

OCAS Meeting Report

7/19/01

Topic: Discussion with MJW Corp. regarding lessons learned from the Mound internal dose reconstruction project

Date/Location: July 19, 2001; Cincinnati - NIOSH / Hamilton

Attendees (Affiliation):

Larry Elliott; Greg Lotz, Jim Neton, Mary Schubauer-Berigan, Randy Smith,
Ted Katz (NIOSH / OCAS)

Tim Taulbee, Thurman Wenzl, Steve Ahrenholz, Cynthia Robinson (NIOSH / HERB)
Jim Griffin, Dave Dooley, Liz Brackett (MJW Corp.)

General summary: MJW provided an overview of their experience with the reconstruction of internal doses at the DOE Mound facility in Miamisburg, Ohio. A presentation provided by Liz Brackett and Dave Dooley covered their approach to this project and a discussion issues encountered by MJW in estimating doses for a cohort of workers employed at Mound between 1943 and 1985. A copy of the overheads used during the presentation are attached.

Specific findings

The project was divided into two phases - Phase 1 was devoted to data assembly and screening while phase 2 was the actual dose assessment. Phase 1 took much longer than expected.

While ^{239}Pu and ^{238}Pu were the main radionuclides of interest, exposure other radionuclides were evaluated.

A screening process was used at the very beginning of the project to eliminate all workers with internal exposures less than 20 rem.

All dose calculations, with the exception of ^{210}Po , were performed using the ICRP 30 models. For polonium, the ICRP 66 lung model was used. All doses were calculated as 50 year committed effective dose equivalents. This calculation is incompatible with the needs of OCAS which must calculate the annual dose equivalent received by the organ of interest from the time of first covered employment period to the date of cancer diagnosis.

During the records review process, they encountered a number of record formats, many of which were difficult to interpret without resorting to workers with institutional memory. The sources of these records was quite varied. For their project, air sample results were not found to be particularly useful. Not until they were well into the project did they discover a useful collection of records at Los Alamos National Laboratory.

NIOSH should be aware of issues related to declassification requirement for documents and the potential for contamination of records. Both of these can lead to an increase in the time and expense required to perform a dose reconstruction. In particular, it took about 2 months to

declassify a laboratory logbook.

The ORAU REACTS center is the designated archival center for all chelation documentation.

The project started with about 6,000 people, with about 1550 workers requiring assessments using bioassay records. All dose reconstructions were based on an evaluation of the bioassay results only.

**Mound Pre-1989 Internal Dose
Reconstruction Project**

MJW Corporation, Inc.

**Work supported by BWXT of Ohio,
Inc. under Contract Nos. 14143,
14143-1999, 2000-00372**

Project Summary

Goal: Screen all bioassay results and perform dose assessments for all individuals estimated to exceed 20 rem CEDE from intakes at Mound between 1943 and 1989

Work Process:

Phase I - Data Assembly & Screening

Phase II - Dose Assessment

Radionuclides Evaluated

- Pu-238, 239/240, 241
- Th-230 (Ionium)
- Th-232
- Po-210
- Pa-231
- H-3
- U-233, 234, 235, 238
- Ra-226/Ac-227/Th-228

Phase 1 Process

- Accumulated historical bioassay data
- Developed algorithms to screen for > 20 rem
- Developed model using ICRP 66 lung model for polonium for Phase II assessments
- Established MDAs

Screening

- Developed algorithm for rapid batch screening
- Parameters selected for conservative but reasonable estimate
- Used ICRP 26/30 methodology
- Jones Excretion Model for plutonium intakes, 50% W/50% Y
- ICRP 30 Model for polonium intakes, Class W

Multiple Record Formats

- Electronic databases
- Paper records
- Logbooks
- Microfiche
- Microfilm

Data Sources

- Chemistry logbooks (bioassay results)
- HP logbooks (nosewipes, hair surveys, ...)
- Monthly HP reports
- Weekly HP reports
 - Separate for Pu and Po
- Data cards
- Incident reports
- Microfiche from epidemiology study (mid '70s)
- Air sample results not useful

Multiple Record Locations

- Mound Dosimetry Records Center
 - packing and transferring records to storage for shutdown of site
 - relocated prior to project
 - relocated during project
- Mound short and long term record storage
- Mound classified vault
- Long term storage at LANL
 - potentially contaminated
 - classified

Data Sources

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Data Collection and Organization

- Old, illegible, cryptic records
- Contaminated, classified records
- Cross-correlated logbooks
- Only H-3 and plutonium computerized
- Traveled to LANL to review some records
- Retrieved remainder of records from LANL
- Coordinated classified records review with
Classification Officer

ID of individuals difficult in early days

- **SSN only recently introduced**
- **HP ID number assigned to individuals**
 - numbering system changed several times
- **Results recorded by last name only**
- **Maiden name to married name**
- **Sometimes nickname used**
- **Spent much time cross-correlating various data sources**

Available Data/Limitations: Plutonium

- Database with 58,000 records (1956-1990)
- Results converted to pCi, assumptions applied
- KARDEX cards
- Found additional hardcopy records for 1951-1952
- Total Pu prior to 1981, isotopic thereafter
- No reported analytical errors prior to 1981
- Some fecal results, most not in database

Plutonium Chelation Records

- Incomplete, scattered
- Bioassay results following administration not always entered into logbook
- Dates of administration, reason (date and description of incident) not always documented
- Records from ORAU don't always agree with reality

Determination of Pre-1981 Plutonium

Detection Limits

- Changed several times during project
- Little or no information for calculation
- Results were from gross alpha counting
- Instrument background was not routinely recorded
- Blank and spike data were sparse and not correlated with samples
- Counting efficiency and chemical yield were assumed

History of Pu-238 MDAs (pCi)

Date	Rev. 0	June 1998	March 1999	Aug. 1999 (final)	Mound procedure
Before 1957	0.15	0.1	0.1	0.1	0.15
1957	0.15	0.11	0.11	0.11	0.15
1958	0.15	0.07	0.07	0.11	0.15
1959	0.15	0.06	0.06	0.11	0.15
1960-1966	0.11	0.05	0.05	0.11	0.11
1967 - 5/1981	0.11	0.11	0.11	0.11	0.11
6/1981 - 12/1981	0.11	0.010	0.066	0.066	0.11
1/1982 - 5/1982	0.11	0.010	0.063	0.063	0.11
6/82-9/82	0.010	0.010	0.063	0.063	0.11
10/1982 - 12/1982	0.017	0.017	0.063	0.063	0.11
1/1983 - 4/1983	0.017	0.017	0.064	0.064	0.11
5/1983 - 12/1983	0.022	0.022	0.064	0.064	0.11
1984	0.11	0.11	0.066	0.066	0.11
1985	0.036	0.036	0.047	0.047	0.036
1986	0.029	0.029	0.042	0.042	0.026

Examples of Cryptic Comments in Bioassay Logbooks

- * (next to volume) ■ ES
- T (in Name column) ■ NCR
- NNS ■ B.S.
- 46 PO ■ REG & T.A
- HOPPIES ■ PLIP
- SP=28 CTS/HR ■ 1/5 OF SAMPLE
- CE BGR. INCLUDED ACTUALLY
IN COUNT PROCESSED

Available Data/Limitations: H-3

- Database contains dose per year
 - not clear if “year” is FY or CY
- Urine results in logbooks
- No documentation of dose algorithm pre-1981
- Recalculated pre-1981 doses using ANSI N13.14 algorithm
- Recalculated doses lower (variable) than those in database

Available Data/Limitations: Polonium

- 208,000 records (1944 -1971)
- Spot urine samples
- Unconverted results (cpm)
- Questions about plating efficiency
- Some blood samples

Polonium database development required

- Cards sorted into folders by Mound prior to project
- Reviewed for duplication, uniquely numbered using Bates stamp
- Developed data entry software
- Procedures and training for data clerks
- Substantial QA effort (double key entry, other checks)
- 40 person-months of effort

Polonium Weekly Report

Group Leader	Process #	Station Group #	Production
Group Leader	11	4/250 m3	Unit 3 = 67 % Unit 4 = 60 %
Group Leader	12		
Group Leader	13		
Group Leader	14		
Group Leader	15		
Group Leader	16		
Group Leader	17		
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Group Leader	98		
Group Leader	99		
Group Leader	100		

Production Review
3/7/74

Unit 3 = 67 %
Unit 4 = 60 %

(450 c/min - 24 hrs) total = 1240 cc

(1840 c/min - 24 hrs) total = 2400 cc

(270 c/min - 24 hrs) total = 910 cc

Polonium Logbook

MOHAWK CHEMICAL COMPANY
CENTRAL RESEARCH DEPARTMENT

Nº 141764

SUBJECT

DATE Jan. 7 1946

NO.	NAME	DATE	pH	DISC NO.	c/m BEFORE	c/m AFTER	NET c/m	REMARKS
1		1-7	4	X156	2/1	4/9	18	
2		"	"	Z18	1/1	4/9	13	
3		"	"	X102	2/2	5/5	7	
4		"	"	39	0/2	7/8	13	
5		"	"	X197	1/2	6/3	6	
6		"	"	X152	2/5	4/9	8	
7		"	"	X120	3/1	4/6	12	
8		"	"	83	4/0	5/6	10	
9		"	"	292	2/3	2/9	4	
10		"	"	1	3/3	4/4	4	
11		"	"	2	1/1	4/2	3	
12		"	"	X86	0/1	7/14	126	
13		"	"					
14		"	"	X54	7/2	4/4	16	
15		"	"	Y204	1/1	3/6	5	
16		"	"	X204	3/1	4/4	2	
17		"	"	X197	1/0	1/4	9	
18		"	"	C20	0/1	3/6	23	
19		"	"	X1	0/2	3/0	11	
20		"	"					
21		"	"	F75	0/1	4/6	41	
22		"	"	F93	1/1	2/11	31	
23		"	"	28	1/1	1/4	3	
24		"	"	59	0/2	7/5	10	
25		"	"	X149	3/1	4/1	10	
26		"	"	X223	0/1	3/4	5	

SIGNATURE

OFFICIAL USE ONLY

Available Data/Limitations: Other Radionuclides

- Ra, Ac, Th, Pa, U
- ~2,000 records
- Primarily from the 1950s
- Logbooks and count room sheets
- Very cryptic
- Unconverted results
- No results listed for many samples

Other Radionuclides (cont.)

- All results were gross alpha
- Generally assumed daughters in equilibrium with parent radionuclides in urine
- Pa was not directly measured, it was inferred from Ra and Th gross alpha
- Differential decay analysis to determine Ra-226, Ra-223, and Ra-224 for Ra/Ac/Th

Protactinium Logbook

*Collected from 5/11/54
 5/11/54
 5/11/54*

*Very thorium fraction in unphysico records,
 Protactinium samples
 all samples followed by Pa.*

	$\frac{Ox/Na}{Pa}$	$\frac{Ca/Na}{Pa}$
5817-1 Pa 0477	5.03	1.03
5818-2 Pa 0408	1.11	2.31
5821-3 Pa 0990	6.54	5.54
5824-4 Pa 0660	1.96	5.00
5829-5 Pa 1025	12.02	6.83
5906-1 Pa 0599	5.92	6.04
51017-1 Pa 10034	2.42	3.98
51107-1 Pa 10448	5.17	5.96
51108-2 Pa 0608	2.22	1.56
51128-3 Pa 2109	7.71	8.57

Ra/Ac/Th Logbook

Code Number	Time of Separation	g/hr Ra-226	g/hr Ra-228	g/hr Ac-227	g/hr Ra-226	g/hr Ac-227	g/hr Ra-226	g/hr Ac-227	TREB Ra-226	TREB Ac-227	TREB Th-232	TOTAL TREB
0426-32B	1/14-3 ²¹	6.4			6.0		0.01				0.02	0.03
0518-42B	5/10-2 ²⁵		6.0 NA				0.02	→				0.02
0525-63B	5/28-11 ²¹		10.1 NA				0.033	→				0.033
0629-60B			2.5 NA				0.027	→				0.023
1102-1B			13.5 NA						0.041			0.041
1122-22B			16.3 NA						0.049			0.049
1214-18B			5.8 NA						0.017			0.017
1228-32B			13.4 NA						0.040			0.040
411-20B			6.4 NA						0.019			0.019
4701-2B			7.3 NA						0.022			0.022
5215-14			10.3 NA						0.031			0.031
5728-9			5.3 NA						0.010			0.010
51017-7			8.3 NA						0.025			0.025
51212-9			10.3 NA						0.031			0.031

Ra/Ac/Th Logbook

2122-55-3338

Code Number	Time of Separation	C/hr Ra-226	C/hr Ra-223	C/hr Ra-224	C/hr Ac-227	FP20 Ra-226	FP20 Ac-227	FP20 Th-232	Total FP20
0105-38	1/7-11 th	6	9.6			0.01	0.12		0.13
0126-58	1/28-10 th	3.6	9.6			0.006	0.023		0.029
0316-118	2/27-2 nd	3.6	21			0.006	0.07		0.076
0400-318	4/21-3 rd		5.3 NA				0.04		0.04
0504-48	5/5-3 rd		12		7		0.04		0.04
0601-38	6/2-3 rd	10.0	5.0	6.5		0.015	0.017	0.022	0.054
0615-298	6/6-3 rd	6.7	1.9	6.2		0.01	0.006	0.021	0.037
0624-248	6/20-3 rd	7.0	14.5			0.02	0.033		0.053
0803-48	8/15-10 th	62.5	1.0			0.125	0.003		0.128
0810-178	8/11-2 nd	14.0	15.2	17.6		0.028	0.046	0.053	0.127
0908-108	9/6-3 rd	6.3	7.0	3.9		0.013	0.021	0.014	0.048
0921-338			15.6 NA				0.047		0.047

Revised

Thorium Count Room Sheet

0-318

BIO-ASSAY

SAMPLE NO. 4510-10T PROCESSING DATE _____
SAMPLE DATE _____ PROCESSING TIME _____
BACKGROUND 1.62 c/hr. SCALING FACTOR 8 PLATING TIME _____
MACHINE NO. 173

DATE	TIME	ELAPSED TIME	REG. & INTERPOLATE				
6-2	4:15	0	0.40				
6-3	8:15	16:00	19.2	8		8.00	

RESULTS Plu

Phase 2 - Assessments

- ~2400 assessments for 1550 people
- ~30 assessors around the country
- Substantial training program provided
- Data packets sent to assessors
 - copies of information from dosimetry records' folders
 - employment information from Mound database
- Clerks on site to retrieve data

Phase 2 - Assessments

- Assessments
 - CINDY used for plutonium calculations
 - FeedCINDY
 - MJW program developed for automated data input and evaluation of multiple Pu intakes for CINDY
 - > 90% reduction in CINDY data entry
 - New code developed for polonium
 - CINDY used for remaining nuclides
- Peer reviewed

ICRP 26/30 vs. ICRP 66/67

Dose (Sv) indicated by a 24-h urinary excretion of 1 Bq at various times post intake

1 micron AMAD

Days	Class W	Type M	Ratio W/M	Class Y	Type S	Ratio Y/S
5	2.6	1.2	2.1	35	30	1.2
10	4.9	2.5	1.9	68	46	1.5
50	8.4	3.8	2.2	110	53	2.2
600	40	10	4.0	96	45	2.1
2000	74	20	3.8	96	50	1.9
10000	93	47	2.0	150	97	1.5

5 micron AMAD

Days	Class W	Type M	Ratio W/M	Class Y	Type S	Ratio Y/S
5	1.9	0.8	2.2	7.4	18	0.40
10	4.0	2.1	1.9	16	37	0.42
50	8.7	3.9	2.3	36	50	0.70
600	42	11	3.9	78	48	1.6
2000	73	20	3.6	90	53	1.7
10000	92	48	1.9	130	100	1.3

Assessment Issues

- Aimed for consistency
- Assumed intake dates
- Assumed Pu isotope for early intakes
- Detection levels
- Many assumptions for Ra, Ac, Th, Pa assessments
- Much information difficult to interpret

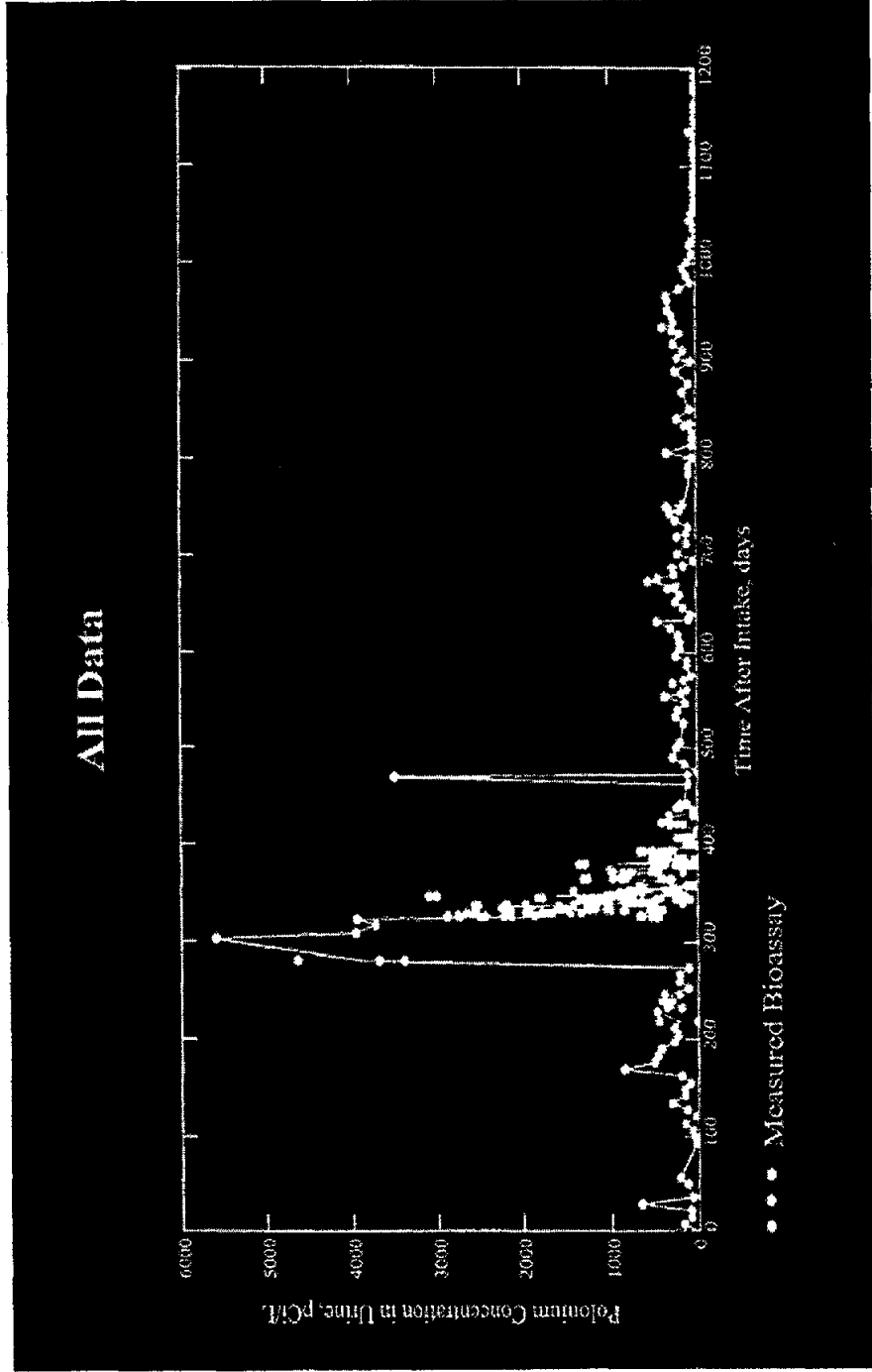
Assessment Issues for Other Radionuclides

- Pa-231
 - assumed exposure to source material rather than pure Pa-231
 - no dose assessed for Pa-231
 - gross Th results were assumed to be a mixture of Th-232, Th-230, Th-228
- Ac-227
 - intake was calculated from Ra-223 result
 - calculated Ra-223 intake was assumed to be equal to Ac-227 intake

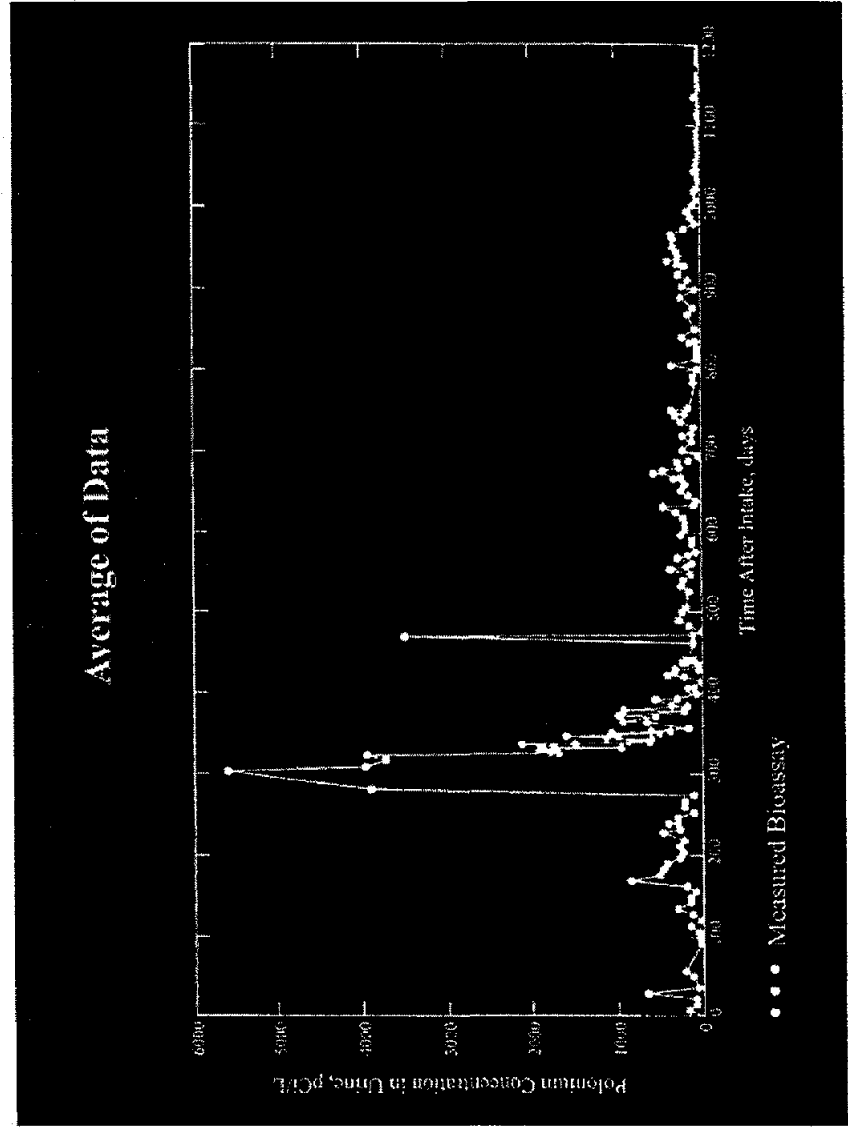
Assessment Issues for Other Radionuclides (cont.)

- Th-228
 - Ra-224 result was used as a Th-228 result for intake calculation
- Th-232
 - gross thorium results were assumed to be a mixture of Th-232, Th-230, and Th-228
- No doses were assessed for Ra-223 or Ra-224 because they were relatively insignificant

Polonium Case



Polonium Case with Results Averaged



Doses from Polonium Case

Intake, Effective Dose Estimate, and Organ Dose Estimates using the Numerical Integration of Urine Excretion Data based on the Modified Type M Resp. Tract Model (1 μ AMAD) and Leggett & Eckerman (Mound) Systemic Model:

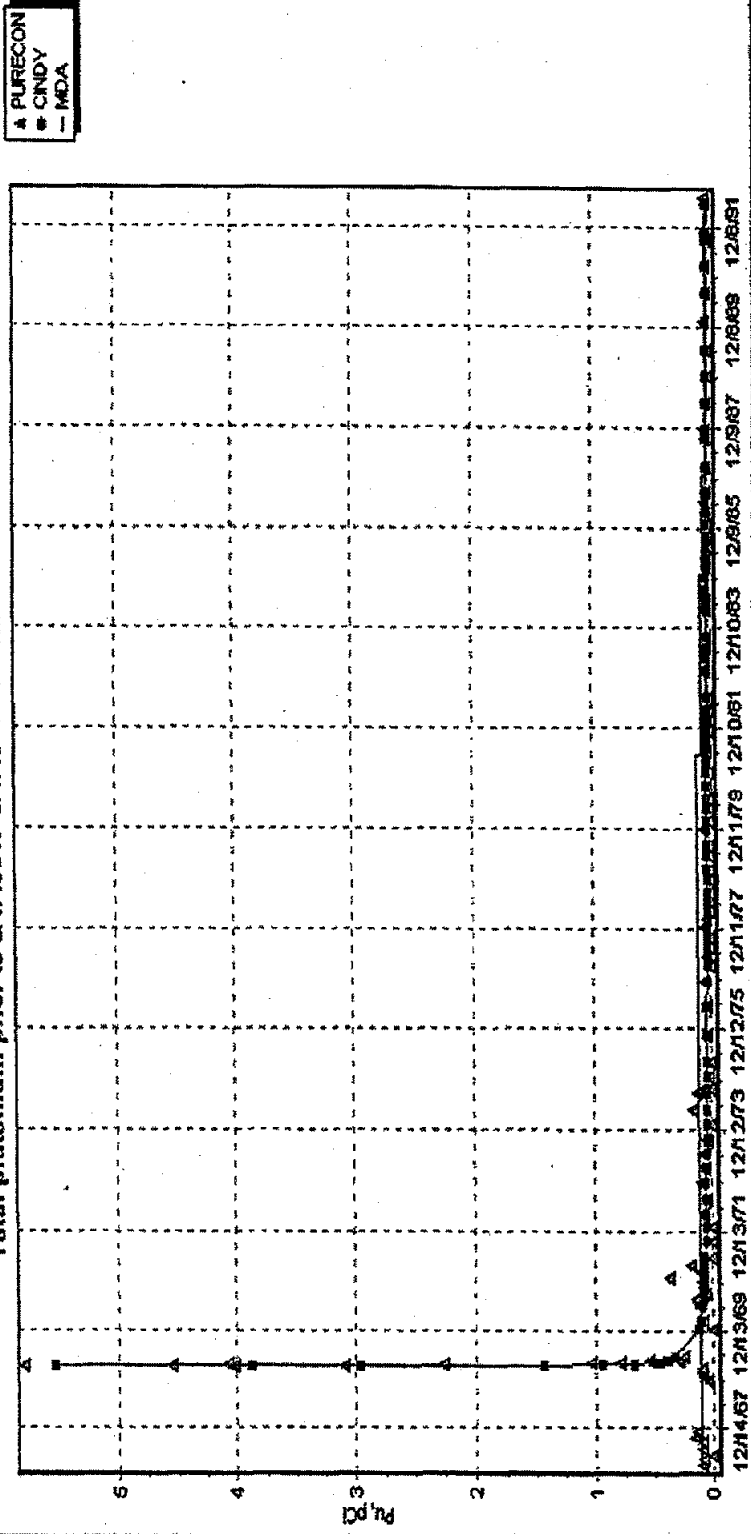
$$\text{Intake} = 2.10 \cdot 10^7 \text{ pCi}$$

$$\text{Dose} = 2.24 \cdot 10^2 \text{ rem}$$

Organ	Dose (rem)
Lung	1.7E+03
Kidneys	1.3E+02
Gonads	8.3E+01
Liver	5.6E+01
Bone Surfaces	4.4E+01
Spleen	3.7E+01
Breast	2.4E+00
Red Bone Marrow	1.2E+01
Thyroid	2.4E+00
Stomach	2.4E+00
Small Intestine	2.4E+00
Upper Large Intestine	2.8E+00
Lower Large Intestine	3.5E+00
Remainder	4.6E+00
Effective Dose	2.2E+02

Plutonium Case Example

Total plutonium prior to 6/1/1981. 6/1/1981 and later is Pu238.



Mound Project Summary: Lessons Learned

- **Strong project management team needed**
 - Trained, experienced staff is essential
 - Need for good clerical/data entry staff
 - Communication of project status/changes
- **Organization of site data/info is critical**
- **Clear and concise procedures required**
- **Assumptions must be well documented**
 - Must take site specific information into account
- **Analytical approach must be consistent and defensible**
- **Versatile file/tracking system needed**