1	0.249	0.454

Unless work was short term, it may not be possible to determine if a worker was exposed to natural uranium ore or tailings.

Attachment A: Relevant Excerpts from the Revised GJOO Template (continued)

Most of the bioassay samples available for the post-SEC period will probably have been analyzed isotopically. In cases where the bioassay is reported in total uranium mass, the uranium data can be evaluated as natural uranium, using the specific activity of 683 pCi/mg to calculate the uranium activity. Corresponding intakes of radium-226 and thorium-230 should be calculated using the ratios from the table above based on ore or tailings (whichever is more claimant-favorable).

Fitted internal doses are applied in IREP as a lognormal distribution with a geometric standard deviation of 3.000. Missed internal doses are applied as a triangular distribution.

Incidents

In the post-January 1975 period, the number of documented incidents that could have resulted in internal doses was relatively small. There are two reports of interest. In 1992, there was a spill of yellowcake during disposal of what was thought to be UMTRA soil samples. Nine individuals were involved, and initial 24-hour urine samples and follow-up samples were collected. A formal investigation was conducted. This report indicates that one of the employees involved, but who was not contaminated, intentionally contaminated his bioassay sample with material not involved in the spill. The identities of the individuals involved are not given in the report, but can be determined from a 1992 report of internal doses to DOE. In a second incident in 1994, a water leak in the attic in Building 7 occurred during work involving conversion of old yellowcake processing areas into office space, causing contamination of the spaces below. Fecal samples were collected from 4 workers. There was "no significant activity in the samples." The names of the individuals involved are given.

Unmonitored Individuals

Sample Preparation and Analytical Chemistry Operations

As noted above, sample preparation was the highest on-site exposure scenario in the post-SEC period and prior to D&D operations. It is logical to divide the sample preparation activities at GJOO into two time periods:

<u>1975–1984</u>

When samples potentially containing ore and samples potentially containing tailings were prepared for the NURE and GJRAP programs, intake rates were calculated using the July 1980 sample. The July 1980 sample was a high sample for the time and was cited as an upper bound in environmental reports of subsequent years. The mass loading of uranium in air could be converted to an air concentration of tailings, but the assumption of ore is more favorable. The intakes are provided in the table below and are assigned as constant values.

<u>Post-1984</u>

The values selected were for the highest worker, and it was assumed that the values measured were thorium-230. This is favorable since it is likely that total activity was measured and compared to thorium-230 (most restrictive MPC). These values are higher than would be calculated from the one-day air samples collected through June 2002.

Attachment A: Relevant Excerpts from the Revised GJOO Template (continued)

The data are assigned to all operations personnel. Intakes for other workers were determined using the ratios between job classes found in Section 8.5.1 of the Technical Basis Document: Site Profiles for Atomic Weapons Employers That Worked Uranium Metals. Laborers received one-half the intake of operators, supervisors receive one-quarter, and administrative personnel receive one-tenth of the supervisor intake. The intakes are provided in the table below and are assigned as constant values.

Decontamination and Decommissioning

The 95th percentile of the lognormal analysis was used to determine the intake rates to be assigned. The 95th percentile from the collective analysis resulted in intakes about 40% higher than the year-by-year analyses (assuming exposure during the D&D entire period). The use the air samples to determine a chronic intake over a year's period will be favorable to claimants involved in D&D work. The results are shown for both ore and tailings in the table below. The ore values overestimate the doses from yellowcake by assuming that radium-226 and thorium-232 are in equilibrium with uranium-238.

Table 4. Inhalation and Ingestion Intake Rates (1975–2006)

Job Category[a]	Uranium		Radium-226		Thorium-230	
	Inhalation (µCi/yr)	Ingestion (µCi/yr)	Inhalation (µCi/yr)	Ingestion (µCi/yr)	Inhalation (µCi/yr)	Ingestion (µCi/yr)
Sample Preparation 1975–1984 (Ore)						
Operators	7.57E-03	1.59E-04	7.57E-03	1.59E-04	7.57E-03	1.59E-04
General Labor	3.79E-03	7.95E-05	3.79E-03	7.95E-05	3.79E-03	7.95E-05
Supervisors	1.89E-03	3.98E-05	1.89E-03	3.98E-05	1.89E-03	3.98E-05
Administrative	1.89E-04	3.98E-06	1.89E-04	3.98E-06	1.89E-04	3.98E-06
Sample Preparation 1985–2003 (Tailings)						
Operators	5.74E-04	1.21E-05	2.83E-03	5.95E-05	2.83E-03	5.95E-05
General Labor	2.87E-04	6.03E-06	1.42E-03	2.98E-05	1.42E-03	2.98E-05
Supervisors	1.44E-04	3.01E-06	7.08E-04	1.49E-05	7.08E-04	1.49E-05
Administrative	1.44E-05	3.01E-07	7.08E-05	1.49E-06	7.08E-05	1.49E-06
Decontamination and Decommissioning 1989–2006 Natural Uranium (Ore, Yellowcake)						
Operators	3.21E-03	6.74E-05	1.59E-03	3.33E-05	1.59E-03	3.33E-05
General Labor	3.21E-03	6.74E-05	1.59E-03	3.33E-05	1.59E-03	3.33E-05
Supervisors	8.02E-04	1.68E-05	3.97E-04	8.34E-06	3.97E-04	8.34E-06
Administrative	8.02E-05	1.68E-06	3.97E-05	8.34E-07	3.97E-05	8.34E-07
Decontamination and Decommissioning 1989–2006 (Tailings)						
Operators	5.87E-04	1.23E-05	2.90E-03	6.09E-05	2.90E-03	6.09E-05
General Labor	5.87E-04	1.23E-05	2.90E-03	6.09E-05	2.90E-03	6.09E-05
Supervisors	1.47E-04	3.08E-06	7.25E-04	1.52E-05	7.25E-04	1.52E-05
Administrative	1.47E-05	3.08E-07	7.25E-05	1.52E-06	7.25E-05	1.52E-06

a. If worker duties cannot be determined, then the most claimant-favorable intake rate should be assumed.

Attachment A: Relevant Excerpts from the Revised GJOO Template (continued)

Radon

By February 1975, the last of the drums containing uranium concentrate had been shipped off site and the radium-226 in surface contamination, in soils, and under/around the buildings remained relatively constant until the remediation of the outdoor areas. Radon in buildings was studied extensively in the D&D era (1989–2001). There are indoor radon-decay-product measurements for most of the buildings, including 300 daughter measurements taken in 1985 in some of the former pilot plant buildings. Only Building 34, the former boiler building for the Large Pilot Plant, exceeded 0.02 WL (averaged over 100 hours). In 1990, the site implemented and participated in the DOE radon study that included all occupied buildings on site at that time. The available radon measurements can be used to establish the dose from radon and radon decay products for February 1, 1975, to December 31, 2001. After 2001, the site radon values were reduced to background levels, and there were no occupational exposures to radon at the GJOO site. The table below provides the results of a lognormal analysis of the 1990 radon study.

Table 5. Radon Concentrations (1975–2001)

Year	Concentration (pCi/L)	WL	WLM/yr	Distribution
1975–1998	5.7	2.85E-02	3.4E-01	Constant
1999–2001	1.6	8.00E-03	9.6E-02	Constant

ATTACHMENT B: EXPOSURE DATA FOR GJOO WORKERS

EXHIBIT B-1. (Source: NIOSH 2011)

Statistical Data on Annual Photon Exposure Reported by REMS and Annual DOE Report*							
Year	**No. of Individuals**	**Average (millirem)**	**Maximum (millirem)**	**Geometric Mean (millirem)**	**Geometric Standard Deviation**	**95th Percentile (millirem)**	**Source**
1975	54			0		468.88	26904
1976	33			0		0.00	26903
1977	90			0		94.11	26902
1978	120			0		101.00	26901
1979	150			0		268.79	26887
1980	180			0		250.00	26888
1981				55.07		250.00	REMS/26888
1982				55.07		250.00	REMS/26888
1983				55.07		250.00	REMS/26888
1984				55.07		250.00	REMS/26888
1985	118	126.91	8500	55.07	1.7	132.18	REMS
1986	54	48.44	145	41.67	1.75	104.91	REMS
1987	115	23.39	120	20.28	1.66	46.80	REMS
1988	62	23.45	146	18.03	1.9	51.99	REMS
1989	81	23.83	134	18.25	1.91	53.08	REMS
1990	147	21.45	442	16.45	1.73	40.64	REMS
1991	36	31.86	411	20.81	1.91	60.53	REMS
1992	46	38.41	193	30.39	1.85	83.86	REMS
1993	3	53	125	31.07	2.85	174.92	REMS
1994	12	61.08	317	25.92	3.09	166.75	REMS
1995	10	21.5	40	19.66	1.54	40.09	REMS
1996	24	15.58	30	14.92	1.34	24.18	REMS
1997	4	17.5	30	15.65	1.6	33.99	REMS
1998	120	40.41	189	31.94	1.99	99.41	REMS
1999	14	23.14	48	19.35	1.82	51.98	REMS
2000	34	5.5	35	3.29	2.7	16.94	REMS
2001	33	3.3	13	2.47	2.11	8.47	REMS
2002	31	6	17	4.38	2.33	17.69	REMS
2003	37	6.68	25	5.21	1.98	16.08	REMS
2004	41	5.51	29	3.87	2.24	14.64	REMS
2005	6	11.83	17	9.84	2.08	32.95	REMS
2006	4	12.5	24	11.13	1.57	23.43	REMS
2007	10	2.8	15	1.68	2.28	6.54	REMS
2008	39	3.23	25	2.28	2.12	7.88	REMS
2009	10	52.5	499	4.25	5.3	66.60	REMS

* Doses do not include three missed doses or 30 mrem.

EXHIBIT B-2. Photon Doses for 118 GJOO Workers in 1985 with Measurable Dosimeter Doses Plus Missed Dose

	MON_START_DATE	MON_END_DATE	DDE_PHOTON	days	year	fraction	annual rem	Missed	Total	ln(Total)
1	01-Jan-85	31-Dec-85	8500	364	1985	1.00	8.500	0.030	8.530	2.143589
2	01-Jan-85	31-Dec-85	175	364	1985	1.00	0.175	0.030	0.205	-1.58475
3	01-Jan-85	31-Dec-85	175	364	1985	1.00	0.175	0.030	0.205	-1.58475
4	01-Jan-85	31-Dec-85	175	364	1985	1.00	0.175	0.030	0.205	-1.58475
5	01-Jan-85	31-Dec-85	175	364	1985	1.00	0.175	0.030	0.205	-1.58475
6	01-Jan-85	31-Dec-85	175	364	1985	1.00	0.175	0.030	0.205	-1.58475
7	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
8	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
9	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
10	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
11	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
12	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
13	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
14	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
15	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
16	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
17	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
18	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
19	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
20	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
21	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
22	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
23	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
24	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
25	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
26	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
27	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
28	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
29	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
30	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
31	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
32	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
33	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
34	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
35	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
36	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
37	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
38	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573

EXHIBIT B-2. Photon Doses for 118 GJOO Workers in 1985 with Measurable Dosimeter Doses Plus Missed Dose (continued)

	MON_START_DATE	MON_END_DATE	DDE_PHOTON	days	year	fraction	annual rem	Missed	Total	ln(Total)
39	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
40	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
41	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
42	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
43	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
44	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
45	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
46	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
47	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
48	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
49	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
50	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
51	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
52	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
53	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
54	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
55	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
56	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
57	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
58	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
59	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
60	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
61	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
62	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
63	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
64	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
65	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
66	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
67	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
68	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
69	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
70	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
71	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
72	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
73	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
74	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
75	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
76	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
77	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573

EXHIBIT B-2. Photon Doses for 118 GJOO Workers in 1985 with Measurable Dosimeter Doses Plus Missed Dose (continued)

	MON_START_DATE	MON_END_DATE	DDE_PHOTON	days	year	fraction	annual rem	Missed	Total	ln(Total)
78	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
79	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
80	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
81	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
82	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
83	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
84	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
85	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
86	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
87	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
88	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
89	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
90	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
91	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
92	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
93	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
94	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
95	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
96	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
97	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
98	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
99	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
100	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
101	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
102	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
103	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
104	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
105	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
106	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
107	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
108	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
109	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
110	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
111	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
112	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
113	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
114	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
115	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573

EXHIBIT B-2. Photon Doses for 118 GJOO Workers in 1985 with Measurable Dosimeter Doses Plus Missed Dose (continued)

	MON_START_DATE	MON_END_DATE	DDE_PHOTON	days	year	fraction	annual rem	Missed	Total	ln(Total)
116	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
117	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
118	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573

Average Dose: 18.515/118 = 0.156 rem

GM Dose = $e^{(-288.662/118)}$ = 0.087 rem

95^{th} percentile = $(GSD^{1.645})(50^{th}$ percentile) + missed dose

95^{th} Percentile = $(1.7^{1.645})(0.0557) + (0.030) = 0.163$ rem

EXHIBIT B-3. Photon Doses for 528 GJOO Workers in 1985 with Measurable and Non-Measurable Dosimeter Doses Plus Missed Dose

	MON_START_DATE	MON_END_DATE	DDE_PHOTON	days	year	fraction	annual rem	Missed	Total	ln(Total)
1	01-Jan-85	31-Dec-85	8500	364	1985	1.00	8.500	0.030	8.530	2.143589
2	01-Jan-85	31-Dec-85	175	364	1985	1.00	0.175	0.030	0.205	-1.58475
3	01-Jan-85	31-Dec-85	175	364	1985	1.00	0.175	0.030	0.205	-1.58475
4	01-Jan-85	31-Dec-85	175	364	1985	1.00	0.175	0.030	0.205	-1.58475
5	01-Jan-85	31-Dec-85	175	364	1985	1.00	0.175	0.030	0.205	-1.58475
6	01-Jan-85	31-Dec-85	175	364	1985	1.00	0.175	0.030	0.205	-1.58475
7	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
8	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
9	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
10	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
11	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
12	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
13	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
14	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
15	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
16	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
17	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
18	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
19	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
20	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
21	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
22	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
23	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
24	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
25	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
26	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
27	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
28	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
29	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
30	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
31	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
32	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
33	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
34	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
35	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
36	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
37	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573

EXHIBIT B-3. Photon Doses for 528 GJOO Workers in 1985 with Measurable and Non-Measurable Dosimeter Doses Plus Missed Dose (continued)

	MON_START_DATE	MON_END_DATE	DDE_PHOTON	days	year	fraction	annual rem	Missed	Total	ln(Total)
38	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
39	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
40	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
41	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
42	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
43	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
44	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
45	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
46	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
47	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
48	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
49	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
50	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
51	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
52	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
53	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
54	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
55	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
56	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
57	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
58	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
59	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
60	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
61	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
62	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
63	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
64	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
65	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
66	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
67	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
68	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
69	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
70	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
71	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
72	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
73	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
74	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573

EXHIBIT B-3. Photon Doses for 528 GJOO Workers in 1985 with Measurable and Non-Measurable Dosimeter Doses Plus Missed Dose (continued)

	MON_START_DATE	MON_END_DATE	DDE_PHOTON	days	year	fraction	annual rem	Missed	Total	ln(Total)
75	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
76	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
77	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
78	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
79	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
80	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
81	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
82	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
83	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
84	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
85	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
86	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
87	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
88	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
89	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
90	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
91	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
92	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
93	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
94	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
95	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
96	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
97	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
98	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
99	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
100	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
101	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
102	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
103	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
104	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
105	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
106	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
107	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
108	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
109	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
110	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
111	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573

EXHIBIT B-3. Photon Doses for 528 GJOO Workers in 1985 with Measurable and Non-Measurable Dosimeter Doses Plus Missed Dose (continued)

	MON_START_DATE	MON_END_DATE	DDE_PHOTON	days	year	fraction	annual rem	Missed	Total	ln(Total)
112	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
113	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
114	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
115	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
116	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
117	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
118	01-Jan-85	31-Dec-85	50	364	1985	1.00	0.050	0.030	0.080	-2.52573
119	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
120	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
121	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
122	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
123	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
124	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
125	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
126	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
127	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
128	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
129	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
130	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
131	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
132	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
133	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
134	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
135	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
136	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
137	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
138	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
139	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
140	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
141	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
142	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
143	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
144	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
145	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
146	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
147	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
148	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888

EXHIBIT B-3. Photon Doses for 528 GJOO Workers in 1985 with Measurable and Non-Measurable Dosimeter Doses Plus Missed Dose (continued)

	MON_START_DATE	MON_END_DATE	DDE_PHOTON	days	year	fraction	annual rem	Missed	Total	ln(Total)
149	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
150	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
151	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
152	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
153	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
154	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
155	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
156	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
157	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
158	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
159	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
160	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
161	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
162	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
163	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
164	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
165	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
166	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
167	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
168	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
169	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
170	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
171	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
172	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
173	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
174	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
175	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
176	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
177	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
178	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
179	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
180	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
181	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
182	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
183	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
184	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
185	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888

EXHIBIT B-3. Photon Doses for 528 GJOO Workers in 1985 with Measurable and Non-Measurable Dosimeter Doses Plus Missed Dose (continued)

	MON_START_DATE	MON_END_DATE	DDE_PHOTON	days	year	fraction	annual rem	Missed	Total	ln(Total)
186	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
187	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
188	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
189	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
190	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
191	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
192	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
193	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
194	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
195	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
196	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
197	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
198	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
199	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
200	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
201	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
202	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
203	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
204	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
205	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
206	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
207	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
208	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
209	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
210	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
211	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
212	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
213	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
214	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
215	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
216	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
217	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
218	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
219	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
220	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
221	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
222	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888

EXHIBIT B-3. Photon Doses for 528 GJOO Workers in 1985 with Measurable and Non-Measurable Dosimeter Doses Plus Missed Dose (continued)

	MON_START_DATE	MON_END_DATE	DDE_PHOTON	days	year	fraction	annual rem	Missed	Total	ln(Total)
223	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
224	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
225	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
226	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
227	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
228	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
229	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
230	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
231	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
232	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
233	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
234	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
235	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
236	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
237	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
238	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
239	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
240	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
241	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
242	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
243	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
244	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
245	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
246	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
247	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
248	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
249	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
250	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
251	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
252	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
253	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
254	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
255	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
256	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
257	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
258	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
259	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888

EXHIBIT B-3. Photon Doses for 528 GJOO Workers in 1985 with Measurable and Non-Measurable Dosimeter Doses Plus Missed Dose (continued)

	MON_START_DATE	MON_END_DATE	DDE_PHOTON	days	year	fraction	annual rem	Missed	Total	ln(Total)
260	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
261	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
262	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
263	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
264	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
265	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
266	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
267	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
268	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
269	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
270	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
271	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
272	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
273	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
274	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
275	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
276	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
277	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
278	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
279	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
280	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
281	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
282	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
283	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
284	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
285	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
286	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
287	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
288	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
289	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
290	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
291	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
292	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
293	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
294	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
295	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
296	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888

EXHIBIT B-3. Photon Doses for 528 GJOO Workers in 1985 with Measurable and Non-Measurable Dosimeter Doses Plus Missed Dose (continued)

	MON_START_DATE	MON_END_DATE	DDE_PHOTON	days	year	fraction	annual rem	Missed	Total	ln(Total)
297	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
298	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
299	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
300	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
301	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
302	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
303	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
304	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
305	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
306	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
307	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
308	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
309	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
310	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
311	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
312	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
313	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
314	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
315	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
316	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
317	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
318	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
319	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
320	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
321	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
322	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
323	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
324	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
325	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
326	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
327	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
328	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
329	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
330	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
331	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
332	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
333	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888

EXHIBIT B-3. Photon Doses for 528 GJOO Workers in 1985 with Measurable and Non-Measurable Dosimeter Doses Plus Missed Dose (continued)

	MON_START_DATE	MON_END_DATE	DDE_PHOTON	days	year	fraction	annual rem	Missed	Total	ln(Total)
334	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
335	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
336	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
337	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
338	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
339	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
340	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
341	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
342	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
343	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
344	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
345	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
346	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
347	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
348	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
349	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
350	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
351	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
352	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
353	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
354	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
355	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
356	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
357	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
358	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
359	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
360	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
361	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
362	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
363	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
364	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
365	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
366	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
367	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
368	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
369	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
370	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888

EXHIBIT B-3. Photon Doses for 528 GJOO Workers in 1985 with Measurable and Non-Measurable Dosimeter Doses Plus Missed Dose (continued)

	MON_START_DATE	MON_END_DATE	DDE_PHOTON	days	year	fraction	annual rem	Missed	Total	ln(Total)
371	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
372	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
373	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
374	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
375	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
376	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
377	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
378	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
379	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
380	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
381	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
382	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
383	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
384	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
385	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
386	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
387	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
388	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
389	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
390	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
391	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
392	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
393	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
394	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
395	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
396	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
397	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
398	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
399	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
400	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
401	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
402	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
403	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
404	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
405	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
406	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
407	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888

EXHIBIT B-3. Photon Doses for 528 GJOO Workers in 1985 with Measurable and Non-Measurable Dosimeter Doses Plus Missed Dose (continued)

	MON_START_DATE	MON_END_DATE	DDE_PHOTON	days	year	fraction	annual rem	Missed	Total	ln(Total)
408	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
409	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
410	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
411	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
412	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
413	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
414	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
415	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
416	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
417	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
418	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
419	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
420	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
421	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
422	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
423	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
424	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
425	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
426	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
427	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
428	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
429	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
430	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
431	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
432	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
433	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
434	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
435	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
436	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
437	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
438	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
439	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
440	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
441	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
442	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
443	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
444	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888

EXHIBIT B-3. Photon Doses for 528 GJOO Workers in 1985 with Measurable and Non-Measurable Dosimeter Doses Plus Missed Dose (continued)

	MON_START_DATE	MON_END_DATE	DDE_PHOTON	days	year	fraction	annual rem	Missed	Total	ln(Total)
445	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
446	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
447	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
448	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
449	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
450	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
451	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
452	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
453	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
454	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
455	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
456	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
457	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
458	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
459	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
460	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
461	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
462	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
463	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
464	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
465	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
466	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
467	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
468	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
469	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
470	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
471	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
472	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
473	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
474	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
475	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
476	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
477	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
478	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
479	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
480	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
481	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888

EXHIBIT B-3. Photon Doses for 528 GJOO Workers in 1985 with Measurable and Non-Measurable Dosimeter Doses Plus Missed Dose (continued)

	MON_START_DATE	MON_END_DATE	DDE_PHOTON	days	year	fraction	annual rem	Missed	Total	ln(Total)
482	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
483	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
484	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
485	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
486	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
487	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
488	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
489	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
490	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
491	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
492	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
493	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
494	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
495	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
496	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
497	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
498	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
499	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
500	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
501	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
502	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
503	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
504	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
505	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
506	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
507	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
508	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
509	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
510	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
511	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
512	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
513	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
514	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
515	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
516	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
517	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888

EXHIBIT B-3. Photon Doses for 528 GJOO Workers in 1985 with Measurable and Non-Measurable Dosimeter Doses Plus Missed Dose (continued)

	MON_START_DATE	MON_END_DATE	DDE_PHOTON	days	year	fraction	annual rem	Missed	Total	ln(Total)
518	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
519	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
520	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
521	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
522	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
523	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
524	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
525	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
526	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
527	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888
528	01-Jan-85	31-Dec-85	0	364	1985	1.00	0.000	0.040	0.040	-3.21888

Mean Dose = 34.915 rem/528 = 0.066 rem

GM Dose = $e^{-1608.4/528}$ = 0.0475 rem

95th Percentile Dose = $(GSD)^{1.645}$ (50th Percentile Dose)

95th Percentile Dose = $(1.477^{1.645})(0.0475)$ rem = 0.090 rem

EXHIBIT B-4. (Source: NIOSH 2011)

Statistical Data on Annual Beta Exposure Reported by REMS and Annual DOE Report						
Year	**No. of Individuals**	**Average (millirem)**	**Maximum (millirem)**	**Geometric Mean (millirem)**	**Geometric Standard Deviation**	**95th Percentile (millirem)**
1975				0		562.65
1976				0		0.00
1977				0		112.93
1978				0		121.20
1979				0		322.54
1980				0		300.00
1981				66.084		300.00
1982				66.084		300.00
1983				66.084		300.00
1984				66.084		300.00
1985		0	0	0		0.00
1986	48	57.85	323	39.23	2.29	153.94
1987	126	29.99	426	22.82	1.86	63.53
1988	76	31.84	146	22.62	2.22	84.33
1989	91	80.12	2441	27.02	3.1	174.76
1990	156	26.15	462	18	1.94	53.72
1991	50	38.6	411	26.59	2.05	86.92
1992	60	45.58	193	35.8	1.93	105.94
1993	7	62.43	170	36.96	2.73	193.82
1994	13	80.92	349	34.65	3.51	275.08
1995	12	21.33	40	19.3	1.58	41.05
1996	26	24.77	240	17.25	1.81	45.92
1997	7	32.86	60	26.43	2.02	84.32
1998	125	45.38	255	35.19	2.04	114.11
1999	18	31.44	70	25.67	1.94	76.61
2000	50	7.56	58	3.84	2.94	22.76
2001	40	4.8	14	3.72	2.1	12.65
2002	36	6.72	19	5.25	2.07	17.44
2003	41	7.61	28	6.08	1.98	18.77
2004	54	7.67	61	4.29	2.79	23.32
2005	52	5.65	28	4.06	2.25	15.47
2006	48	7.29	29	5.04	2.41	21.52
2007	39	6.03	27	4.19	2.27	16.21
2008	49	7.82	131	3.93	2.66	19.74
2009	17	48.76	471	6.68	4.98	94.45

EXHIBIT B-5. (Source: NIOSH 2011)

Statistical Data on Annual Neutron Exposure Reported by REMS and Annual DOE Report						
Year	**No. of Individuals**	**Average (millirem)**	**Maximum (millirem)**	**Geometric Mean (millirem)**	**Geometric Standard Deviation**	**95th Percentile (millirem)**
1975						
1976						
1977						
1978						
1979						
1980						
1981						
1982						
1983						
1984						
1985		0	0	0		0.00
1986	6	94.17	181	79.21	1.79	207.01
1987	18	26.61	68	19.17	2.47	85.23
1988	13	51.38	180	40.59	1.92	119.09
1989	2	50.5	76	43.59	1.74	108.72
1990	9	36.44	128	28.91	1.8	76.25
1991	5	67.4	223	40.98	2.47	182.19
1992	3	22	31	21.12	1.32	33.39
1993		0	0	0		0.00
1994		0	0	0		0.00
1995		0	0	0		0.00
1996	1	20	20	20	1	20.00
1997	1	20	20	20	1	20.00
1998	3	62	70	61.75	1.09	71.19
1999	3	37.33	49	36.5	1.23	51.36
2000		0	0	0		0.00
2001		0	0	0		0.00
2002		0	0	0		0.00
2003	1	15	15	15	1	15.00
2004		0	0	0		0.00
2005	1	15	15	15	1	15.00
2006		0	0	0		0.00
2007		0	0	0		0.00
2008		0	0	0		0.00
2009		0	0	0		0.00

EXHIBIT B-6. Neutron Measurements Used to Derive Dose in Table 2 of the GJOO Template

MON_YEAR	DDE_NEUTRON		Ln(Total)			
1986	55		4.007333			
1986	181		5.198497		31.47686	GM
1986	161		5.081404		2.294372	GSD
1986	47		3.850148		123.391	95th
1986	41		3.713572			
1986	80		4.382027			
1987	19		2.944439			
1987	35		3.555348			
1987	68		4.219508			
1987	33		3.496508			
1987	21		3.044522			
1987	6		1.791759			
1987	30		3.401197			
1987	40		3.688879			
1987	30		3.401197			
1987	8		2.079442			
1987	60		4.094345			
1987	40		3.688879			
1987	33		3.496508			
1987	33		3.496508			
1987	6		1.791759			
1987	8		2.079442			
1987	3		1.098612			
1987	6		1.791759			
1988	40		3.688879			
1988	50		3.912023			
1988	50		3.912023			
1988	70		4.248495			
1988	180		5.192957			
1988	29		3.367296			
1988	70		4.248495			
1988	25		3.218876			
1988	28		3.332205			
1988	20		2.995732			
1988	18		2.890372			
1988	70		4.248495			
1988	18		2.890372			

EXHIBIT B-6. Neutron Measurements Used to Derive Dose in Table 2 of the GJOO Template (continued)

MON_YEAR	DDE_NEUTRON		Ln(Total)			
1989	25		3.218876			
1989	76		4.330733			
1990	25		3.218876			
1990	40		3.688879			
1990	32		3.465736			
1990	15		2.70805			
1990	21		3.044522			
1990	20		2.995732			
1990	128		4.85203			
1990	21		3.044522			
1990	26		3.258097			
1991	42		3.73767			
1991	22		3.091042			
1991	223		5.407172			
1991	33		3.496508			
1991	17		2.833213			
1992	31		3.433987			
1992	19		2.944439			
1992	16		2.772589			
1996	20		2.995732			
1997	20		2.995732			
1998	59		4.077537			
1998	70		4.248495			
1998	57		4.043051			
1999	32		3.465736			
1999	49		3.89182			
1999	31		3.433987			
2003	15		2.70805			
2005	15		2.70805			
			227.6507			

EXHIBIT B-7. Derived Dose Estimates Based on Neutron Dosimeter Readings Above LOD (40 mrem)

MON_YEAR	DDE_NEUTRON					
1991	223		5.407172			
1986	181		5.198497		67.8593	GM
1988	180		5.192957		1.675601	GSD
1986	161		5.081404		158.6244	95th
1990	128		4.85203			
1986	80		4.382027			
1989	76		4.330733			
1988	70		4.248495			
1988	70		4.248495			
1988	70		4.248495			
1998	70		4.248495			
1987	68		4.219508			
1987	60		4.094345			
1998	59		4.077537			
1998	57		4.043051			
1986	55		4.007333			
1988	50		3.912023			
1988	50		3.912023			
1999	49		3.89182			
1986	47		3.850148			
1991	42		3.73767			
1986	41		3.713572			
1987	40		3.688879			
1987	40		3.688879			
1988	40		3.688879			
1990	40		3.688879			
	2047		109.6533			

ATTACHMENT C: EXCERPTS FROM THE NINETEENTH ANNUAL REPORT, RADIATION EXPOSURES FOR DOE AND DOE CONTRACTOR EMPLOYEES – 1986

EXHIBIT C-1 (Source: U.S. DOE 1987)

TABLE 4. Distribution of Annual Whole-Body Exposures for DOE/DOE Contractor Employees and Visitors by Facility Type, 1986(a)

Facility Type	Total Persons Monitored	Number of Persons Receiving Exposures in Each Dose-Equivalent Range (rem)																		Total Person-rem
		<Meas.	Meas.- <0.10	0.10- 0.25	0.25- 0.50	0.50- 0.75	0.75- 1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12	
Reactor	7,260	2,628	2,747	701	500	163	112	279	130											1,391
Fuel Fabrication	1,733	165	767	300	329	119	21	31	1											356
Fuel Processing	3,038	1,132	942	329	289	122	62	151	11											598
Uranium Enrichment	1,134	581	481	60	12															39
Weapon F&T	21,109	10,285	7,921	1,446	664	290	147	296	60											1,802
Gen. Research	30,449	24,004	4,728	701	409	165	113	215	79	35										1,357
Accelerator	4,794	2,990	1,437	186	97	39	12	26	7											232
Other	22,493	11,071	7,920	1,481	997	458	202	300	61		1		1					1		2,117
Visitors	63,463	55,670	7,251	321	126	45	28	21		1										554
DOE Offices	2,030	1,725	283	14	7	1														20
TOTAL PERSONS	157,503	110,251	34,477	5,539	3,430	1,402	697	1,319	349	36	1		1					1		
TOTAL PERSON-REM			1,724	969	1,286	876	610	1,979	873	126	5		6					11		8,465

(a) Throughout this report there may be minor variations in collective dose-equivalent values because of rounding.

EXHIBIT C-2 (Source: U.S. DOE 1987)

TABLE 3. Distribution of Whole-Body Ionizing Radiation Exposures for DOE/DOE Contractor Employees, 1965-1986

	Number of Employees Receiving Exposures in Each Dose-Equivalent Range (rem)														
	0-1[(a)]														Total
Year	<Meas.	Meas.-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12	Monitored
1965	128,360		4,158	1,704	515	294	70	32	26	25	22	6	2		135,214
1966	131,522		3,706	1,630	593	313	88	47	24	6	2			1	137,932
1967	102,510		3,472	1,572	555	168	35	29	23	17	4	1			108,386
1968	103,206		2,799	1,408	425	144	3	1							107,986
1969	98,625		2,554	1,313	335	86	4					1			102,918
1970	92,185		2,698	1,329	279	158	5	4	2		1				96,661
1971	90,640		2,380	888	275	118	8	3				1		2	94,315
1972	86,077		2,130	929	219	95	8	2							89,460
1973	89,071		1,944	727	172	60	2	1							91,977
1974	43,184	32,500	1,667	688	149	40	4								78,232
1975	43,310	42,141	1,846	753	232	142				1					88,425
1976	40,083	47,886	1,679	475	70	6	1								90,200
1977	43,017	49,948	1,579	545	103	23			1	2				2	95,220
1978	44,898	55,296	1,323	439	53	11									102,020
1979[(b)]	50,003	53,235	1,286	416	33	10	1							2	104,986
1980	45,054	38,895	1,113	387	16										85,465
1981[(b)]	45,224	36,561	967	263	29	5									83,049
1982	48,968	34,949	1,010	313	56	28									85,324
1983	49,871	36,768	1,270	294	49	31									88,283
1984[(b)]	47,327	42,696	1,226	312	31	11									91,603
1985	55,939	38,085	1,366	356	51	8				1					95,806
1986	54,581	37,774	1,298	349	35	1		1					1		94,040

(a)Separation of data before 1974 is unavailable.
(b)The data differ slightly from those listed in previous reports because of errors reported by individual contractors after publication of the annual report.