# Memorandum

To: Subcommittee for Procedure Reviews
From: SC&A, Inc.
Date: September 9, 2022
Subject: DCAS-PER-049 Subtask 4 – Internal Dose Followup

At the August 18, 2022, meeting of the Advisory Board on Radiation and Worker Health, SC&A presented its subtask 4 case review for DCAS-PER-049, "Paducah Gaseous Diffusion Plant." Although SC&A's review only evaluated external and occupational medical doses that were impacted by PER-049, SC&A did point out that the internal dose significantly increased. The increase in dose is questionable because the original dose reconstruction (DR) assigned hypothetical internal dose, while the rework used the energy employee's (EE's) bioassay data. During the meeting, the Board ask SC&A to evaluate the internal dose in more detail and report its findings to the Subcommittee for Procedure Reviews (SCPR). This memo provides a chronology of events and a summary of the internal dose calculations.

## Chronology of DCAS-PER-049 Subtask 4 Review

- **August 5, 2016:** NIOSH issued DCAS-PER-049.
- **March 2, 2018:** SC&A submitted its review of one case under subtask 4. SC&A had reviewed the Paducah Gaseous Diffusion Plant (PGDP) technical basis document (TBD) separately in 2006, and the 25 findings were resolved under the Gaseous Diffusion Plant Work Group.
- **October 31, 2018:** SC&A presented its subtask 4 review of PER-049 to the SCPR. There were no findings, and the SCPR closed the review.

## Followup Discussion about Internal Dose

**March 6, 2018.** After receiving and reviewing SC&A's PER-049, subtask 4 report, the Designated Federal Official (DFO) sent the following email to SC&A:

> I'm curious. You reported that the "hypothetical" intakes originally estimated for internal doses were only about half of the actual internal doses estimated using the EEs bioassay records. I recognize this wasn't part of your tasking but do you know the basis for the hypothetical intakes? I assume the bioassays weren't captured at the time of the early DR but my question is whether there is anything to be learned from the original approach, whatever it was, to reduce the likelihood

of underestimating should there be similar circumstances (the limited data available at the time of the original dose reconstruction) at other sites.

I'm not asking you to do any digging on this at the moment, if you don't know about the original basis. In that case, I'll raise the issue directly with DCAS as it seems to me it could have some importance.

**March 6, 2018.** SC&A responded to the DFO's email as follows:

In the original 2005 DR it was stated (pages 5 and 6):

Internal dose monitoring records were reviewed. Most measurement results for non-naturally occurring radionuclides showed an activity less than the level of detection for the given radionuclides and bioassay method. However, to account for any incidental dose that may have been received but not documented, internal dose was assigned based on a hypothetical intake assuming an intake of 28 radionuclides. This results in an intake that greatly exceeds any possible actual intake by [the EE] because these nuclides would not all be found in a single location on site. The total internal dose assigned was 18.332 rem.

[The EE] was monitored routinely during [the EE's] career. Several urinalysis results were slightly above the minimum detectable values provided in PGDP internal dose TBD. An evaluation of the measurements that were above the level of detection was made for this dose reconstruction by comparing the bioassay results against the predicted results of the data provided in the Maximum Internal Dose Estimates for Certain DOE Complex Claims [NIOSH, 2004] The internal dose assigned based on the hypothetical intake is significantly higher than if the highest urinalysis result in [the EE's] records was assumed to apply to a chronic intake over the entire employment period. This methodology applies and is considered claimant-favorable. . . .

In the reworked 2016 DR it was stated (pages 8 and 9):

Internal dose monitoring records were reviewed and it was determined that [the EE] was monitored for internal dose via [the EE's] participation in the in vitro and in vivo bioassay programs in place at the Paducah Gaseous Diffusion Plant. [The EE] submitted several urine samples [redacted] that were analyzed for total uranium concentration. [redacted] Fitted and missed internal doses were calculated in accordance with the Technical Information Bulletin: Internal Dose Reconstruction . . . and the Technical Basis Document for the Paducah Gaseous Diffusion Plant – Occupational Internal Dose. . . .

The total internal dose assigned was [redacted] rem.

The internal dose assigned to the [redacted] in this dose reconstruction represents an increase from that assigned previously. This is due to the approach used in this

> dose reconstruction (a reasonable overestimate) as compared to the maximizing approach used in the previous dose reconstruction. Previously, the dose was based on hypothetical intakes. As stated above, the internal dose assigned in this dose reconstruction used [the EE's] bioassay data, which presents a claimant-favorable estimate which more closely approaches the true internal dose received by [the EE].
>
> There appears to be a contradiction between the two DRs concerning which is the larger dose resulting from the two internal dose methods (hypothetical or bioassay), that could use NIOSH's clarification. I checked NOCTS for this EE and only a few external dose docs were added since the original 2005 DR, no additional internal data. I noticed this issue during in my evaluation but only briefly mentioned it in my report because of being tasked with a focus external dose review per PER-049, which did not include internal dose. For SC&A to investigate it further would require analyzing the info from the related OTIBs and TBDs used in the DRs and the IMBA files, etc.

**March 7, 2018.** The DFO sent the following email to NIOSH:

> Would you please take a look (or have someone else take a look) at this DR and clarify what transpired to result in the original intended overestimate of the internal dose being only about half of the actual dose based on bioassays, as determined in the redone DR. Just want to make sure there isn't a problem with the earlier method that might apply to other cases (for which bioassay is NOT available) at this site or at other sites. I recognize the first DR for this case was early on, so maybe whatever the problem might be, it is long ago resolved. I've attached the SC&A PER Review report so you can identify the case. (SC&A wasn't tasked with addressing the internal dose procedure, which wasn't subject to the PER being reviewed.)

SC&A is unaware of the outcome of this email or whether NIOSH provided a followup.

## ORAUT-OTIB-0002, Maximum Internal Dose Estimates for Certain DOE Complex Claims

In the original DR, NIOSH used ORAUT-OTIB-0002, revision 01 PC-2 (NIOSH, 2004; "OTIB-0002"), to assess the hypothetical internal dose for the PER-049 case. A summary of the OTIB-0002 sections relevant to internal dose follows. It should be noted that OTIB-0002 has been canceled. The date of cancellation approval is unknown to SC&A.

### *OTIB-0002 application*

OTIB-0002, section 2.0, "Background," states the following:

> In accordance with OCAS-IG-002 (Internal Dose Reconstruction Implementation Guideline, Rev. 0, August 2002), internal dose is assigned to employees who were monitored but had no detectable activity ("positive") in their samples and to employees who were not included in a bioassay program, because there is some

> amount of intake and associated dose that is not detectable by an internal dosimetry program. For employees who were monitored and who do have detectable activity ("positive") in their samples, those sample results will be evaluated to ensure the method described in this TIB results in a greater probability of causation. To expedite the dose reconstructions, cases that met the criteria above will first be evaluated with the method described in this TIB. If the outcome yields a probability of causation >50%, a dose reconstruction using more reasonable assumptions will be performed. [NIOSH, 2004, pp. 3–4]

### *OTIB-0002 assumptions*

OTIB-0002, section 3.1, Assumptions," states the following:

> For claims where it is considered likely that the covered employee had no significant internal radiation exposure, a method to expedite claims has been developed in accordance with 42 CFR 82.10(k)(2). This method assumes the "largest reasonably possible value" of the source term comprised of radionuclides that are/were typically the more significant radionuclides (by either preponderance or by internal dose significance) on a site. For this "worst-case" estimate of internal dose, it is assumed that on the first day of the first year of employment, the covered employee had an acute inhalation intake of each of the radionuclides in the source term, in the amounts listed below. [NIOSH, 2004, p. 4]

Additional assumptions provided in section 3.1.1 include:

- Inhalation intakes are the standard 5 micrometer activity median aerodynamic diameter (AMAD).
- The most soluble form of the radionuclides specified in International Commission on Radiological Protection Publication 66 was used.
- Doses are calculated assuming 10 percent of the maximum permissible body burden
- For sites without a reactor, table 3.1.1-2 lists 12 radionuclides of interest and associated parameters.
- For sites with a reactor, table 3.1.1-2 lists 28 radionuclides for which dose is calculated.
- Table 3.1.1-4 lists 22 organs appropriate for applying the maximum internal dose.

### *OTIB-0002 limitations*

Section 5.0 of OTIB-0002 states the limitations of using this maximizing approach. Limitations applicable to this DR are as follows:

- The EE's initial hire date was after 1969. If OTIB-0002 is used prior to 1969, the DR report much include an explanation that demonstrates the doses resulting from table 3.1.1-2 intakes overestimate actual or potential doses received by the worker.
- The target organ must be listed in table 3.1.1-4.

- The EE has no significant exposure to uranium.
- Employment must be at a U.S. Department of Energy (DOE) site or national laboratory with an active radiation protection program.

[redacted]

## Reworked Internal Dose Estimates

The reworked DR used the EE bioassay data to calculate internal dose. A summary of the approach used by NIOSH follows.

The EE submitted several urine samples [redacted] that were analyzed for total uranium. [redacted] NIOSH calculated both fitted dose to account for the positive results and missed dose to account for the less-than-MDA results.

The uranium results were reported in units of milligrams uranium per liter excreted urine (mg U/L). These results were normalized to a daily excreted urine volume of 1.4. Uranium was assumed to be enriched to 2 percent, and the specific activity of 1.05 picocuries per microgram (pCi/µg), 2.22 disintegrations per minute (dpm) per pCi, and the conversion factor of 1,000 µg/mg were used in the conversion of units of mg/L to dpm/day.

### *Fitted uranium*

The EE's urine bioassay data were fitted in the Interactive Modules for Bioassay Analysis (IMBA) program, using a combination of chronic intakes and acute intakes to determine a fit that represented a reasonable overestimate of the actual intakes. Positive bioassay data were assumed to have a normal distribution with ±30 percent error, and the uranium-in-urine activity curve either overpredicted the urine bioassay data or was contained within the 30 percent uncertainty band. The acute intake dates were initially estimated to be the midpoint between the date of the positive sample and the previous negative sample. However, the intake dates were adjusted as necessary to arrive at a reasonable fit of the intake regimes to the bioassay data. IMBA was used to generated uranium intake activities associated with absorption types F, M, and S. A comparison of the absorption types showed that type S solubility resulted in the highest dose.

### *Missed uranium*

Missed dose was derived using one-half the appropriate MDA as bioassay input to IMBA. MDA values were taken from the EE's bioassay records and the PGDP occupational internal dose TBD, ORAUT-TKBS-0019-5, revision 03 (NOISH, 2012). A chronic intake period of [redacted] was used. IMBA-generated uranium intake activities associated with absorption types F, M, and S were calculated and compared. NIOSH determined that type S solubility resulted in the highest dose.

### *Recycled uranium*

The recycled uranium components were also assessed. This assessment was based on the [redacted] operations ratios to uranium in ORAUT-TKBS-0019-5. Absorption types for the

recycled uranium components were determined using table 3-1 of ORAUT-OTIB-0060, revision 01, "Internal Dose Reconstruction" (NIOSH, 2014).

### *Total uranium dose*

The fitted doses were compared to the missed doses on a year-by-year basis and the higher annual organ dose used in the Interactive RadioEpidemiological Program (IREP). This resulted in the assignment of a total internal dose of [redacted] rem.

## References

National Institute for Occupational Safety and Health. (2004). *Technical information bulletin – Maximum internal dose estimates for certain DOE Complex claims* (ORAUT-OTIB-0002, rev. 01 PC-2). https://www.cdc.gov/niosh/ocas/pdfs/arch/tibs/or-t2-r1-p2.pdf

National Institute for Occupational Safety and Health. (2012). *Paducah Gaseous Diffusion Plant – Occupational internal dose* (ORAUT-TKBS-0019-5, rev. 03). SRDB Ref. ID 117897

National Institute for Occupational Safety and Health. (2014). *Internal dose reconstruction* (ORAUT-OTIB-0060, rev. 01), SRDB Ref. ID 135808