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National Institute for Occupational Safety and Health

A Review of NIOSH's Program Evaluation Report DCAS-PER-090, "Grand Junction Operations Office"

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Abbreviations and Acronyms

ABRWH, Board	Advisory Board on Radiation and Worker Health
AEC	Atomic Energy Commission
DR	dose reconstruction
D&D	decontamination and decommissioning
EE	energy employee
GJOO	Grand Junction Operations Office
IREP	Interactive RadioEpidemiological Program
LOD	limit of detection
NIOSH	National Institute for Occupational Safety and Health
NOCTS	NIOSH Claims Tracking System
ORAUT	Oak Ridge Associated Universities Team
pCi/mg	picocuries per milligram
PER	program evaluation report
POC	probability of causation
SEC	special exposure cohort
SPR	Subcommittee for Procedure Reviews
Th	thorium

1 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) 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.

A program evaluation report (PER) provides a critical evaluation of the effects that a given issue or 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 on the probability of causation (POC) of previously completed DRs with POCs less than 50 percent.

During a teleconference by the Advisory Board on Radiation and Worker Health (Board) Subcommittee for Procedure Reviews (SPR) on November 8, 2024, the Board tasked SC&A to review DCAS-PER-090, revision 0, "Grand Junction Operations Office" (NIOSH, 2019; "PER-090"). 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 and characterization of the issue addressed in the PER 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. When the PER involves a technical issue that is supported by documents (e.g., white papers, technical information bulletins, 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 and 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 reevaluation. The second step may have important implications, where the universe of previously denied DRs is very large and, for reasons of practicality, NIOSH's reevaluation 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 of 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 Board will select the DRs and the total number of DR audits for each PER.)
- **Subtask 5:** Prepare a written report that contains the results of DR audits under subtask 4, along with our review conclusions.

2 Relevant Background Information Pertaining to Facility Operations, Potential Source Terms, and Worker Monitoring Protocols

2.1 Facility operations

The main function of the facilities at Grand Junction Colorado was to handle, process, and assay uranium ore and mine tailings. Some operations involved thorium contained in tailings and also as thorium ore, but uranium was the main material involved in the operations. The site was known by several different names, depending on its mission at the time; examples are Grand Junction Facilities, Grand Junction Project Office Remedial Action Project, Grand Junction Remedial Action Project, and Grand Junction Operations Office. Because PER-090 uses the term Grand Junction Operations Office (GJOO), the site will be referred to as the GJOO in this report.

ORAUT-TKBS-0060, revision 00 (ORAUT, 2018), section 2.0, provides a site description of the GJOO site. A brief summary follows:

- In 1943, the Manhattan Engineer District purchased the GJOO site.
- A refinery was operated on site from 1943 to 1946 to treat and concentrate uranium oxide from green sludge, a byproduct of vanadium production in the area.
- In late 1947, the U.S. Atomic Energy Commission (AEC) established the Colorado Raw Materials Office on site for the purpose of managing the domestic uranium procurement program. This office was responsible for the receipt, sampling, and analysis of uranium and vanadium concentrates the AEC purchased from ore processing operations in the western United States.
- A research program was conducted to test experimental uranium ore milling techniques in a small pilot mill from 1953 to 1954 near the location of building 46 and in a larger pilot mill on the southern end of the facility from 1954 to 1958. At the end of the program, some of the mill buildings and their support facilities were converted to other uses.
- Tailings from the nearby commercially operated Climax Mill had been used for construction and as fill in the Grand Junction area. To address this issue, the Grand Junction Remedial Action Program was funded. GJOO assisted in the cleanup of 600 vicinity properties in the Grand Junction area from 1972 to September 30, 1988.
- From 1974 to 1984, GJOO supported the National Uranium Resource Evaluation Program, which was a nationwide uranium modeling effort. During this program, mainly non-ore samples (drilling cores, etc.) were collected from offsite locations.
- Starting in 1978, GJOO participated in the Uranium Mill Tailings Remedial Action program to clean up commercial mill sites and vicinity properties. Again, the work was offsite with onsite analysis and support.

- On September 30, 2001, the U.S. Department of Energy (DOE) transferred ownership of the site to Riverview Technology Corporation. However, DOE continues to lease portions of the site, provides some ongoing remediation services, and continues to conduct the Long-Term Surveillance and Maintenance Program. In December 2001, the ownership of remaining eight acres were transferred to the U.S. Army Reserve. As of 2001, only building 20 remained contaminated. In April 2006, DOE demolished building 20 and remediated the associated contamination.

- In June 2006, DOE issued a report indicating the rest of the site was released with some institutional controls in place to deal with ground and surface water that contain contaminants in concentrations exceeding regulatory limits. In addition, portions of the subgrade structures and soil beneath building 12 still contain uranium and radium contamination. This contamination was left in place to preserve the structural integrity of the building. Surveys were conducted that indicate the contamination associated with building 12 does not pose any increased health risk to occupants. All exterior land areas have been remediated and were released for unrestricted use. Lastly, the borehole containing radium foil used for calibrating down-hole logging instrumentation was decommissioned but was not removed. A metal plaque, with a warning not to disturb, marks the borehole's location.

2.2 Source terms

Some of the major sources of internal exposure at GJOO included uranium, thorium, radium, radon, and thoron from handling and processing of the uranium and thorium ores and tailings.

A Special Exposure Cohort (SEC) has been established from March 23, 1943, through January 31, 1975, because NIOSH has determined that it lacks sufficient information to reconstruct doses from radon and other internal exposures from uranium and thorium potentially experienced by unmonitored GJOO workers during that time period. In addition, NIOSH has determined that it lacks sufficient information to reconstruct doses associated with external exposures from 1943 through 1959 to unmonitored GJOO workers (NIOSH, 2011).

Additionally, an SEC has been established from February 1, 1975, through December 31, 1985, because NIOSH has determined that it lacks sufficient information to reconstruct doses from nonradon internal exposures to unmonitored GJOO workers during that time period (NIOSH, 2015).

The internal radiological exposure potentials at the GJOO applicable to the post-1975 period for radon and thoron and the post-1985 period for uranium and thorium were from the following sources:

- Uranium: After 1985, uranium was a source of exposure due to contamination from previous operations and support work for other programs, including remediation of the GJOO buildings and grounds. There is little information concerning any enrichment of uranium at GJOO. Therefore, because of the large amount of natural uranium handled at GJOO, it is assumed that potential uranium intakes consisted of natural uranium.

- Thorium (Th)-232 was not a major contaminant of concern for the overall GJOO site. However, Th-232 was handled as part of the development of the instrument calibration sources or models. This work was performed in the Sample Preparation Laboratory, where the main source of exposure occurred during the crushing and grinding operations. Also, Th-230 was present as a contaminant of the uranium ore.

- Radium-226 was present as a contaminant of the uranium ore and assumed to be in equilibrium with uranium-234.

- Radon would have been present in areas and buildings that processed or handled uranium or in buildings built on tailings piles.

- Thoron would have been present in the Sample Preparation Laboratory that processed and handled thorium.

The radiation source (other than x-ray procedures) for external exposure at GFOO was primarily uranium. External exposures were (1) the result of direct radiation exposure from handling and working with uranium ore and tailings and (2) submersion in the contaminated dust cloud. The photons were from uranium, radium, and uranium progeny. There were high-energy beta radiation exposures for workers in close proximity to the ore that contributed to shallow dose. Neutron radiation was also present from californium-252 and americium-241–beryllium sources and neutron generators used for well logging during some periods.

2.3 Worker monitoring at GJOO

The processing of uranium ore and tailings at GJOO, as outlined in section 2.2 of this report, produced source terms that resulted in potential internal and external radiation exposure to workers from alpha particles, photons, electrons, and occasionally neutrons. A summary of internal, air, and external monitoring is provided in sections 2.3.1, 2.3.2, and 2.3.3 of this report.

2.3.1 Internal monitoring

There was no sitewide routine bioassay program established for GJOO workers and, therefore, no comprehensive database of bioassay results. Depending on the exposure potential, urinalyses for uranium were performed. These data can be used in DR if available. For unmonitored workers who were potentially exposed but no bioassay records are available, the recommended intakes, as provided in ORAUT-TKBS-0060, revision 00 (ORAUT, 2018), tables 5-4, 5-5, 5-6, and 5-7, can be applied. These intakes were based on measured air concentration or a methodology using maximum permissible limits.

2.3.2 Air monitoring

Early on, air samples were taken during visits or inspections by AEC. Eventually, the GJOO organizations acquired their own sampling and analytical capabilities. Some air sample data from before the start of the decontamination and decommissioning (D&D) work in 1989 are available. Before 1989, the most radiologically hazardous onsite work appears to have taken place in the Sample Plant. A 1980 environmental monitoring report stated that the Sample Plant prepared approximately 1,000 samples per month, but that the majority of the samples were exploration samples of low radioactivity rather than of uranium ores. It indicated that the principal

environmental problem was the dust generated from grinding and crushing. For the D&D period from 1989 to 2001, numerous air monitoring results are available including breathing zone samples.

2.3.3 External monitoring

External exposure records are maintained at GJOO and in a database maintained by Idaho National Laboratory. A data report was provided by Idaho National Laboratory that includes personnel believed to be associated with GJOO. This report had external exposure data between the years 1982 and 1998 and contains over 15,000 records, each with a gamma and beta result. There were also occasional neutron results in this spreadsheet. The persons listed in this report may include individuals involved in offsite remediation work. As a claimant-favorable assumption, all exposures listed in this report would be assumed to have occurred on site. Although NIOSH found that it is not possible to bound the external dose prior to 1960, any external monitoring data that might become available for an individual claim during this time period can be included if applicable.

For unmonitored workers who were potentially exposed but for whom no external exposure records are available, dose reconstructors can apply the recommended co-exposure dose values provided in ORAUT-TKBS-0060, rev. 00 (ORAUT, 2018), table 6-4 for photons, table 6-5 for neutrons, and table 6-4 in conjunction with section 6.5.2 for betas.

3 Subtask 1: Identify the Circumstances that Necessitated DCAS-PER-090

3.1 Chronology of GJOO documents relevant to DCAS-PER-090

1. **Unknow date:** NIOSH created the original GJOO DR template and DR methodology for DR purposes.

2. **September 5, 2012:** NIOSH revised the GJOO DR template and DR methodology.

3. **March 26, 2014:** NIOSH issued DCAS-PER-047 (NIOSH, 2014) because of the revisions in the GJOO template.

4. **February 10, 2015:** SC&A issued a subtasks 1–3 review of DCAS-PER-047 (SC&A, 2015).

5. **May 18, 2018:** NIOSH issued ORAUT-TKBS-0060, revision 00, the site profile for GJOO (ORAUT, 2018).

6. **July 17, 2019:** NIOSH issued PER-090 (NIOSH, 2019) because of the new site profile (ORAUT, 2018) that contained changes from the September 5, 2012, GJOO DR template.

7. **August 17, 2021:** SC&A issued a review of ORAUT-TKBS-0060, revision 00 (SC&A, 2021).

8. **October 26, 2023:** SC&A reviewed two NIOSH-reworked DR cases under DCAS-PER-047, subtask 4.

9. **November 8, 2024:** The SPR tasked SC&A with a subtasks 1–3 review of PER-090.

3.2 SC&A's comments

SC&A concurs with NIOSH that the new GJOO site profile (ORAUT, 2018) warranted the need for PER-090 (NIOSH, 2019) and had no findings pertaining to subtask 1. However, SC&A had the following observation.

Observation 1: Complete DR templates needed

To allow SC&A to evaluate site profiles and PERs completely and efficiently, SC&A needs access to the complete DR template with date of origin or date of revision, not just a copy of one that has been used for DR of a case (which usually does not contain a date on the form nor the complete template). This was pointed out in observation 1 of SC&A's subtask 1–3 review (SC&A, 2015, p. 9) of DCAS-PER-047 (NIOSH, 2014) but was apparently not resolved.

4 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 was previously reviewed by SC&A, subtask 2 will simply provide a brief summary/conclusion of this review process. SC&A issued a review of ORAUT-TKBS-0060, rev. 00, on August 17, 2021. In that review, SC&A had no findings but did have five observations concerned with (1) potential misleading wording of text in the occupational medical section, (2) inconsistency in derived air concentration values used, (3) additional consideration of radon calibration chamber exposure, (4) neutron dose assignments for job categories other than geologist, and (5) substantiation for not assigning co-exposure neutron dose after 1985. Observation 3 was discussed and closed at the SPR conference call on February 16, 2023. The current status of these five observations is:

- Observations 1 and 2 are in abeyance awaiting revisions to ORAUT-TKBS-0060.
- Observation 3 was addressed and closed at the February 16, 2023, SPR meeting.
- Observation 4 is being addressed further by NIOSH and is in progress.
- Observation 5 is in abeyance awaiting revisions to ORAUT-TKBS-0060.

The resolution of these observation would not impact the review or use of PER-090.

4.1 Modifications identified in DCAS-PER-090

Section 2.0 of PER-090 (pp. 1–2) provides the following summary of the modifications to DR as a result of the issuance of ORAUT-TKBS-0060, revision 00:

- The photon dose conversion factor to be used was changed from deep dose equivalent to exposure for the years 1981–1985.
- Applicable film badge [limit of detection] LOD and unmonitored dose changed in 1981.
- Previously, unmonitored beta dose was not assigned after 1980. The site profile describes this dose beyond 1980 through present.
- The specified Neutron LOD increased from 1960 through 1981.
- The assumed fraction of uranium radioactive constituents changed after 1985.
- Exposure to thorium was added for 1986–1988 and 2001.
- Uranium intake rates were changed after 1985.

4.2 SC&A's review of DCAS-PER-090

SC&A compared the DR recommendations in ORAUT-TKBS-0060 (ORAUT, 2018) to those in the GJOO DR template of September 5, 2012, to identify differences that could potentially increase the external or internal doses assigned in a DR case. Additionally, SC&A evaluated the seven modifications listed in section 2.0 of PER-090 (reproduced in section 4.1 of this report) to determine if PER-090 adequately addressed the differences between ORAUT-TKBS-0060 and the GJOO DR template. The following sections summarize SC&A's evaluation. Note that the

page numbers quoted for the GJOO DR template are only approximate because they may vary in different DR cases.

4.2.1 SC&A's comparison of ORAUT-TKBS-0060 to GJOO DR template

SC&A found the following changes in ORAUT-TKBS-0060 compared to the GJOO DR template of September 5, 2012, that could potentially increase assigned external or internal doses. There were other changes, but they would not increase dose assignments.

- Page 25 of ORAUT-TKBS-0060 recommends that the photon dose conversion factors be changed from deep dose equivalent to exposure for the years 1981–1985, compared to page 10 of the GJOO DR template that recommends exposure dose conversion factors be used only prior to 1981.

- Page 26, table 6-4, of ORAUT-TKBS-0060 contains an increase in dose value for unmonitored workers for the year 1981 (because of a change in film badge LOD in table 6-1) compared to the table on page 11 of the GJOO DR template for unmonitored dose for 1981.

- Page 25, table 6-2, in conjunction with section 6.5.2, of ORAUT-TKBS-0060 recommends beta dosimeter LOD and dose values for 1960–present, whereas previously, the GJOO DR template, page 12, recommended the assignment of shallow dose only during the period 1960–1980.

- Page 26, table 6-3, of ORAUT-TKBS-0060 contains neutron dosimetry LOD values that have increased for the period 1960–1981 compared the LOD values recommended in the table on page 13 of GJOO DR template.

- Page 17, section 5.2.2, of ORAUT-TKBS-0060 recommends using a natural uranium specific activity of 684 picocuries per milligram (pCi/mg), whereas the GJOO DR template, page 16, recommends using a natural uranium specific activity of 683 pCi/mg.

- Page 15, table 5-3, of ORAUT-TKBS-0060 added potential exposure to thorium ore for 1986–1988, and page 21, table 5-6, note b., added potential exposure to thorium ore for 2001. In contrast, the GJOO DR template did not include exposure to thorium ore, only thorium contained in uranium tailings.

- Page 21, tables 5-4 and 5-6, of ORAUT-TKBS-0060 recommend increases in the alpha inhalation and ingestion intake rates after 1985 compared to the table of intakes rates recommended in the table on page 17 of the GJOO DR template.

4.2.2 SC&A's evaluation of DCAS-PER-090 modification recommendations

SC&A evaluated changes in ORAUT-TKBS-0060 compared to the GJOO DR template of September 5, 2012, and found that PER-090 adequately addressed the changes that could potentially increase assigned external or internal doses. SC&A had no findings or observations associated with subtask 2.

5 Subtask 3: Evaluate the PER's Stated Approach for Identifying the Number of DRs Requiring Reevaluation of Dose

5.1 NIOSH's selection criteria

Section 3.0 of PER-090 described the method NIOSH used to identify previously completed claims requiring reevaluation using DR guidance in revision 00 of ORAUT-TKBS-0060 (ORAUT, 2018) and mandated by PER-090 (NIOSH, 2019). NIOSH searched their databases for GJOO DR cases and identified 125 claims that needed consideration. The following summarizes NIOSH's search results.

- 125 claims were identified.
- 28 claims had a previous POC of greater than 50 percent.
- 18 claims had been pulled from DR (primarily due to inclusion in the SEC).
- 4 claims had been returned to NIOSH from the Department of Labor for other reasons. Those four claims required a new DR using the site profile, so no further evaluation under PER-090 was necessary.
- 5 claimants were never at the GJOO site. The GJOO site was mentioned in the DR report, but the worker was not present at the site.
- 11 claims were removed because the worker only had employment between 1947 and 1959. Due to the SEC, only monitored dose can be assigned in that era, and no changes were made in the site profile that would affect the monitored dose during that time.
- 4 claims were removed because the workers were visitors to GJOO and had no monitoring data there. The original DR did not assign GJOO dose because assuming exposure at the home site was favorable to unmonitored visitor dose at GJOO.
- 10 claims were deemed eligible for the SEC and removed from further consideration.

This resulted in a list of 45 potentially affected claims. Doses for these 45 claims were recalculated using the site profile and all other applicable procedures, with the following results:

- 38 claims resulted in a new POC below 45 percent.
- 3 claims had POC values that fell between 45 percent and 50 percent. For those claims, the Interactive RadioEpidemiological Program (IREP) was run 30 times with 10,000 iterations for each run in accordance with NIOSH procedures. As a result, all 3 claims remained below 50 percent.
- 4 claims resulted in a new POC greater than 52 percent. NIOSH provided the U.S. Department of Labor with the list of all the claims evaluated under this PER. Furthermore, NIOSH will request the return of the four claims that would now result in a POC greater than 50 percent.

5.2 SC&A's comments

Due to the Cybersecurity Modernization Initiative, SC&A does not have access to the NIOSH Claims Tracking System (NOCTS) to review the data used to identify and quantify those cases that qualify for reevaluation. Therefore, SC&A's evaluation is limited to the methodology and criteria employed by NIOSH to identify cases potentially impacted by PER-090.

SC&A finds that the selection criteria used by NIOSH for previously completed DRs that required reevaluation under PER-090 were valid.

There are no findings or observations associated with subtask 3.

6 Subtask 4: Conduct Audits of a Sample Set of Reevaluated DRs Mandated by DCAS-PER-090

Previous sections of this report described changes introduced in revision 00 of the GJOO site profile (ORAUT, 2018) that could potentially increase external or internal dose assignments.

For SC&A to satisfy its commitment under subtask 4, SC&A suggests that a set of reworked DRs be selected for a focused review that include the following dose assignments in one or more of the reworked cases:

1. A non-skin cancer case where the energy employee (EE) was assigned external photon dose during part or all of the period of 1981–1985.

2. The EE was assigned unmonitored external dose during the year 1981.

3. The EE was assigned unmonitored beta dose after 1980.

4. The EE was assigned missed and/or unmonitored neutron dose prior to 1981.

5. The EE was assigned uranium radioactive constituents intakes after 1985.

6. The EE was assigned an intake of thorium from thorium ore during 1986–1988 and/or 2001.

7. The EE was assigned uranium intake after 1985, preferably during 1986–1990 and also after 1990.

7 References

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