SC&A's Evaluation of ORAUT-OTIB-0049, Revision 02, "Estimating Doses for Plutonium Strongly Retained in the Lung"

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Timeline

- Revision 01 PC-2 issued November 29, 2010
- Revision 02 issued September 1, 2020
  - Total rewrite
- Board tasked SC&A with review of revision 02 on February 18, 2021
  - SC&A issued review October 7, 2021

Purpose of OTIB-0049

- Specifies a biokinetic model to evaluate the deposition, retention, and removal of inhaled very insoluble (type super S or type SS) plutonium particulates from the respiratory tract

What is type Super S plutonium?

- Historical studies have shown that, in some instances, the rate of removal of plutonium from the lung was slower than predicted by type S
  - Organ doses over time were underpredicted by type S
- Phenomenon known as type Super S (SS)

NIOSH's new approach

- Combines guidance from ICRP 130, ICRP 67, and ICRP 30
- "hybrid" model introduces modified dissolution parameters that lower predicted urinary excretion
  - fraction of inhaled material absorbed by blood relatively rapidly (F_r) = 0.001029
  - rate at which material is absorbed (S_r) = 100.1
  - remaining fraction of material ($1 - F_r$) absorbed at slower rate (S_s) = 1×10^{-6}

Observation 1

ICRP has published updated biokinetic models appropriate for type SS plutonium

SC&A suggests:

1. ICRP 141 should be used to determine the Pu-239 dioxide absorption parameters, and the absorption parameters from the alimentary tract should be used for all other type SS plutonium dioxides.
2. The ICRP 141 S_r value of 0.4 d^{-1}, the rate at which the material is absorbed, should be used.
3. The dosimetric data from ICRP 141 should be used to determine the parameters for the inhalation of Pu-239 dioxide for all type SS plutonium. These data should also be used to determine the parameters for the dose per activity content in the lungs and in daily excretion of urine and feces.

Comparison of parameters

Parameter description	ORAUT-0049 rev. 02 value	ICRP 141 value
Fraction of rapidly dissolved material (F_r)	0.001029	0.004
Rapid dissolution rate (S_r)	100.1	0.4
Slow dissolution rate (S_s)	$1x10^{-6}$	$1x10^{-5}$
Fraction of dissolved material retained in a bound state (F_b)	Not evaluated (default value in IDOT_SS is 0)	0.002
Bound dissolution rate (S_b)	Not evaluated (default value in IDOT_SS is 0)	0
GI tract fraction (f1) or fraction to the alimentary tract (f_A)	$1x10^{-5}$	$2x10^{-6}$

Observation 2

Section 4.1 of OTIB-0049, rev. 02, lists an incorrect F_r value

- The F_r value calculated by NIOSH, listed in attachment A of OTIB-0049, rev. 02, and used in the IDOT_SS tool, is 0.001029. Section 4.1 of OTIB-0049 erroneously identifies the F_r values of 0.001209.

Observation 3

NIOSH failed to consider long-term binding of plutonium

- There is no reference to long-term binding of plutonium in OTIB-0049.
- ICRP 141 identifies in some instances that some dissolved material appears to be attached to lung structural components and is removed only by absorption to blood.
- ICRP assigned the value of 0.2% for the bound fraction (f_b) to the whole respiratory tract, (except for the ET1 region).

Observation 4

Revision 02 has not used ICRP 141 updates to the ICRP 67 systemic model

- ICRP Publication 141 updates the plutonium model of ICRP Publication 67.
- OTIB-0049, revision 02, uses the ICRP Publication 67 systemic model instead of the updated model.
- Excretion rates using the two models should be compared.

Observation 5

NIOSH should consider using the OIR Data Viewer software

- SC&A suggests that the Occupational Intakes of Radionuclides (OIR) Data Viewer software (the electronic annex to the OIR series), ICRP 134, ICRP 137, and ICRP 141 should be used to calculate dose per intake coefficients, dose per content functions, and reference bioassay functions for Pu-239 dioxides (type SS plutonium).

Comparison of methods

Revision 01

- Did not actually model type SS
- Applied CF to modeled type S to account for Super S
- Intakes from urinary excretion modeled using factor of 4 approach implemented through OTIB-0049 Tool

Revision 02

- New model for type SS
- No adjustment factors
- Uses ICRP guidance and historical intakes to develop new dose and intake parameters
- Minimal guidance on application to a DR case

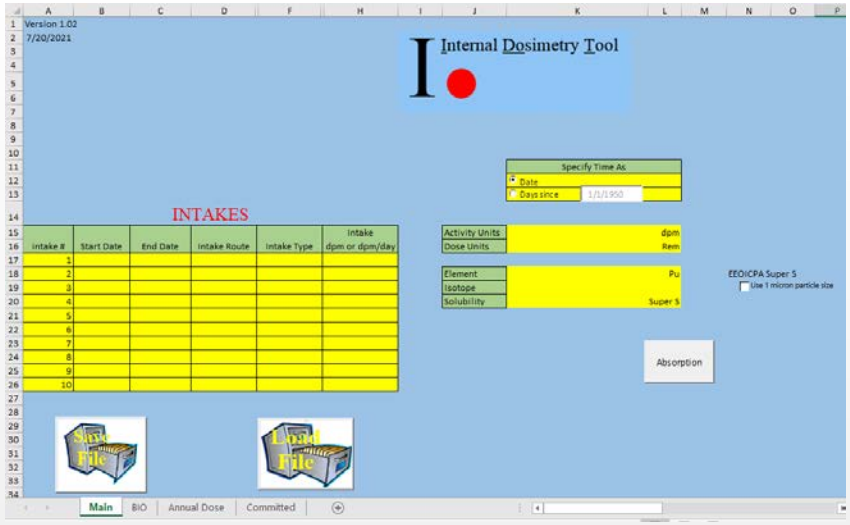
Observation 6

OTIB-0049 lacks information about its application to dose reconstruction

- SC&A found limited guidance instructing dose reconstuctors how to apply the guidance to a DR.
- Unambiguous guidance is necessary to ensure cases are processed consistently.
- OTIB-0049 should specify that a tool has been developed for the implementation of guidance.

IDOT user interface

- Internal Dosimetry Tool
- Replaces old IMBA and OTIB-0049 tool
- Similar to IMBA interface
  - Main
  - Bio
  - Annual Dose
  - Committed Dose



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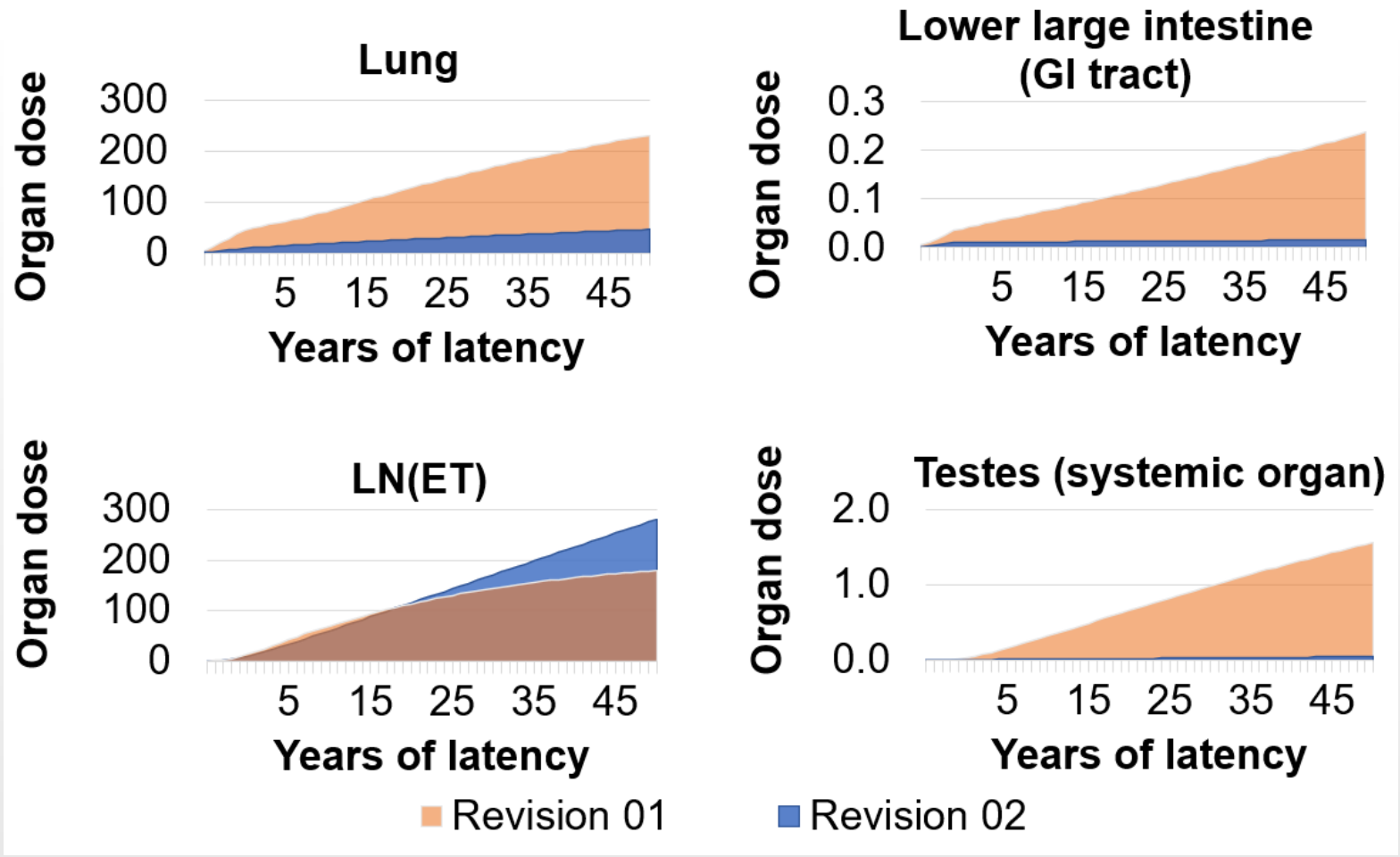
IDOT documentation

- Additional documentation
  - User Guide
  - DCAS-RPT-007
  - IDOT Bioassay and Dose Benchmark
- SC&A confirmed tool is functioning
- SC&A did not review supporting files in detail or perform independent benchmarking/validation calculations

Comparison of doses (rem) from 5-year 100dpm/d chronic intake of Pu-239



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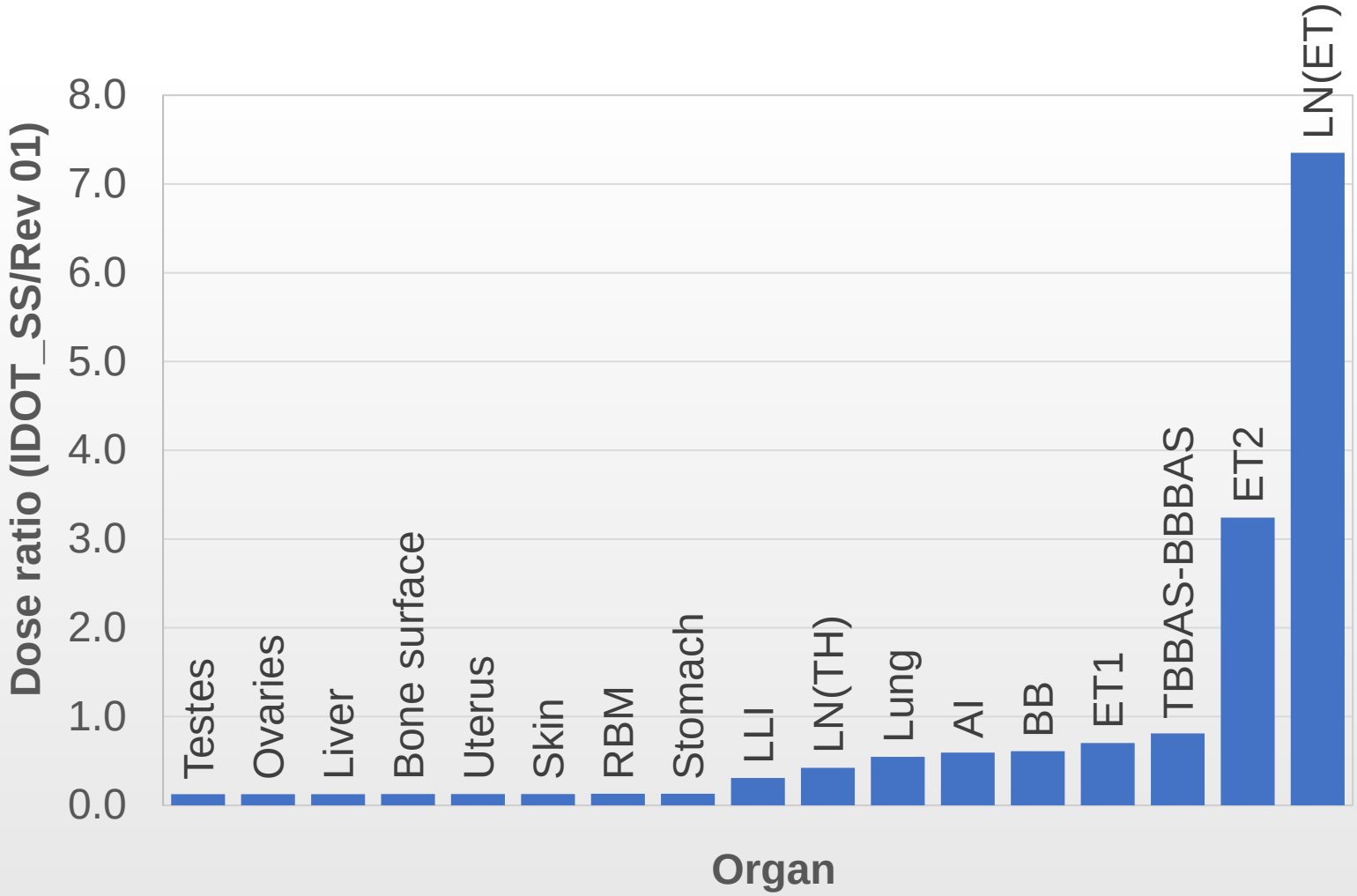
Analysis of two cases using typical DR data

- Case A: short exposure period and long latent period
- Case B: long exposure period and short latent period
- Derived IDOT_SS intakes and organ doses using typical DR bioassay data
- Derived IMBA intakes and used revision 01 PC-2 of OTIB-0049 (2010; “Revision 01 (2010)”) to derive organ doses using the same typical DR bioassay data
- Compared the organ doses derived by the two methods

Analysis of Case A bioassay data – chronic Pu-239



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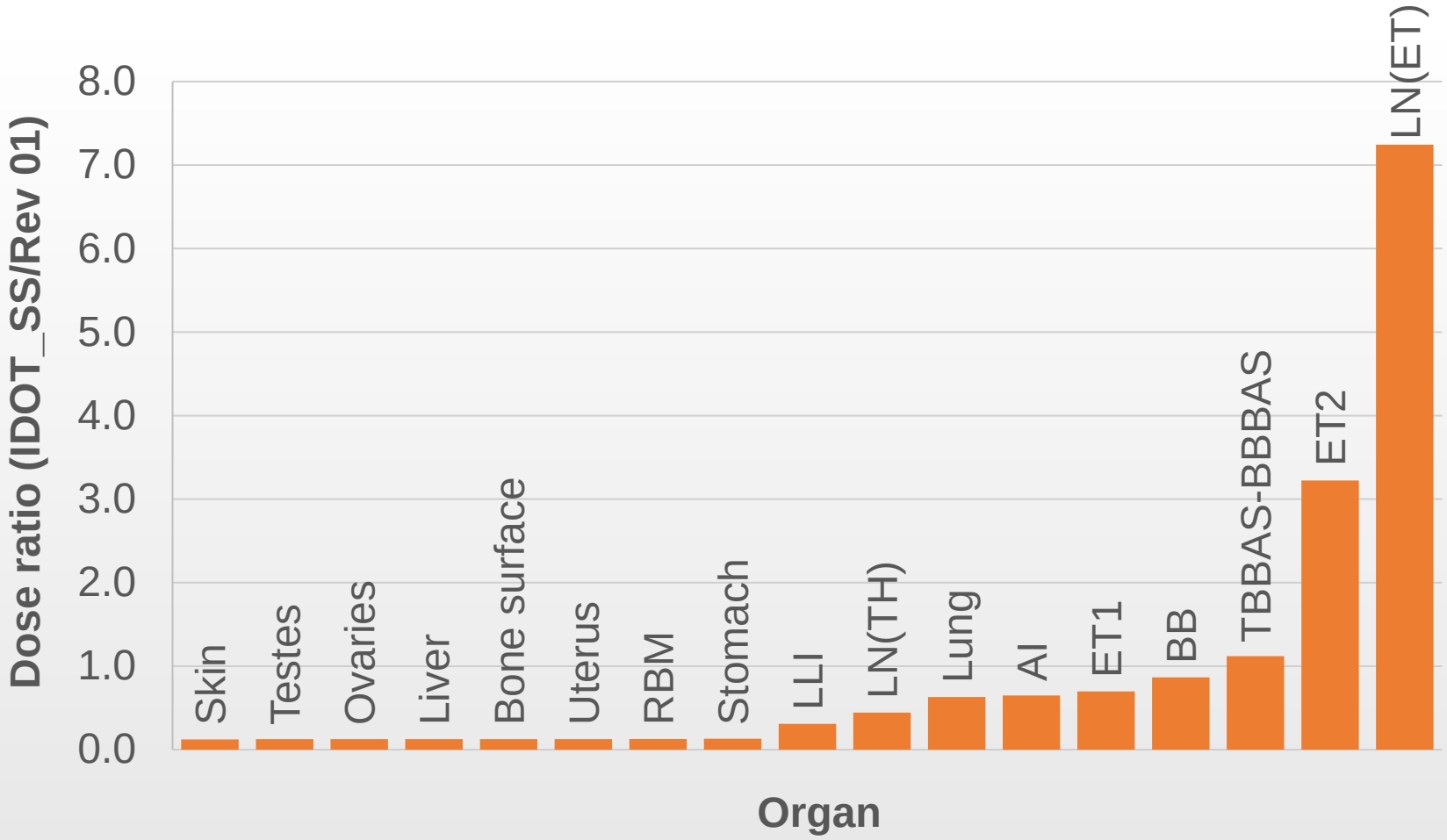
Analysis of Case A bioassay data – acute Pu-239



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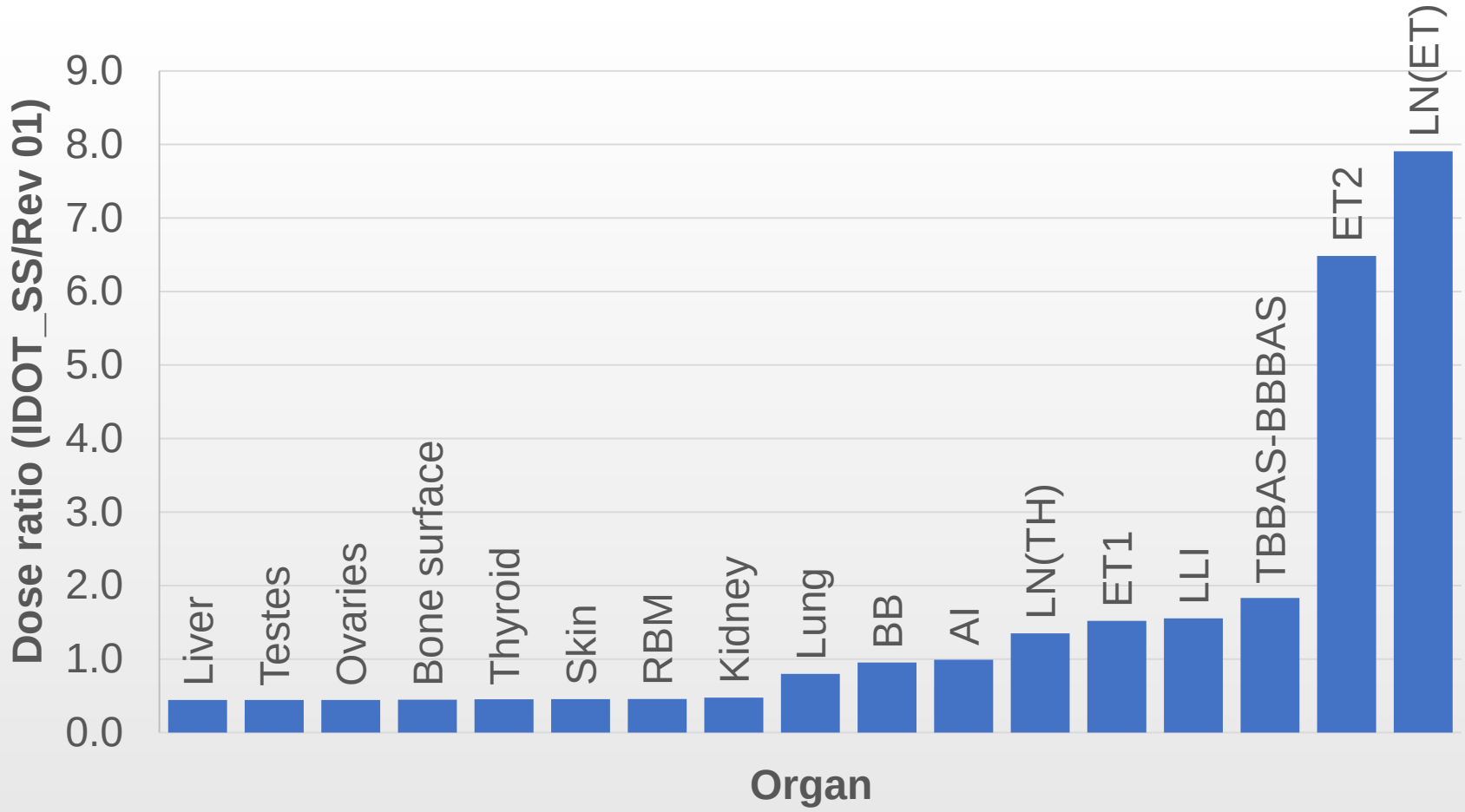
Analysis of Case B bioassay data – chronic Pu-239



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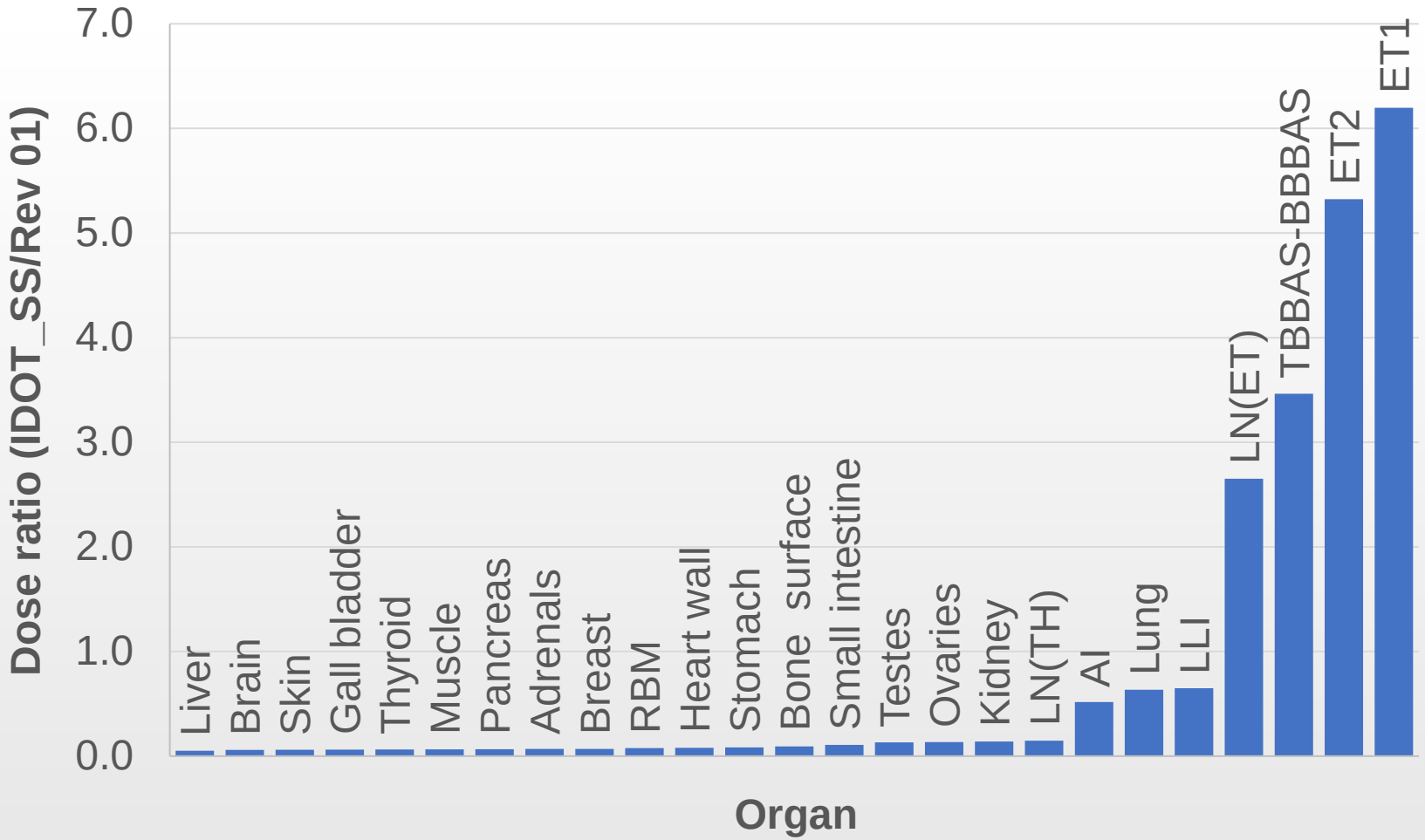
Analysis of Case B bioassay data – chronic Am-24



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Results of analysis of two cases

- Doses to the thoracic and extrathoracic regions can be greater using the IDOT_SS method compared to using the Revision 01 (2010) method
- Doses to the systemic organs are generally less using the IDOT_SS method compared to using the Revision 01 (2010) method

Observation 7

A program evaluation report may be required

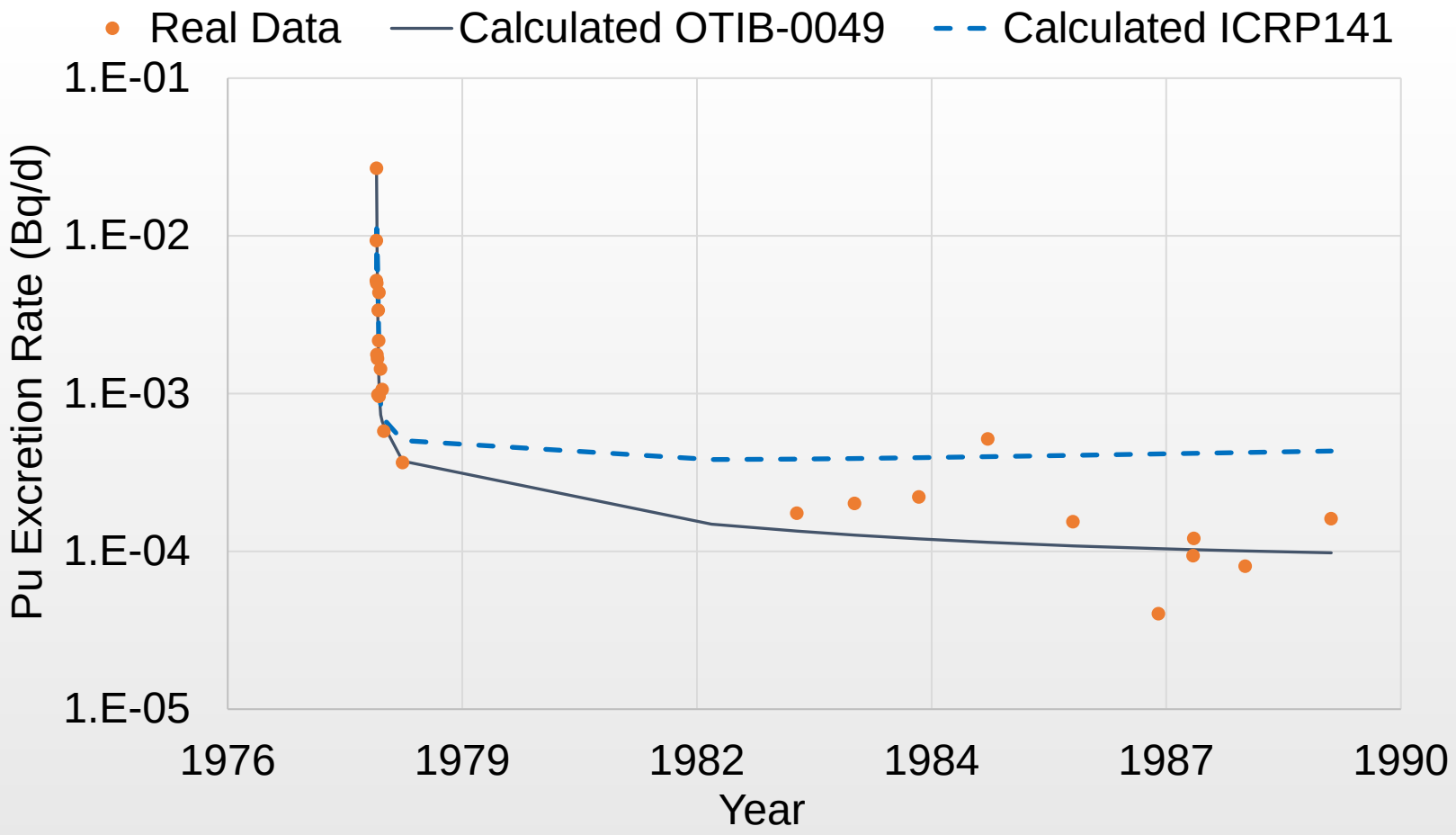
- NIOSH should specify if the dose results using the methods in revision 02 have been compared to the doses derived using the former methods for assessing intakes of type SS plutonium.
- It is important to establish if there are situations where the doses derived using revision 02 are greater than those derived using the previous OTIB-0049 methods, which may necessitate a PER.
- Preliminary analysis indicates organs in the thoracic and extrathoracic regions may receive higher doses using revision 02 in some instances.

Finding 1

IDOT_SS does not provide annual doses for the urinary bladder

- SC&A found that, while IDOT_SS would calculate a total committed dose to the urinary bladder, the results returned for the annual doses to the urinary bladder were “N/A.”

Comparison of bioassay projections for the HAN-1 case



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Observation 8

ICRP Publication 141 parameters appear to be more claimant favorable

- Analysis of the HAN-1 case indicates that use of the ICRP 141-derived absorption parameters results in higher doses to all evaluated organs when compared to the OTIB-0049-derived absorption parameters.

Questions?