



Assessment of Los Alamos National Laboratory Plutonium Bioassay Programs 1996 to 2001 (ORAUT- RPRT-0102)

LaVon Rutherford, CHP

Health Science Administrator

LANL Work Group Meeting

March 23, 2022

Presentation Overview

- Background
- Report Overview
- Study Design
- Data Analysis
- Summary and Conclusions

Background

- The 1999 audit of the Los Alamos National Laboratory (LANL) bioassay program listed several deficiencies in the bioassay program that were of regulatory significance
- Of particular concern to this report was finding 1
 - Radiation workers are not consistently placed on the appropriate routine bioassay program
 - The issues discussed in this finding included ineffective HP checklists, workers failing to submit bioassay samples per RWP requirements, and Johnson Controls Northern New Mexico (JCNNM) personnel not fully participating in required bioassay programs

Background cont.

- The finding prompted the work group to ask NIOSH
 - *Do the 1999 LANL findings regarding bioassay program deficiencies imply data inadequacy and incompleteness significant enough to impair dose reconstruction?*
- At the Nov. 25th, 2018, work group meeting, NIOSH committed to reviewing RWPs and developing a sampling plan for determining whether workers were complying with bioassay requirements and what affect that may have on dose reconstruction
- After capturing RWPs, we decided a sampling plan would not be necessary, we would include all the RWPs that met the study design criteria for the analysis

Report Overview

Report Overview cont.

- Since co-exposure models are used to perform dose reconstructions for individuals without monitoring data, the question by the work group changes to
 - *Do the indicated bioassay program deficiencies imply data inadequacy and incompleteness significant enough to impair development of a co-exposure model?*
- Report 102 was developed to answer the question for plutonium
 - Bioassay programs for plutonium are specifically addressed because plutonium posed the greatest radiological hazard to workers at LANL during the study period (1996 to 2001)
 - If LANL was correctly monitoring for plutonium what evidence makes us think the monitoring was different for other radionuclides of concern

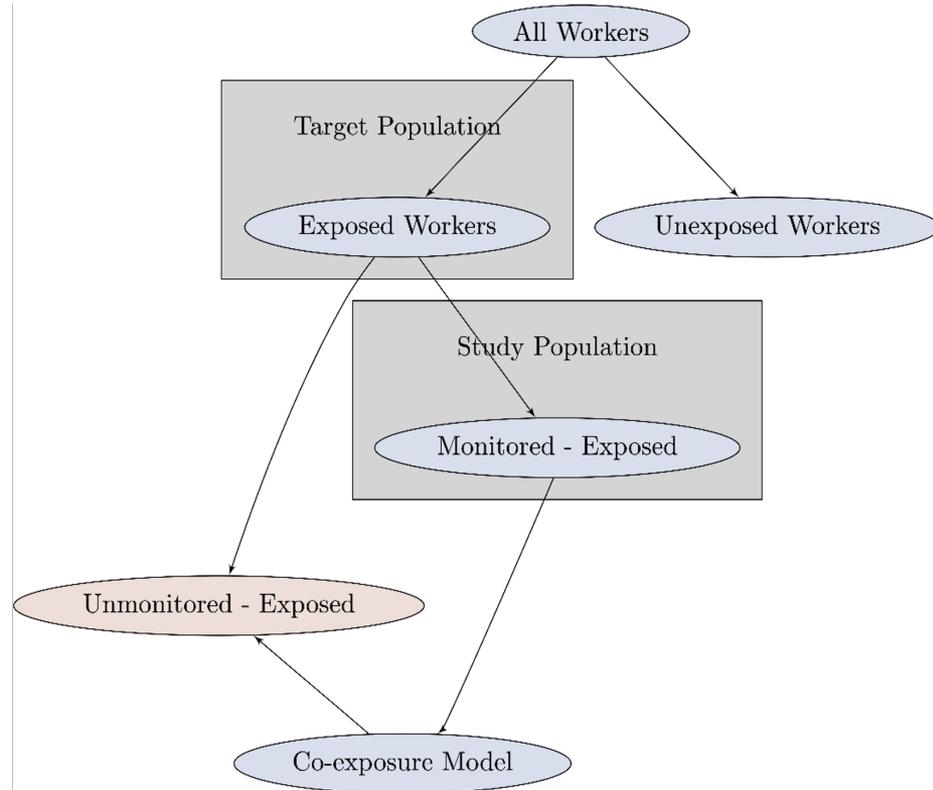
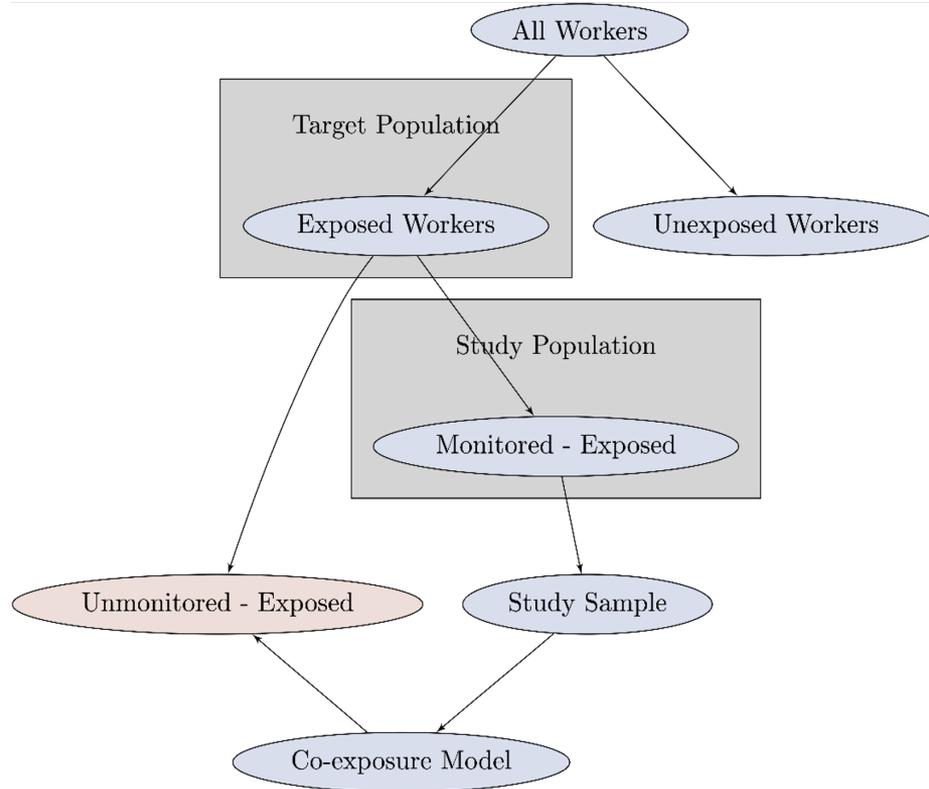
Co-exposure Models

- The goal of a co-exposure study is to estimate the probability distribution of external doses or internal intakes to a “target population”
- All members of the target population who were monitored are referred to as the “study population”
- The distribution of intakes in the study population is referred to as a “co-exposure model,” and it can be used to estimate the distribution of intakes in the target population
- The co-exposure model is then used to estimate intakes to exposed workers who were unmonitored

Co-exposure Models cont.

- In the event the entire study population is not available, the co-exposure model is constructed from the “study sample”
- Three conclusions can be made
 - All the workers in the target population do not have to be monitored to construct a co-exposure model
 - If the co-exposure model is generated from the study population, a bounding model can be generated if a significant portion of the most highly exposed workers in the target population are monitored
 - If the co-exposure model is generated from a study sample, a bounding model can be generated if the previous condition holds, and the study sample is not missing a significant portion of the most highly exposed workers from the study population

Co-exposure Models - Diagram



Regulatory Compliance vs Co-exposure Modeling

Regulatory Compliance

- The 1999 audit was intended to assess whether LANL was in compliance with the regulations promulgated in 10 C.F.R. Part 835
- These regulations established criteria for limiting dose to workers and for acceptable design and implementation of internal dosimetry programs that were used to demonstrate compliance with these dose limits
- Because compliance with regulations helps to minimize and limit dose received by individuals, even one instance of noncompliance is of interest to the regulator and the site

Regulatory Compliance vs Co-exposure Modeling cont.

Dose Reconstruction

- Dose reconstruction is concerned with making a reasonable estimate of the radiation doses received by an individual
- To obtain a reasonable estimate of radiation exposure based on a co-exposure model, it need only be based on a representative (or bounding) sample of the workers performing radiological work
- Compliance with the regulations in place at the time the radiological work was performed is not required in order to perform a dose reconstruction or develop a co-exposure model

Study Design

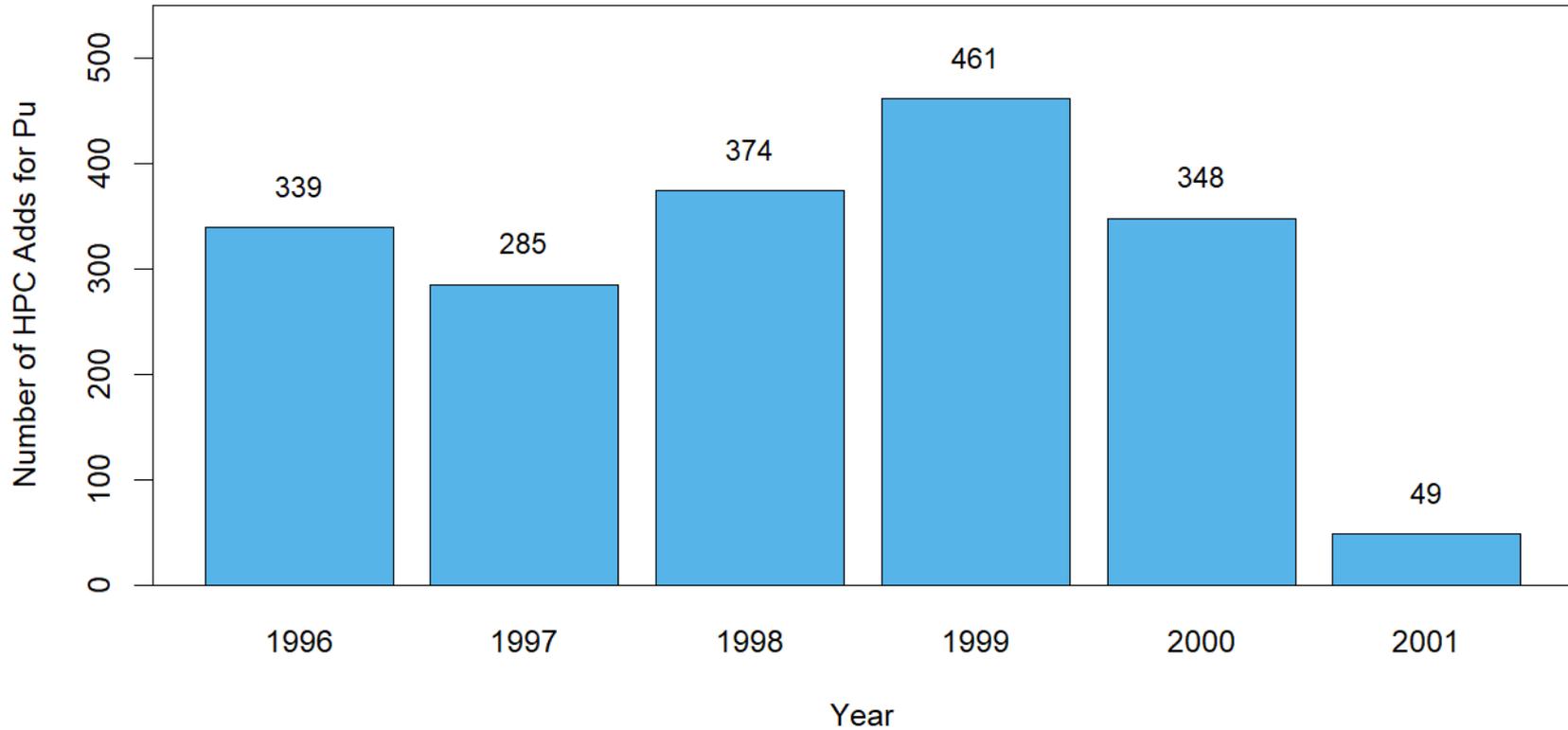
Study Design cont.

- The approach used in this study was to assemble and analyze all the relevant available data about the plutonium monitoring program at LANL during the 1996 to 2001 study period
 - Health Physics Checklists (HPC)
 - Bioassay Enrollment Scheduling and Tracking (BEST)
 - Plutonium in vitro bioassay
 - Plutonium in vivo bioassay
 - External dose
 - RWPs that require plutonium bioassay

Health Physics Checklist

- The HPC is a paper form that a worker, the manager, and a representative from Environmental Safety and Health (ESH) filled in to make changes in the worker's in vitro, in vivo, and external dose monitoring programs
- ORAUT captured HPCs covering years 1985 to 2002
- An HPC database was developed for the study period 1996 to 2001
- The study looked at the HPC adds which means an individual was added to the plutonium bioassay program

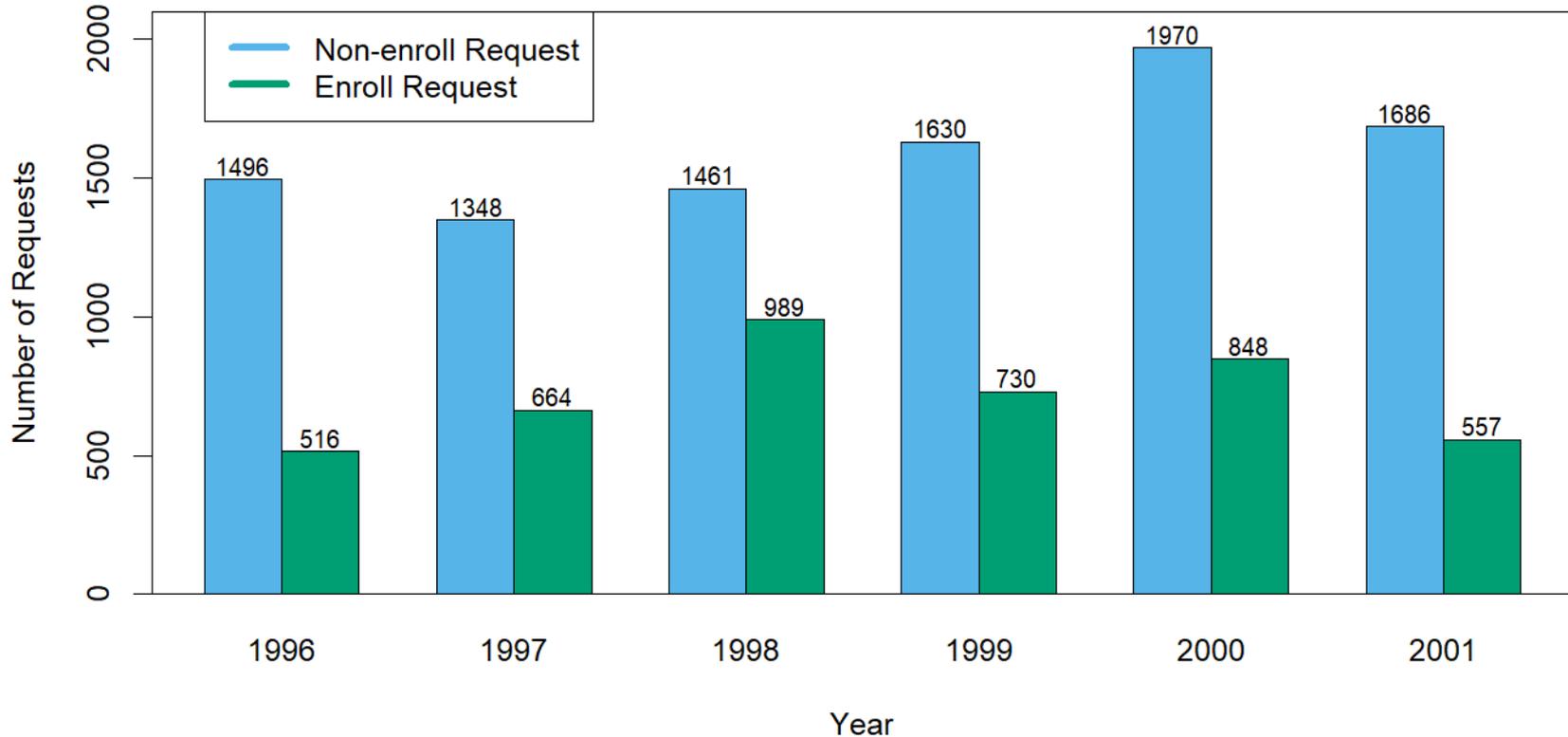
Health Physics Checklist Adds



Bioassay Enrollment, Scheduling, and Tracking

- BEST is a system that was used to manage bioassay program enrollments, which included adding and removing workers from routine, baseline, termination, and special monitoring programs
- BEST data set
 - enrollments that placed workers on bioassay programs are referred to as adds which always had an associated sample request that is referred to as an Enroll Request
 - Sample requests not associated with adds were for routine (e.g., annual) samples, which are referred to as Non-enroll Requests
 - Sum of the Enroll Requests and Non-enroll Requests is the total of number of plutonium bioassay requests in a year

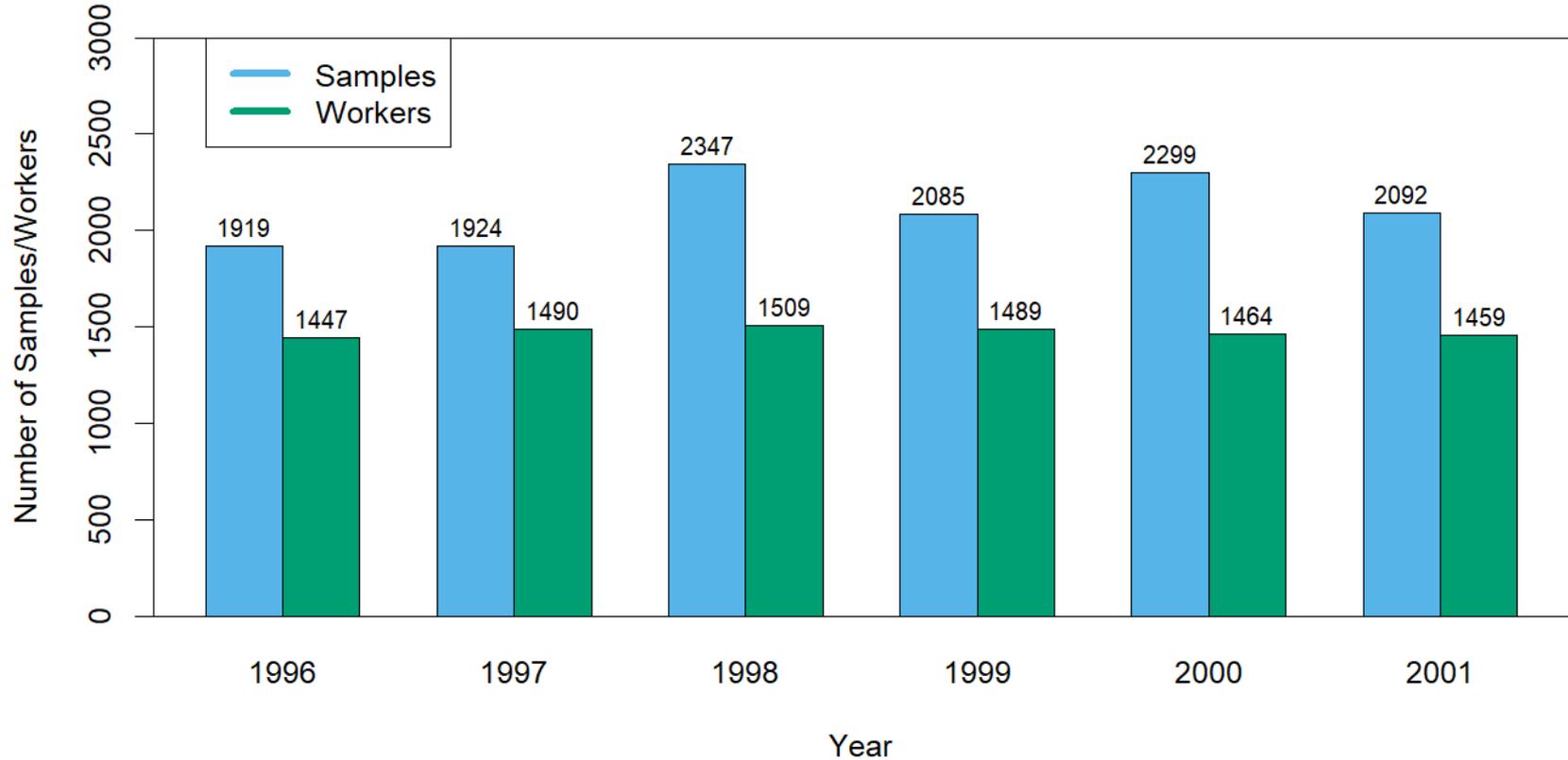
BEST Sample Requests 1996 - 2001



In vitro Bioassay Dataset

- The in vitro bioassay dataset was already created in support of ORAUT-OTIB-0063, *LANL Bioassay Repository Database*
- The dataset includes 12,666 plutonium urine and fecal bioassay samples from 3,219 workers during the study period
 - The 12,619 urine bioassay results are the data that would be used for a co-exposure model for plutonium LANL

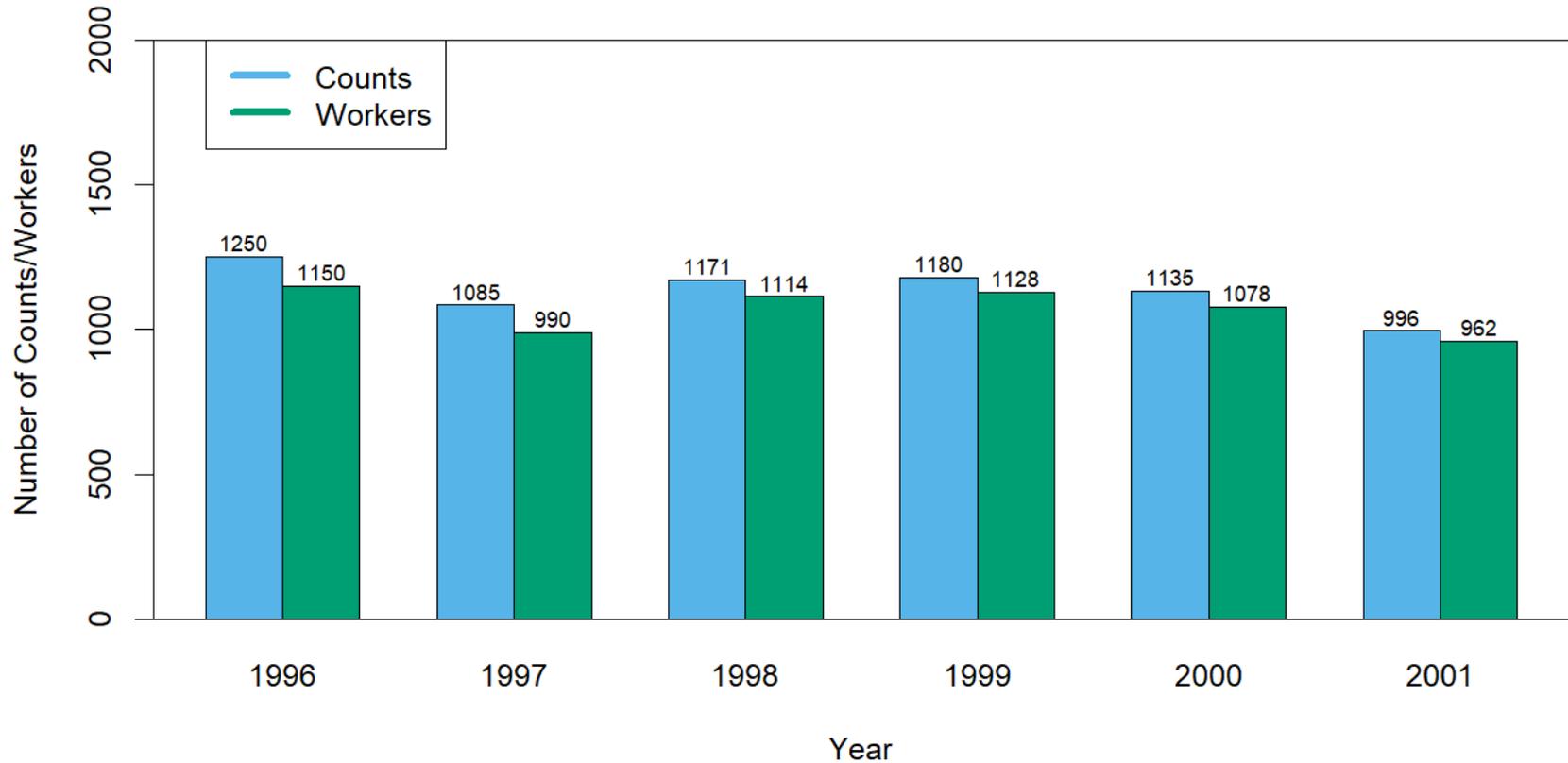
In vitro Bioassay Dataset 1996 - 2001



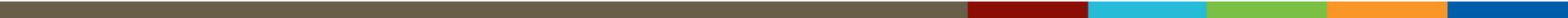
In vivo Bioassay Dataset

- The in vivo bioassay dataset was already created in support of ORAUT-OTIB-0063, *LANL Bioassay Repository Database*
- The dataset includes 6,817 plutonium/americium chest counts from 3,282 workers during the study period
- The number of workers monitored by chest counting and in vitro bioassay is essentially constant over the study period
- Approximately 80% of the workers monitored for plutonium by in vitro bioassay also were monitored by chest counting

In vivo Bioassay Dataset 1996-2001



External Dose Dataset

- The external dose records of LANL workers provide a comprehensive list of individuals who performed radiological work
 - The external dosimetry records were used to help identify individuals who were missing employee numbers in other datasets and as an aid in the entry of those datasets
 - The external dose data consists of the 3.4 million records in the Access dataset
 - There were approximately 11,000 workers at LANL who were monitored for external dose each year during the study period
- 

Radiological Work Permit - Overview

- RWPs were used to control work with a high potential for exposures to radiation
 - All other radiological work was performed according to Safe Operating Procedures
- RWPs with plutonium access list (PAL) checked required that a person be on a plutonium monitoring program before performing work under the RWP

Radiological Work Permit and Acknowledgment Sheets

- RWPs and acknowledgment sheets were transcribed by the ORAU Team from the documents that were captured during the nine targeted visits
- Notable RWPs were targeted for capture, where a “notable” RWP is defined as an RWP that
 - Occurred within the study period (Jan. 1, 1996 to Dec. 31, 2001)
 - Required urinalysis as noted on the RWP by having “Special Urinalysis” or “Pu Access List” checked or contained other equivalent terminology or notation indicating urinalysis was required
 - Contained an associated roster (acknowledgment sheet) with names of personnel acknowledging the RWP

Plutonium Access List and Acknowledgement Sheets

- PALs were generated monthly and mailed as a memorandum to designated field contacts
- Workers signed an acknowledgment sheet during the pre-work briefing, which was required before working under the RWP
- The signature on the acknowledgment sheet indicated that the worker understood the monitoring requirements of the RWP
 - Note that a worker could have signed an acknowledgment sheet and never performed work under that RWP; it is not a sign-in sheet

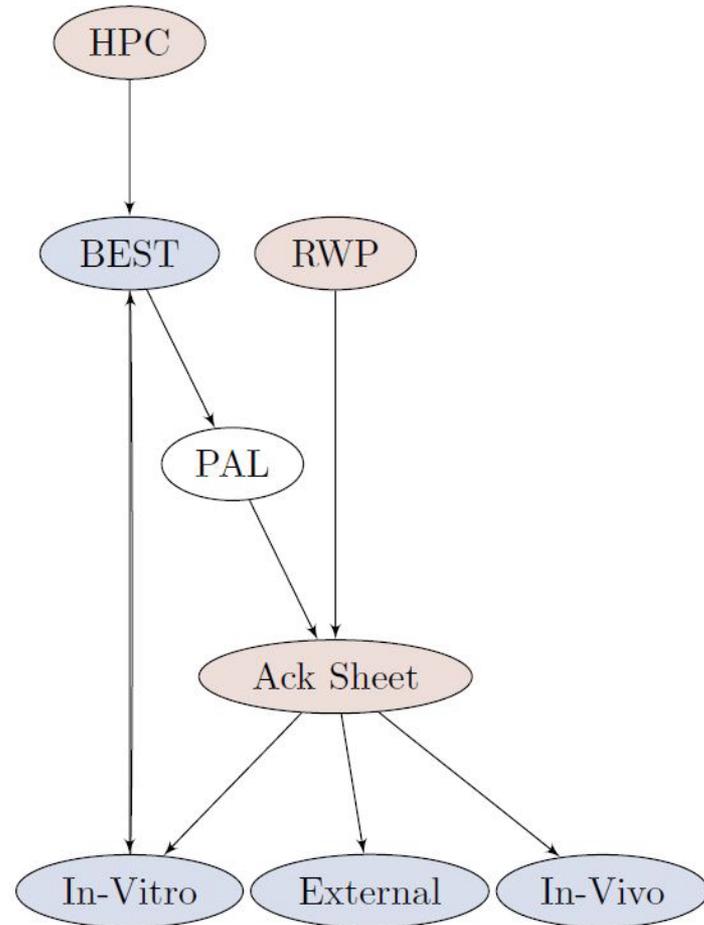
Radiological Work Permit Dataset

- During the study period there are 19,568 records in the RWP dataset, where each record is the signature of one worker on the acknowledgment sheet of a particular RWP that had a PAL requirement
 - There are signatures from 1,942 workers
- A reasonable number of RWPs were obtained for the primary plutonium facilities at LANL

Data Analysis

Dataset - Diagram

- The LANL datasets are interrelated
- Analysis of the HPC -> BEST -> IN-VITRO branch should indicate if a worker placed on a plutonium bioassay program submitted samples for analysis



Issues with Health Physics Checklist

- There is a known problem of HPCs not being submitted consistently
 - Analysis of the HPC -> BEST -> IN-VITRO branch cannot indicate anything if the HPC was never submitted
- To address this issue, we analyzed the RWP -> ACKNOWLEDGMENT SHEET -> IN-VITRO/IN-VIVO branch
 - This will show if a worker who did work with potential for exposure to plutonium was monitored for plutonium
 - Note that this analysis is independent of whether a worker submitted an HPC.
 - if an individual performed radiological work that required monitoring for plutonium and was properly monitored, the HPC paperwork is irrelevant

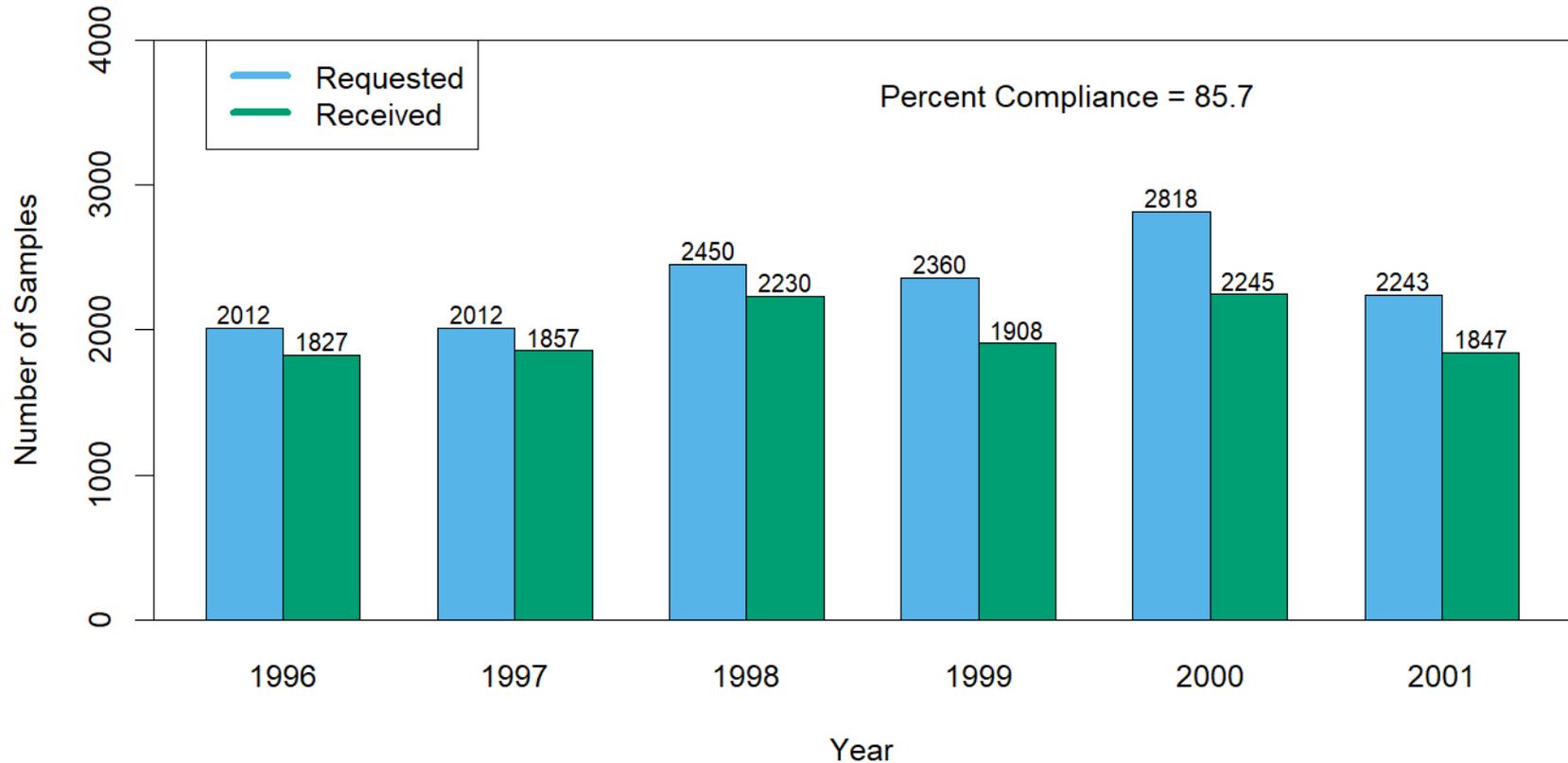
Analysis of Dataset

- From this data set we should be able to answer three critical questions
 - *Were workers who signed an RWP acknowledgment sheet with a PAL requirement monitored in a timely fashion?*
 - *What fraction of workers who signed the acknowledgment sheet for a given RWP was monitored?*
 - *What were the relative exposures of different groups to plutonium?*

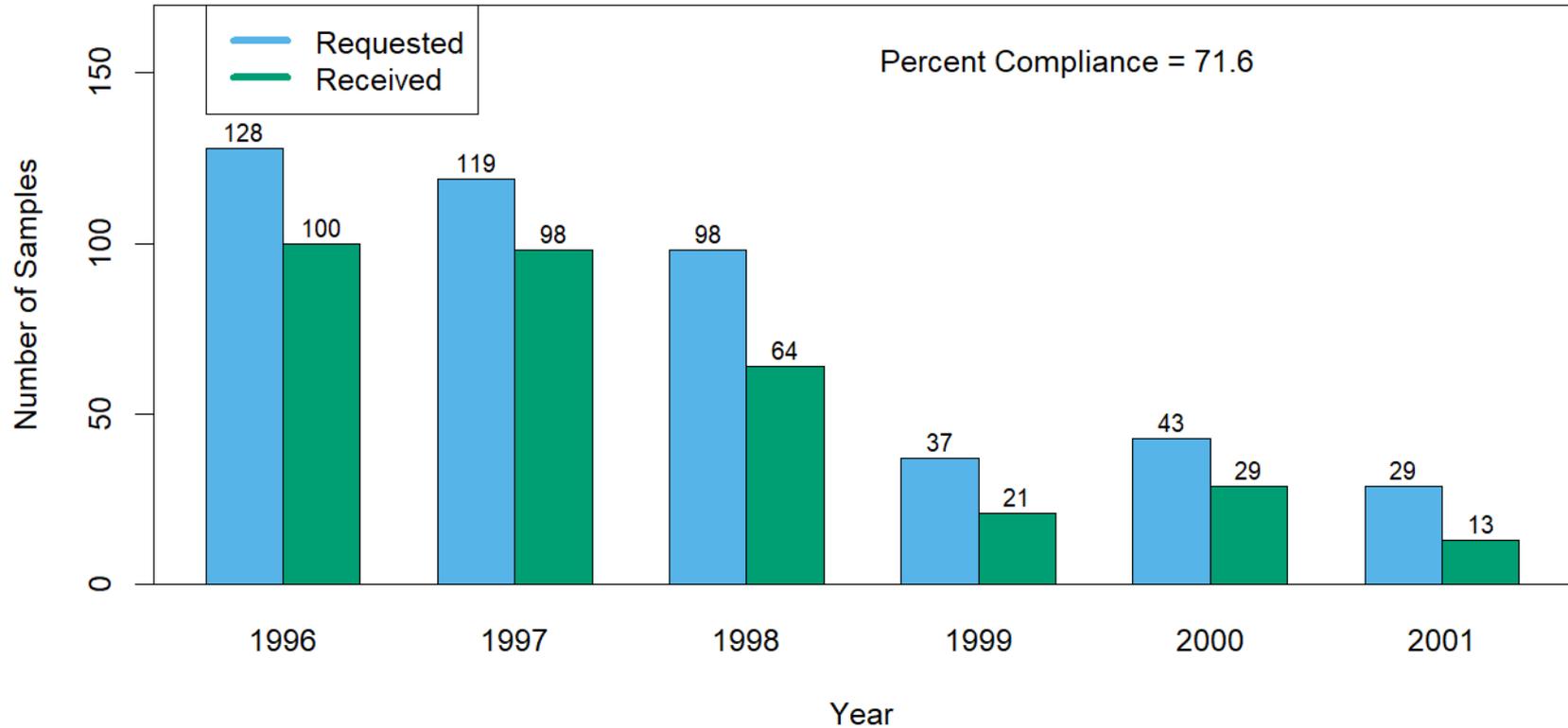
Comparison BEST vs In vitro Dataset

- Overall, out of 13,895 requests made through BEST for samples to be analyzed for plutonium, 11,914 (85.7%) were fulfilled
- All requests from BEST were tracked and most were accounted for with reasons being given for why sample requests were not fulfilled
 - Of the 1,981 samples not received, 1,613 have legitimate reasons for not being received such as termination or extended leave of the individual

Plutonium Samples Requested through BEST and Received for all Workers



Samples requested from JCNNM workers through BEST that were received and analyzed for plutonium



Comparison HPC vs BEST

- There are 1,856 adds via HPCs during the study period for plutonium
- A detailed comparison of the HPC with BEST showed that:
 - 1,802 out of 1,856 = 97.09% of the plutonium adds in HPCs matched BEST (when only considering BEST), and
 - 1,848 out of 1,856 = 99.57% matched when also considering samples in the in vitro dataset that did not have a request in BEST
- Therefore, workers who submitted HPC add forms almost certainly were entered in the BEST system

Compliance with Radiation Work Permits

- A key part of this report is to quantify the extent to which the LANL workforce complied with the bioassay requirements for work involving plutonium
- Workers were required to sign the RWP acknowledgment sheet for an RWP to indicate they understood the monitoring and personal protection equipment requirements of that RWP
 - As indicated earlier their signatures did not denote that they performed any work, only that they understood the requirements to work under that RWP

Compliance with Radiation Work Permits cont.

- In the report, Table 10-1 *Summary of Statistics for monitoring of RWP Work* introduces a couple of terms that need to be explained
 - The table is recreated on the following slide
- Work and Worker columns refer to the percentage of work and workers, respectively, who were properly monitored as determined using the active RWP period and post-RWP window
- Work(O) and Worker(O) columns refer to the percentage of work and workers, respectively, who were properly monitored as determined using the active RWP period, post-RWP window, and open window

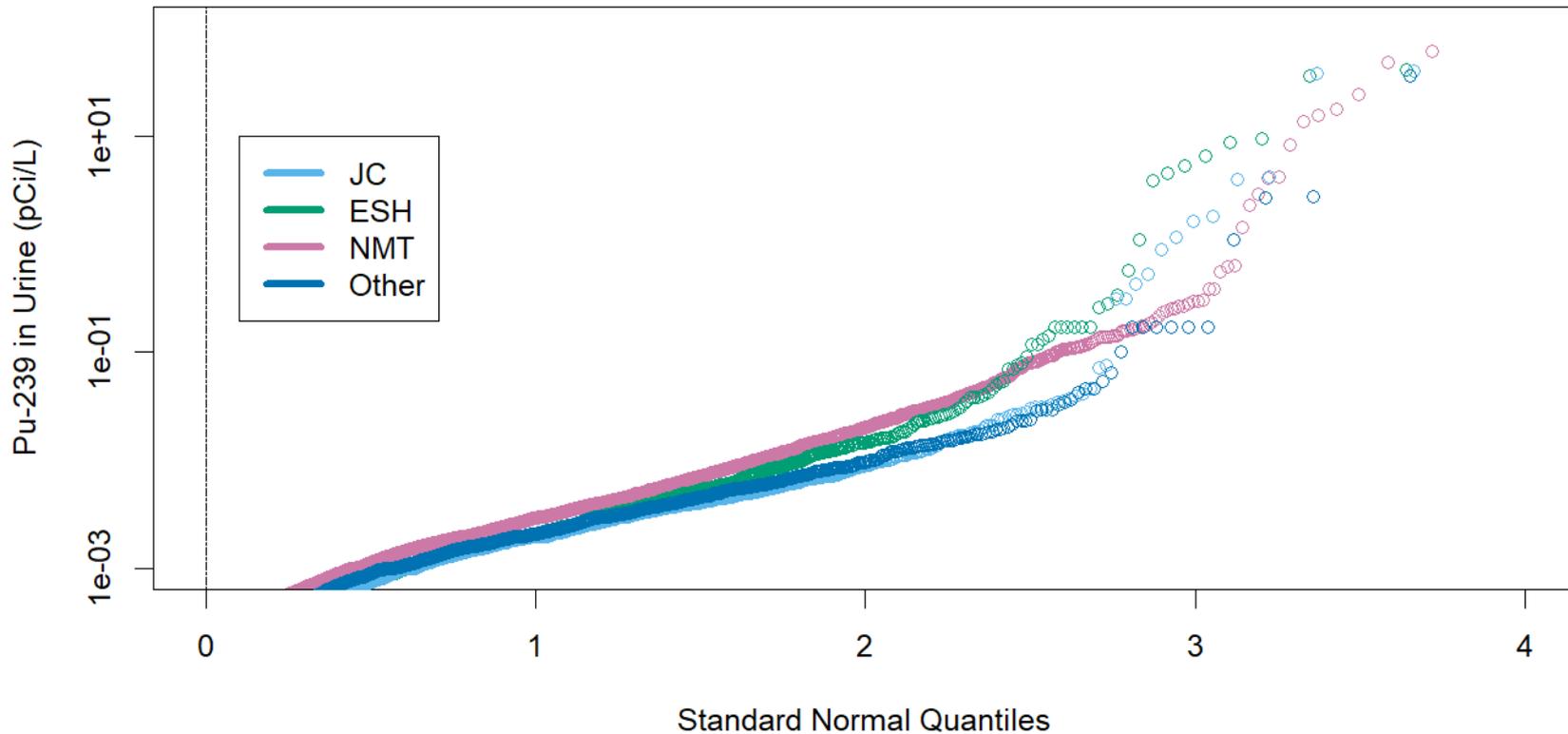
Compliance with Radiation Work Permits Results

Group	Number of workers	Number of RWPs	Work (%)	Worker (%)	Work (O) (%)	Worker (O) (%)
JC	703	1396	81.0	65.1	92.6	83.5
ESH	227	2128	96.5	84.1	98.1	87.8
NMT	660	1393	97.1	95.3	99.0	98.2
Other	556	579	70.6	63.3	81.4	74.5

Plutonium Results for JCNNM, Environmental Safety and Health, Nuclear Metals Technology, and other groups

- NIOSH feels we have established that there is a considerable amount of data available on which to base a co-exposure model for plutonium at LANL
- However, when you break the data into groups (i.e., JCNNM, ESH, etc.), some groups have more plutonium monitoring data than others
- Therefore, it is of interest to compare some measure of relative exposures of the groups to see if the groups with less data are more highly exposed
- An approximate measure of the exposures to each of the four groups is the plutonium in urine analytical results for the groups

Comparison of Pu²³⁹ in Urine of JCNNM, ESH, and NMT Workers



Plutonium Results for Johnson Controls, Environmental Safety and Health, Nuclear Metals Technology, and other cont.

- The data for the four groups are similar, with NMT and ESH being slightly higher
- The few relatively high results of ^{239}Pu for JCNNM workers appears to have been a single event

Summary and Conclusions

Summary

- Comparison of BEST vs. In vitro Dataset
 - 85.7% of sample requests were fulfilled
- Comparison of HPC vs. BEST
 - 97% of additions matched BEST
- Compliance with RWP required sampling
 - Approximately 97% of the 2,252 RWP had 50% or more of the workers monitored.
- Comparison of Pu In vitro results across various Groups
 - Results were similar across Groups with ESH and NMT slightly higher

Conclusions

- The evidence supports the conclusion that the plutonium bioassay data reported by LANL in the 1996 to 2001 study period include a significant portion of the most highly exposed workers
- The data is adequate to construct a co-exposure model for plutonium

For more information, contact CDC
1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

