Draft White Paper

SC&A REVIEW OF "NIOSH EVALUATION OF FERNALD SUBCONTRACTOR BIOASSAY DATA, REVISION 1"

Contract Number 200-2009-28555

Prepared by

Robert Barton III
Harry Chmelynski

S. Cohen & Associates
1608 Spring Hill Road, Suite 400
Vienna, Virginia 22182

Saliant, Inc.
5579 Catholic Church Road
Jefferson, Maryland 21755

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1.0 INTRODUCTION

This report contains a review of the paper on the uranium coworker model titled, *NIOSH Evaluation of Fernald Subcontractor Bioassay Data, Revision 01* (NIOSH 2011). The NIOSH paper looks at the difference between contract employees (mostly construction workers) and other onsite employees. The purpose of this comparison was to address concerns that the coworker model developed in ORAUT-OTIB-0078 (ORAUT 2007) did not adequately cover potential exposures to contract employees. NIOSH has concluded that many of the contractor bioassay records in the HIS_20 database are denoted with a sample type code '50.' These records were not included in the original uranium coworker model analysis because at that time, NIOSH held that these records were part of a "special study" and were not reflective of normal unmonitored operational exposures. An overview of the different record types/designations available in the HIS_20 database is found in Attachment 1 of this report.

The new analysis in NIOSH 2011 shows that many of the Type 50 entries can be traced to hardcopy records of urine samples obtained from contract employees. This practice continued up to the 1990s. The omission of these records from the dataset used to estimate lognormal parameters for the uranium coworker model indicates that contract employees are seriously under-represented in the dataset. There is an open question of how to remedy the situation and ensure that the coworker model is bounding for contract employee exposures. NIOSH presents one approach to this problem in the paper under review (NIOSH 2011).

There are two possible approaches to understanding this problem: (1) a direct comparison of the Type 50 contract employee records as a separate group with the records from onsite employees, or (2) combine the Type 50 records not included in the earlier coworker model into the dataset and compare the "combined" dataset with the original dataset. Both approaches may be used to develop new distributions for the coworker model. NIOSH has adopted the latter approach. The missing Type 50 records were added to the earlier dataset used to estimate the uranium coworker model and the model was re-estimated using the expanded dataset. A direct comparison of the Type 50 contract employee records as a separate group with the records from onsite employees was considered by NIOSH, although no analysis or associated results were presented in the paper. NIOSH states the following:

> *The data show that until the 1980s the number of monitored subcontractors was relatively small compared to the site monitored population, making the geometric mean (GM) of the subcontractor data sensitive to a few high results.* (NIOSH 2011, p. 4)

No quantitative evidence is provided to support this assertion. It is also noted in the white paper that some results appeared to be contaminated, as evidenced by differences of an order of magnitude between samples at the end of shift and samples taken the subsequent morning. The frequency with which this possible contamination was observed is not provided in the report.

When the missing Type 50 records are added to the original model, the coworker estimates of the median exposure from the pooled data go up by a factor around 1.25 to 1.6, depending on the year in question and whether annual or quarterly data are considered. Based on this analysis,

NIOSH proposes to use a correction factor of 2 when the coworker model is applied to contract employees. SC&A is of the opinion that this approach drastically underestimates the difference in exposure between contract construction workers and other onsite employees.

To determine the magnitude of the underestimation, SC&A performed two separate data analyses:

(1) Calculation of the arithmetic mean, median, and geometric mean for the raw data on an annual and quarterly basis from 1960–1985 (see Section 2 for annual data and Attachment 2 for quarterly data).

(2) Lognormal fitting and then comparison of the annual data from four select years: 1959, 1963, 1967, and 1972 (see Section 3).

Based on these two analyses, SC&A believes that contractor records could be higher than the established coworker records by a factor of 5–8 depending on the specific timeframe and analysis method (raw data or lognormal transformation).

2.0 ANALYSIS OF TYPE 50 RECORDS IN HIS_20

SC&A compiled the uranium[1] urinalysis data from 1960–1985 and separated it into the two groups of interest: the '50 series' records and the records used in the formulation of the original coworker model (referred to as the 'coworker group'). The actual sample type codes used for each group are summarized in Table 1. For a full list of available codes in the HIS_20 database, please refer to Attachment 1.

Table 1. List and Description of Sample Codes Used in Analysis

Group	Codes Used in Analysis	# Records	Code Description
50 Series	50	7,905	Special Sample
	5A	274	Off-the-job, Overnight Composite Specimen
	5B	990	Off-the-job, Overnight Individual Sample
	5C	172	Special Correlation Sample
	5D	566	24-Hour Individual Sample from Confined Patients
	5F	212	24-Hour Individual Sample from Unconfined Patients
	5H	296	On-the-Job Individual Sample Collected in the Work Area
	5R	1,880	Recall '50 series' Sample
	Total	**10,443**	
Coworker	00	321	No Code
	03	86	Plant 3
	05	2	Plant 5
	20	23,484	Annual Sample
	30	65,902	Routine Sample
	40	6,262	Incident – Follow-up Sample
	49	4,746	Incident - End of Shift Sample
	R	1,852	Recall Sample
	XX	870	Not specified - likely means the same as 00 or "No Code"
	Total	**107,499**	

Using the records described in Table 1, the arithmetic mean, median, and geometric mean were calculated on an annual basis.[2] The results are shown in Table 2 and include the ratio of the '50 series' records to 'coworker' records; the calculated ratios that are higher than the suggested adjustment factor of 2 are highlighted. The calculated ratios are also depicted in Figures 1–3. As seen in the table and accompanying charts, many of the years analyzed had ratios above the suggested correction factor (13/26 or 50% for the arithmetic mean, 11/26 or 42% for the geometric mean, and 10/26 or 38% for the median). Ratios ranged up to 7 for the arithmetic average and up to approximately 5–6 for the geometric mean and median values.

[1] Though the HIS_20 database does present some isotopic-specific urinalysis results, only those designated as "Total Uranium" and given in units of µg/l were considered for comparison in this section.

[2] For comparisons based on quarterly data, please refer to Attachment 2.

Table 2. Comparison of Coworker Urinalysis Values to Code Type 50 Records from 1960–1985

Year	Arithmetic Mean			Geometric Mean			Median		
	Coworker	50 Series	Ratio	Coworker	50 Series	Ratio	Coworker	50 Series	Ratio
1960	21.58	33.82	1.57	15.03	25.73	1.71	15	27	1.80
1961	18.78	25.88	1.38	14.00	17.72	1.27	14	17	1.21
1962	14.30	25.74	1.80	9.75	17.05	1.75	10	17	1.70
1963	14.02	18.77	1.34	10.20	12.12	1.19	10	12	1.20
1964	15.17	43.78	***2.89***	9.50	20.66	***2.17***	9	20	***2.22***
1965	10.36	24.24	***2.34***	5.95	12.50	***2.10***	6	11	1.83
1966	16.59	67.39	***4.06***	5.29	18.46	***3.49***	6	16	***2.67***
1967	8.38	19.46	***2.32***	5.67	12.58	***2.22***	6	12	2.00
1968	7.48	14.42	1.93	5.04	8.78	1.74	5	9	1.80
1969	6.64	31.18	***4.70***	4.57	14.86	***3.25***	4	11	***2.75***
1970	5.43	-	NA	3.73	-	NA	3	-	NA
1971	6.98	8.14	1.17	4.74	5.63	1.19	4	8	2.00
1972	8.95	62.97	***7.04***	4.78	23.07	***4.82***	4	21	***5.25***
1973	8.96	19.75	***2.20***	5.53	13.59	***2.46***	5	15.5	***3.10***
1974	7.44	15.36	***2.06***	5.18	9.47	1.83	5	8	1.60
1975	7.70	9.17	1.19	5.35	5.97	1.12	5	7.5	1.50
1976	7.17	5.10	0.71	5.11	4.78	0.94	5	5	1.00
1977	6.15	11.32	1.84	4.53	8.12	1.79	4	8.5	***2.13***
1978	5.85	12.38	***2.11***	4.44	11.41	***2.57***	4	10	***2.50***
1979	6.71	6.74	1.01	4.72	4.95	1.05	5	5	1.00
1980	6.11	9.92	1.62	4.59	7.47	1.63	4	7	1.75
1981	4.13	15.86	***3.84***	3.28	9.85	***3.01***	3	10	***3.33***
1982	5.06	9.88	1.95	4.01	5.80	1.45	4	5.5	1.38
1983	5.38	12.57	***2.34***	4.24	9.75	***2.30***	4	9	***2.25***
1984	5.94	20.83	***3.51***	4.31	6.17	1.43	4	5	1.25
1985	5.34	19.21	***3.60***	3.97	15.57	***3.93***	3	19	***6.33***

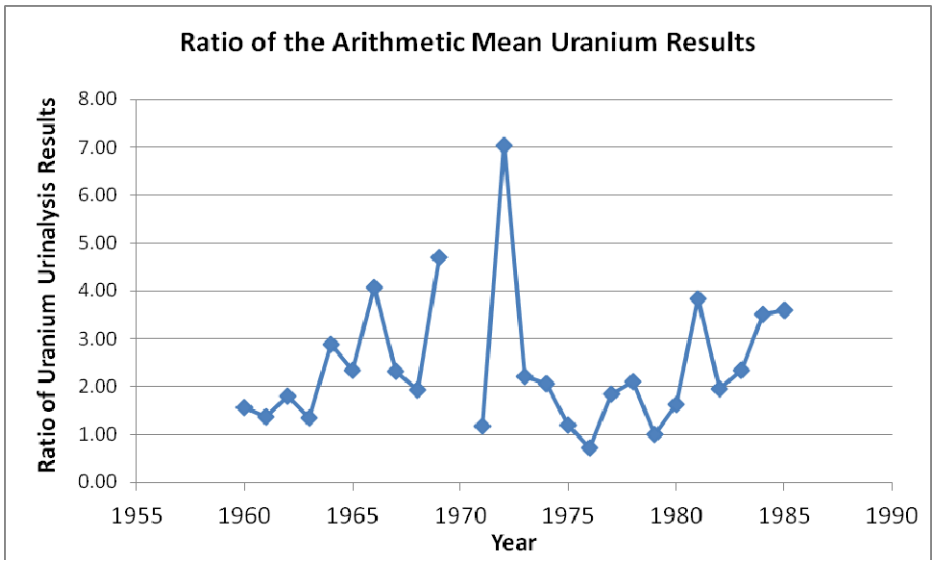

Figure 1. Ratio of the Annual Arithmetic Mean Urinalysis Values for the '50 Series' Records and the 'Coworker' Records

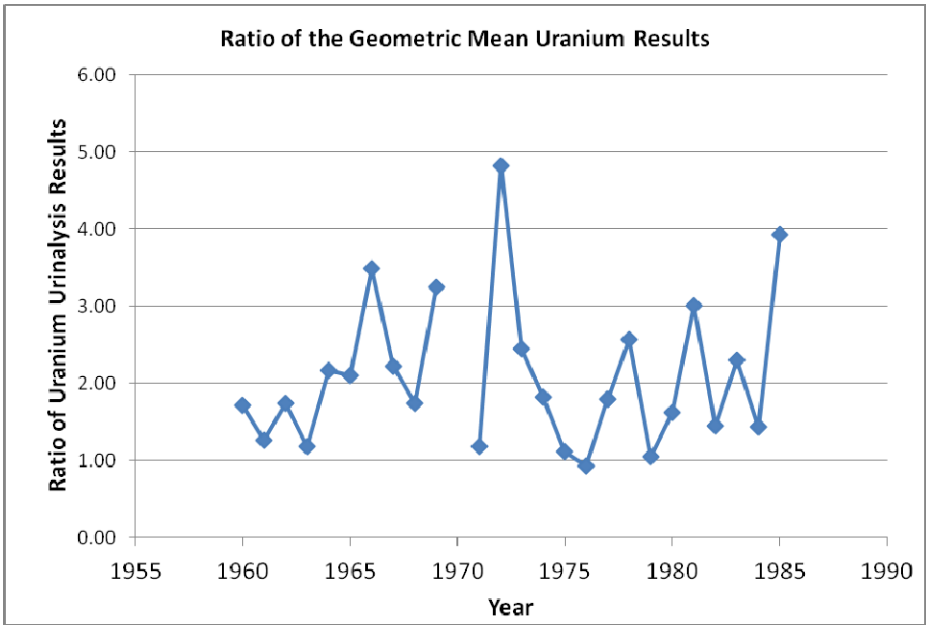

Figure 2. Ratio of the Annual Geometric Mean Urinalysis Values for the '50 Series' Records and the 'Coworker' Records

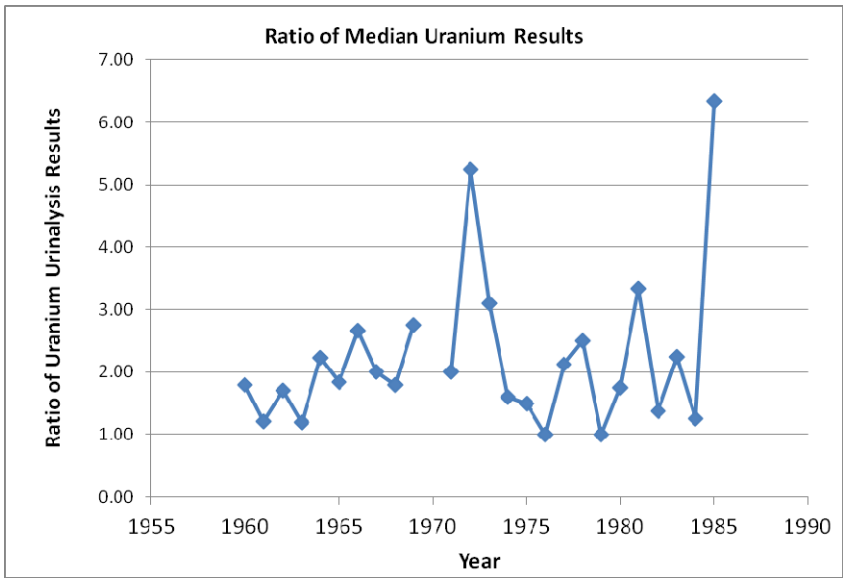

Figure 3. Ratio of the Annual Median Urinalysis Values for the '50 Series' Records and the 'Coworker' Records

NIOSH 2011 states that comparisons were also made on a quarterly basis, and that the highest ratio when comparing the combined group (contractor + coworker) versus the original coworker group occurred in 1972 and was 1.61. SC&A also analyzed the data by quarter, but compared the direct ratio of the contractor versus coworker records instead of the combined group; this analysis is presented in Attachment 2.

3.0 LOGNORMAL ANALYSIS OF TYPE 50 RECORDS FOR SELECT YEARS

The previous section simply analyzed the raw data without any statistical manipulation; however, coworker models are constructed by fitting the raw data to a lognormal distribution to determine the specific parameters used in assigning coworker doses. Therefore, SC&A used the HIS_20 dataset to estimate separate lognormal models for the original coworker data and separately for the Type 50 records in the database. Due to the relatively small number of Type 50 records, the comparison was conducted on an annual basis. Four years were selected for the direct comparison. The years 1959, 1963, 1967 and 1972 were selected to span the period of greatest interest. All HIS_20 uranium urine records in units of mg/l were used in the comparison, but pre-employment records were omitted by excluding codes 10, 70 and 7R ,which is consistent with the original coworker model approach (ORAUT 2007, p. 2). Table 3 shows the relative number of records in the two groups; Type 50 and all other records.

Table 3. Comparison of HIS-20 Uranium Urinalysis Record Counts for Type 50 and Other Codes in Selected Years

Sub-Group	1959	1963	1967	1972
Type 50	1,731	2,326	106	269
(%)	11.9%	24.0%	2.0%	12.2%
Other Codes	12,825	7,353	5,259	1,935
(%)	88.1%	76.0%	98.0%	87.8%
Total	14,556	9,679	5,365	2,204

The total count of records shows a declining trend over the 13-year period covered by the table. In 1963, the Type 50 records accounted for approximately one-quarter of the urine sample records in HIS_20, and one-eighth in 1959. The smallest record count was 106 Type 50 records in 1967. In 1972, the percentage of Type 50 returned to the same level as in 1959.

Lognormal distributions were fitted to the annual datasets for each of the two groups using the graphical approach recommended by NIOSH. The results are shown in Figures 4 through 7 for 1959, 1963, 1967, and 1972, respectively. In all years except 1959, the upper tail of the distribution of Type 50 records is higher than the distribution of other records in HIS_20. The relative uniformity of the upper half of the Type 50 distributions shows no evidence of a few "unusually high" values that NIOSH claims would unduly affect the parameter estimates.

The figures also show the equations of the least squares regression line for each group of records. The intercept of the equation is an estimate of the lognormal parameter μ and the slope of the equation is an estimate of the lognormal parameter σ, where $\exp(\mu)$ is the geometric mean (GM) and $\exp(\sigma)$ is the geometric standard deviation (GSD) of the lognormal distribution.

A comparison of the GSD, GM, mean and 95th percentiles of the Type 50 records and onsite records is shown in Table 4. The table also shows the ratio of the estimate for Type 50 records to the estimate for the onsite records for each year and averaged over all 4 years. Note that all ratios are greater than 1. Every parameter in this table, including μ and σ, has a higher estimate for the Type 50 records. The GSD of the Type 50 records is roughly 20% higher than the GSD

for onsite records. Due to the higher GSD of the Type 50 records, it is not appropriate to compare only the GM (medians) of the two distributions, which was the only comparison used by NIOSH in their approach. The difference in GSDs indicates that other parameters that characterize the upper tails of the distributions should also be compared. The mean and 95th percentiles are used by SC&A in this comparison.

The expected value (mean) falls between the GM and the 95th percentile in all years. Note that the GM, mean, and 95th percentiles have increasing average ratios (averaged over the 4 years for which data were analyzed), indicating a greater spread moving toward the upper tail of the distributions. The same is true for each individual year. The average ratio ranges from 2.5 (Type 50 is 150% higher than onsite) for the GM to an average ratio of 3.5 (Type 50 is 250% higher than onsite) for the 95th percentile. The highest ratios occur in 1972, when the GM, mean, and 95th percentiles have ratios of approximately 5, 7, and 8, respectively, indicating that the Type 50 record parameters range from 400% to 700% higher than the onsite record parameters. NIOSH also found the highest ratios were in 1972. The NIOSH approach arrived at a factor of only 1.24 for this year. In the end, NIOSH recommended using a correction factor of 2 for all years for subcontractor employees.

The analysis above shows that the correction factor of 2 proposed by NIOSH is only a fraction of the actual difference between the Type 50 records assumed to be contractor urinalyses and the onsite employee records. Figure 8 compares the cumulative distribution of the 12 annual ratios shown in bold type in Table 4 (GM, mean, and 95th percentile) to the correction factor of 2 proposed by NIOSH for subcontractor employees. The NIOSH factor is below the three average comparison ratios shown in Table 2 for the GM, mean, and 95th percentile.

Table 4. Comparison of Lognormal Distribution Parameters for HIS_20 Type 50 Records from Contractors with Other Records for On-Site Employees

	YEAR								
	1959		1963		1967		1972		Average Ratio
Parameter	Type 50	Onsite	Type 50	Onsite	Type 50	Onsite	Type 50	Onsite	
Mu (μ)	2.61	2.34	2.46	2.29	2.46	1.68	3.14	1.50	
Sigma (σ)	1.11	0.96	0.91	0.83	1.08	0.92	1.24	0.97	
GSD	3.03	2.62	2.49	2.29	2.94	2.51	3.45	2.63	
Ratio*	1.15		1.09		1.17		1.31		1.18
GM (μg/l)	13.61	10.34	11.75	9.91	11.71	5.34	23.07	4.46	
Ratio*	**1.32**		**1.18**		**2.19**		**5.17**		2.47
Mean (μg/l)	25.12	16.47	17.83	13.96	20.94	8.16	49.60	7.12	
Ratio*	**1.52**		**1.28**		**2.57**		**6.97**		3.08
95th Percentile (μg/l)	84.07	50.56	52.82	38.67	69.01	24.27	176.56	21.88	
Ratio*	**1.66**		**1.37**		**2.84**		**8.07**		3.49

* Ratio = Type 50/Onsite

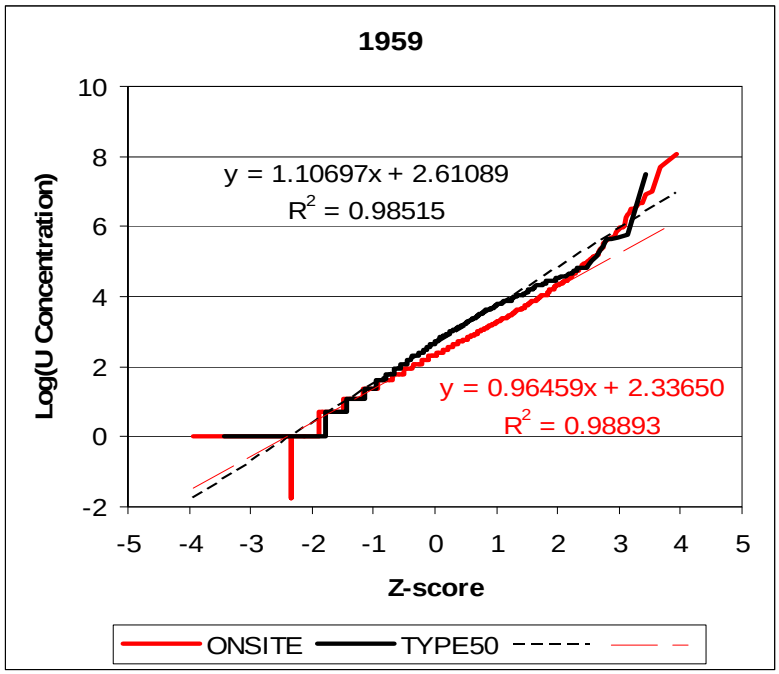

Figure 4. Lognormal Fit of the Data for the Coworker Population and the Type 50 Records in 1959

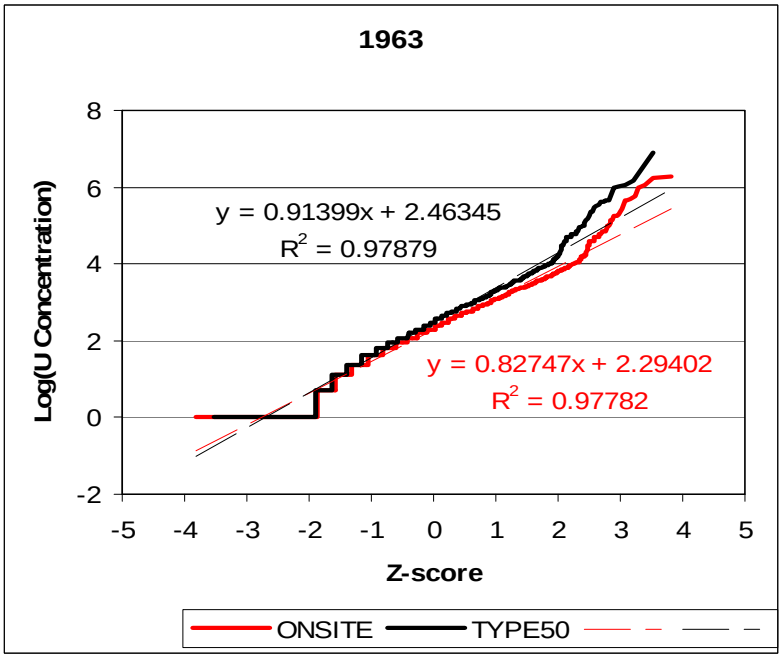

Figure 5. Lognormal Fit of the Data for the Coworker Population and the Type 50 Records in 1963

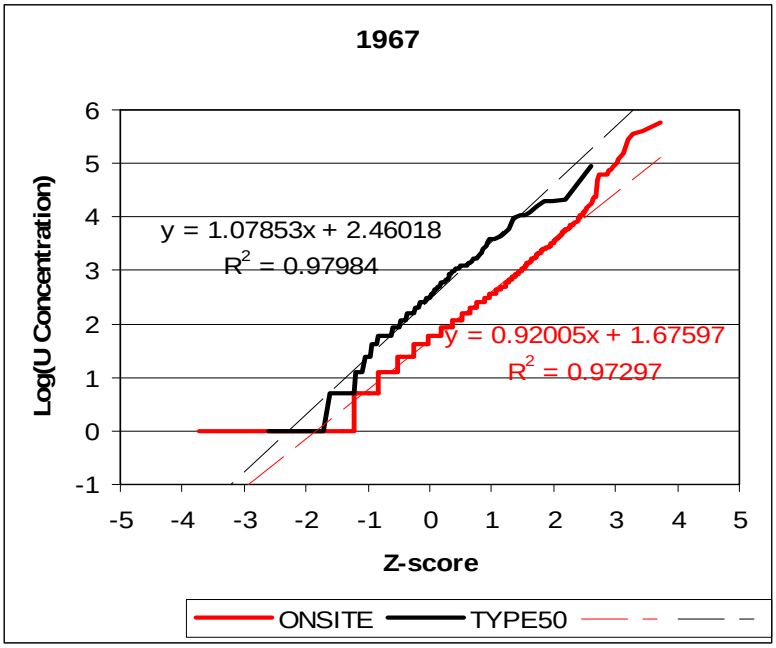

Figure 6. Lognormal Fit of the Data for the Coworker Population and the Type 50 Records in 1967

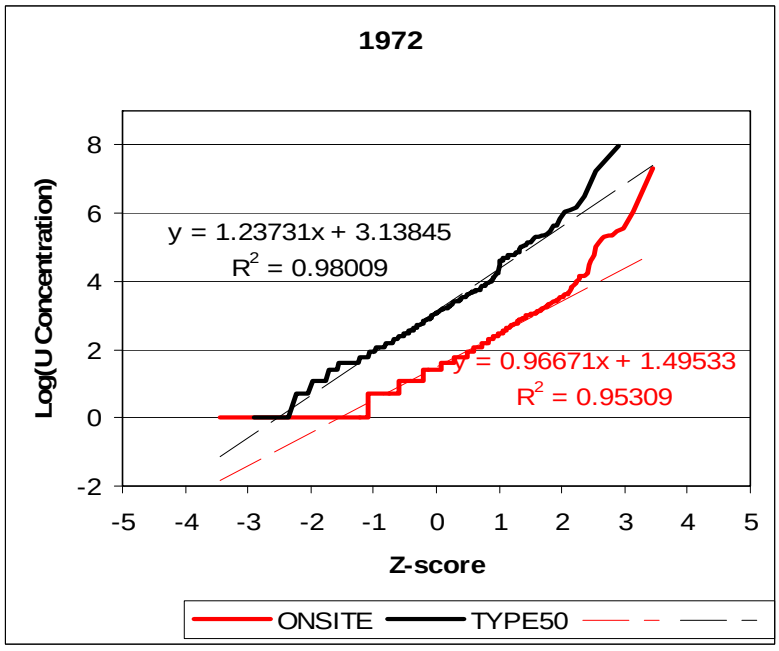

Figure 7. Lognormal Fit of the Data for the Coworker Population and the Type 50 Records in 1972

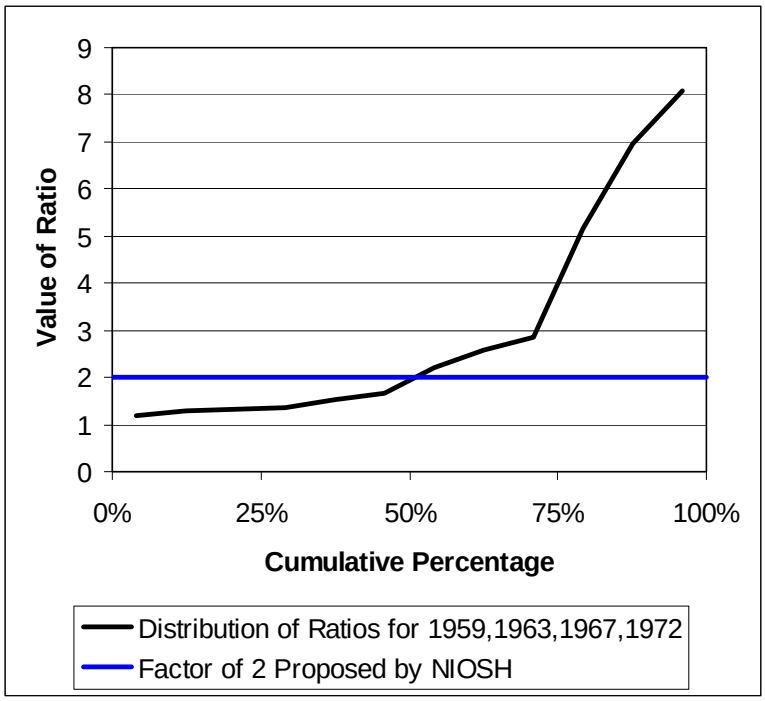

Figure 8. Cumulative Distribution of Ratios Shown in Bold in Table 2 Compared with Proposed Coworker Model Adjustment Factor for Contract Employees

4.0 GENERAL COMMENTS

NIOSH is to be commended for their efforts in furthering our understanding of the history of the uranium urinalysis records in HIS_20, and for recognizing the important implications of having first omitted Type 50 records from the uranium coworker model database. However, the current information about the Type 50 records in HIS_20 is far from complete. The draft report contains minimal details of the data analysis performed by NIOSH; only a simple time series plot of the ratios obtained using the NIOSH approach of comparing the combined dataset with the original coworker dataset. This paper would benefit from additional information, including details of the data analysis, as well as showing sample sizes and fitted lognormal distributions of each set of records, both separately and combined, by time period. This detailed information is usually provided in reporting of coworker model results, including plots useful for identifying the effect of outliers.

Additional NIOSH 2011 Report-Specific Comments:

(1) Page 3: Table 1 provides the SRDB reference numbers to hardcopy bioassay request cards. However, aside from a few specific references indicating only contractor records, no indication is made as to how many contractor cards are included in each report. Only the total number of records is provided. Additionally, information as to how many contractor records in hardcopy form are available per year would help characterize the available dataset.

(2) Page 4 states, "There were far more subcontractor samples designated "50" (start-of-shift sample) than there were "59" (end-of-shift sample)." SC&A was not able to identify any samples in the HIS_20 database designated as Type "59" (see Attachment 1, Table 5, for a breakdown of samples in HIS_20 by sample type code). It is not clear whether this assertion was made based on hardcopy records reviewed or if there are different versions of the HIS_20 database available.

(3) Page 6 states, "The highest quarter was the 1st quarter in 1972 when the GM of the coworker plus added data was 1.61 times higher than the coworker GM. **It should be noted that of the 216 results added for this quarter, 210 were non-subcontractor Code 50s**" [emphasis added]. It is not clear how this conclusion was reached. SC&A identified 210[3] 'Type 50' results in the HIS_20 database for the first quarter of 1972; however, we were not able to determine from the electronic records whether they represented contractor or non-contractor personnel. These 210 records do not appear to be contained in the hardcopy results provided in Table 1 of NIOSH 2011 to verify their job status.

It is also worth noting that in the first quarter of 1972, approximately 43% of the records are 'Type 50' compared to the average quarterly value of 7% (GM of 3%). This is likely the reason it had such a large effect on the ratio of the combined group (contractor +

[3] Six additional entries were found in the hardcopy records identified in Table 1 of NIOSH 2011, giving a total of 216 results.

coworker) versus only the coworker group. The actual ratio of the 'Type 50' records versus the 'coworker' records based on the GM for this quarter is ~4.7. As shown in Attachment 2, the quarterly ratios could range as high as ~6.9 for the GM.

5.0 REFERENCES

NIOSH 2011. *NIOSH Evaluation of Fernald Subcontractor Bioassay Data – Revision 01*. Author: E.W. Potter. National Institute for Occupational Safety and Health, Cincinnati, Ohio. October 7, 2011.

ORAUT 2007. *Uranium Bioassay Study for FEMP – A Proposed Attachment for ORAUT-TKBS-0017-5*, Rev. 1. Oak Ridge Associated Universities Team, Cincinnati, Ohio. November 7, 2007.

ATTACHMENT 1: DESCRIPTION AND OVERVIEW OF SAMPLE CODES FOUND IN THE HIS_20 DATABASE

The HIS_20 bioassay database uses a series of two character alpha-numeric codes to identify the circumstances around which any particular sample was taken. Though no specific reference document was identified by SC&A to decode these sample designations, "keys" are provided in the hardcopy records of claimants who have samples in the database. SC&A used these hardcopy records to interpret the various sample codes. An overview of the available HIS_20 sample codes is shown in Table 5.

Table 5: Overview of HIS_20 Bioassay Codes

Sample Code	Description of Code	Number of Records	First Year of Use	Last Year of Use	# Uranium Urinalysis Records (all records)	# Urinalysis Records (Total Uranium Only)
00	No Code	23,014	1944	2002	23,014	22,968
01	Plant 1	468	1953	1957	468	468
02	Plant 2	447	1953	1958	447	447
03	Plant 3	449	1953	1961	449	449
04	Plant 4	573	1953	1958	573	573
05	Plant 5	2,194	1953	1961	2,194	2,194
06	Plant 6	2,745	1953	1957	2,745	2,745
07	Plant 7	3,879	1953	1957	3,879	3,879
08	Plant 8	1,130	1953	1957	1,130	1,130
09	Plant 9	189	1953	1958	189	189
10	Pre-Employment Sample	16,386	1952	2006	16,384	15,349
20	Annual Sample	44,484	1953	2001	44,484	44,442
30	Routine Sample	251,969	1953	2006	251,965	232,091
40	Incident – Follow-up Sample	12,544	1954	2006	12,541	12,461
49	Incident – End of Shift Sample	9,642	1958	2006	9,640	9,520
50	Special Sample	22,209	1955	2005	20,667	20,209
60	Termination Sample	12,716	1958	2006	12,716	11,206
70	Rehire	1,883	1958	1991	1,883	1,883
24HR	Isotopic Sample for Various Nuclides	136	1993	2006	15	0
5A	Off-the-Job, Overnight Composite Specimen	280	1961	1987	280	280
5B	Off-the-Job, Overnight Individual Sample	990	1961	1968	990	990
5C	Special Correlation Sample	172	1961	1969	172	172
5D	24-Hour Individual Sample from Confined Patients	566	1961	1969	566	566

Table 5: Overview of HIS_20 Bioassay Codes

Sample Code	Description of Code	Number of Records	First Year of Use	Last Year of Use	# Uranium Urinalysis Records (all records)	# Urinalysis Records (Total Uranium Only)
5E	Unknown – Reference not available	3	1987	1987	3	3
5F	24-Hour Individual Sample from Unconfined Patients	212	1961	1961	212	212
5H	On-the-Job Individual Sample Collected in the Work Area	296	1963	1968	296	296
Baseline	Baseline Fecal Results for Thorium Isotopes	3,951	1986	1999	0	0
Follow-up	Followup of Previous Sample – Usually Fecal Analysis	418	1987	2002	0	0
Incident	Incident bioassay – generally fecal analysis for thorium isotopes	346	1995	2006	0	0
New Hire	Self explanatory	35	1954	2002	2	2
R	Recall Sample	2,674	1963	1997	2674	2674
Repeat	Self explanatory	16	1998	2001	0	0
Routine	Self explanatory – mainly whole-body counts for thorium isotopes	170	1995	2002	2	2
Special Re	Unknown – Reference not available	3	1996	1999	0	0
Termination	Self explanatory – whole -body counts for uranium and thorium isotopes	32	1989	2001	0	0
VE	Visitor Exit Sample	3,369	1989	1999	3369	3368
VF	Visitor First Sample	3,829	1989	1999	3829	3827
VR	Visitor Routine Sample	510	1989	1998	510	510
XX	Not specified – likely means the same as 00 or "No Code"	10,873	1950	1988	10873	10873

ATTACHMENT 2: COMPARISON OF CONTRACTOR ('50 SERIES') RECORDS VERSUS COWORKER RECORDS BY QUARTER

Similar to the analysis presented in Section 2, SC&A broke down the HIS_20 records by quarter to compare the assumed contractor records (those designated as 'Type 50') versus those records originally used in the NIOSH coworker model (ORAUT 2007). Ratios of the two groups were calculated by quarter at the mean, median and geometric mean and presented in Table 6, along with the number of available records for analysis. Ratios above the suggested adjustment factor of 2 have been highlighted. Note that the number of records available for analysis will be slightly lower than shown in the Table 6 for the GM comparisons, since only positive results can be used. Figures 9–11 plot the ratios presented in Table 6 against the suggested correction factor of 2 shown in red.

Of the 104 quarters analyzed in this attachment, 18 (or ~17%) had no '50 series' data available for comparison. Of the remaining quarters available for analysis, approximately 40% of the quarters showed ratios higher than the suggested adjustment factor of 2 for all three metrics (arithmetic mean, geometric mean, and arithmetic median).

Table 6. Comparison of Contractor versus Coworker Records by Quarter at the Median, Arithmetic and Geometric Mean

Year	Quarter	Arithmetic Mean			Geometric Mean			Median			# of Available Records in HIS_20		
		Coworker	50 Series	Ratio	Coworker	50 Series	Ratio	Coworker	50 Series	Ratio	Coworker	50 Series	% of Total
1960	1st Quarter	18.39	20.39	1.11	12.39	13.83	1.12	12	13	1.08	3296	310	9.4%
	2nd Quarter	17.31	41.30	**2.39**	12.61	28.35	**2.25**	13	27	**2.08**	3763	497	13.2%
	3rd Quarter	22.88	34.91	1.53	16.30	27.61	1.69	16	28	1.75	4707	1113	23.6%
	4th Quarter	26.32	32.98	1.25	18.59	27.62	1.49	19	28	1.47	4317	922	21.4%
1961	1st Quarter	22.10	26.98	1.22	14.68	22.41	1.53	15	23	1.53	2184	324	14.8%
	2nd Quarter	18.89	20.38	1.08	14.90	17.65	1.18	15	19	1.27	1763	45	2.6%
	3rd Quarter	18.06	26.10	1.45	14.74	16.24	1.10	15	15	1.00	1966	687	34.9%
	4th Quarter	15.53	25.14	1.62	11.80	16.95	1.44	12	16	1.33	1857	357	19.2%
1962	1st Quarter	13.19	26.76	**2.03**	10.40	19.72	1.90	10	19	1.90	1858	331	17.8%
	2nd Quarter	17.13	34.68	**2.02**	12.07	23.05	1.91	12	22	1.83	2204	246	11.2%
	3rd Quarter	9.26	19.03	**2.05**	6.91	12.49	1.81	7	12	1.71	1604	160	10.0%
	4th Quarter	16.60	12.45	0.75	9.43	8.65	0.92	9	8	0.89	1706	110	6.4%
1963	1st Quarter	14.69	30.81	**2.10**	10.58	17.22	1.63	11	16.5	1.50	1785	440	24.6%
	2nd Quarter	14.54	18.17	1.25	11.05	13.20	1.19	11	14	1.27	1983	442	22.3%
	3rd Quarter	11.72	14.94	1.28	8.43	10.20	1.21	8	10	1.25	1758	1242	70.6%
	4th Quarter	15.16	17.38	1.15	10.95	13.21	1.21	11	13	1.18	1586	202	12.7%
1964	1st Quarter	16.88	21.78	1.29	10.21	15.87	1.55	10	18	1.80	2111	63	3.0%
	2nd Quarter	17.75	19.31	1.09	10.92	14.88	1.36	10	16	1.60	1826	61	3.3%
	3rd Quarter	12.87	91.63	**7.12**	8.57	42.74	**4.99**	8	32.5	**4.06**	1391	88	6.3%
	4th Quarter	10.44	21.95	**2.10**	7.47	13.19	1.77	8	11	1.38	1083	61	5.6%
1965	1st Quarter	10.68	12.78	1.20	7.34	10.12	1.38	7	10	1.43	1403	110	7.8%
	2nd Quarter	11.10	11.29	1.02	7.35	8.92	1.21	7	10	1.43	1222	119	9.7%
	3rd Quarter	9.75	34.29	**3.52**	5.70	16.00	**2.81**	6	14	**2.33**	1398	304	21.7%
	4th Quarter	10.08	23.23	**2.30**	4.42	11.92	**2.70**	5	11	**2.20**	1664	247	14.8%

Table 6. Comparison of Contractor versus Coworker Records by Quarter at the Median, Arithmetic and Geometric Mean

Year	Quarter	Arithmetic Mean			Geometric Mean			Median			# of Available Records in HIS_20		
		Coworker	50 Series	Ratio	Coworker	50 Series	Ratio	Coworker	50 Series	Ratio	Coworker	50 Series	% of Total
1966	1st Quarter	26.51	79.71	**3.01**	6.95	24.32	**3.50**	7	24	**3.43**	2336	287	12.3%
	2nd Quarter	8.86	17.83	**2.01**	4.51	12.66	**2.81**	6	14	**2.33**	1099	103	9.4%
	3rd Quarter	11.74	98.71	**8.41**	4.08	11.31	**2.77**	5	10	2.00	1194	75	6.3%
	4th Quarter	6.94	41.47	**5.97**	4.42	16.74	**3.79**	5	15.5	**3.10**	920	30	3.3%
1967	1st Quarter	7.75	18.67	**2.41**	5.58	13.46	**2.41**	6	13	**2.17**	1263	67	5.3%
	2nd Quarter	8.17	27.33	**3.34**	5.51	23.27	**4.22**	5	27	**5.40**	1504	15	1.0%
	3rd Quarter	8.57	16.75	1.96	5.58	6.74	1.21	6	4.5	0.75	1143	24	2.1%
	4th Quarter	9.21	-	-	6.12	-	-	6	-	-	1064	0	NA
1968	1st Quarter	9.73	14.45	1.49	6.00	9.46	1.58	5	10	2.00	782	180	23.0%
	2nd Quarter	7.05	11.39	1.62	5.17	7.53	1.46	5	8	1.60	1192	90	7.6%
	3rd Quarter	6.04	25.90	**4.29**	4.34	13.85	**3.19**	4	12	**3.00**	1016	91	9.0%
	4th Quarter	7.70	8.08	1.05	4.95	6.25	1.26	5	7	1.40	1040	123	11.8%
1969	1st Quarter	7.89	21.00	**2.66**	5.19	8.94	1.72	5	21	**4.20**	851	2	0.2%
	2nd Quarter	6.69	19.73	**2.95**	4.79	11.04	**2.30**	5	7.5	1.50	745	30	4.0%
	3rd Quarter	6.17	50.32	**8.15**	4.36	25.07	**5.75**	4	32	**8.00**	648	19	2.9%
	4th Quarter	5.64	-	-	3.96	-	-	4	-	-	802	0	NA
1970	1st Quarter	6.46	-	-	4.28	-	-	4	-	-	779	0	NA
	2nd Quarter	5.86	-	-	4.23	-	-	4	-	-	752	0	NA
	3rd Quarter	4.85	-	-	3.19	-	-	3	-	-	846	0	NA
	4th Quarter	4.45	-	-	3.30	-	-	3	-	-	638	0	NA
1971	1st Quarter	6.60	-	-	4.75	-	-	5	-	-	850	0	NA
	2nd Quarter	7.85	7.00	0.89	4.66	5.60	1.20	4	8	2.00	515	3	0.6%
	3rd Quarter	8.56	16.00	1.87	5.80	16.00	**2.76**	6	16	**2.67**	370	1	0.3%
	4th Quarter	5.25	6.67	1.27	4.02	4.00	0.99	4	2	0.50	419	3	0.7%

Table 6. Comparison of Contractor versus Coworker Records by Quarter at the Median, Arithmetic and Geometric Mean

Year	Quarter	Arithmetic Mean			Geometric Mean			Median			# of Available Records in HIS_20		
		Coworker	50 Series	Ratio	Coworker	50 Series	Ratio	Coworker	50 Series	Ratio	Coworker	50 Series	% of Total
1972	1st Quarter	15.03	60.80	**4.04**	6.11	28.93	**4.74**	5	27	**5.40**	485	210	43.3%
	2nd Quarter	6.89	147.50	**21.40**	3.90	13.50	**3.47**	3	11	**3.67**	444	26	5.9%
	3rd Quarter	6.13	9.94	1.62	4.26	8.07	1.89	4	8	2.00	342	31	9.1%
	4th Quarter	6.81	14.00	**2.06**	4.87	13.86	**2.85**	5	14	**2.80**	502	2	0.4%
1973	1st Quarter	7.93	37.75	**4.76**	5.27	34.22	**6.50**	5	29.5	**5.90**	579	4	0.7%
	2nd Quarter	7.08	-	-	4.92	-	-	4	-	-	554	0	NA
	3rd Quarter	9.40	17.75	1.89	5.88	14.99	**2.55**	5	16	**3.20**	633	4	0.6%
	4th Quarter	10.76	11.75	1.09	5.95	8.16	1.37	5	8	1.60	760	8	1.1%
1974	1st Quarter	7.62	14.00	1.84	5.51	11.16	**2.03**	5	15	**3.00**	705	9	1.3%
	2nd Quarter	6.29	20.50	**3.26**	4.66	10.77	**2.31**	4	9	**2.25**	526	16	3.0%
	3rd Quarter	6.83	6.63	0.97	4.67	6.08	1.30	4	7	1.75	575	8	1.4%
	4th Quarter	8.91	-	-	5.87	-	-	6	-	-	565	0	NA
1975	1st Quarter	7.89	9.17	1.16	5.58	5.97	1.07	5	7.5	1.50	627	6	1.0%
	2nd Quarter	8.25	-	-	5.46	-	-	5	-	-	570	0	NA
	3rd Quarter	6.79	-	-	4.61	-	-	4	-	-	576	0	NA
	4th Quarter	7.90	-	-	5.92	-	-	6	-	-	430	0	NA
1976	1st Quarter	8.82	-	-	5.75	-	-	5	-	-	537	0	NA
	2nd Quarter	6.55	5.10	0.78	4.93	4.78	0.97	4	5	1.25	496	21	4.2%
	3rd Quarter	6.25	-	-	4.93	-	-	5	-	-	468	0	NA
	4th Quarter	6.85	-	-	4.76	-	-	4	-	-	470	0	NA
1977	1st Quarter	8.54	10.97	1.28	5.25	7.78	1.48	5	8	1.60	462	36	7.8%
	2nd Quarter	5.80	19.00	**3.28**	4.75	19.00	**4.00**	5	19	**3.80**	438	1	0.2%
	3rd Quarter	5.14	16.00	**3.11**	4.14	16.00	**3.87**	4	16	**4.00**	426	1	0.2%
	4th Quarter	4.93	-	-	4.02	-	-	4	-	-	431	0	NA

Table 6. Comparison of Contractor versus Coworker Records by Quarter at the Median, Arithmetic and Geometric Mean

Year	Quarter	Arithmetic Mean			Geometric Mean			Median			# of Available Records in HIS_20		
		Coworker	50 Series	Ratio	Coworker	50 Series	Ratio	Coworker	50 Series	Ratio	Coworker	50 Series	% of Total
1978	1st Quarter	5.61	-	-	4.19	-	-	4	-	-	426	0	NA
	2nd Quarter	6.12	9.00	1.47	4.51	9.00	**2.00**	4	9	**2.25**	405	1	0.2%
	3rd Quarter	5.57	13.50	**2.42**	4.46	11.92	**2.67**	4	11.5	**2.88**	376	4	1.1%
	4th Quarter	6.11	12.00	1.96	4.65	11.66	**2.51**	5	11	**2.20**	392	3	0.8%
1979	1st Quarter	6.74	3.25	0.48	5.31	3.22	0.61	5	3	0.60	379	4	1.1%
	2nd Quarter	6.29	5.20	0.83	4.74	4.92	1.04	5	4	0.80	373	5	1.3%
	3rd Quarter	7.48	6.78	0.91	4.78	4.88	1.02	4	6	1.50	328	32	9.8%
	4th Quarter	6.38	10.17	1.59	4.05	7.72	1.90	4	5	1.25	342	6	1.8%
1980	1st Quarter	6.69	7.20	1.08	4.48	6.69	1.50	4	7	1.75	376	5	1.3%
	2nd Quarter	5.64	11.16	1.98	4.21	8.04	1.91	4	7	1.75	329	19	5.8%
	3rd Quarter	6.10	7.71	1.27	5.00	6.64	1.33	5	7	1.40	321	7	2.2%
	4th Quarter	5.94	10.63	1.79	4.73	7.42	1.57	5	5	1.00	356	8	2.2%
1981	1st Quarter	4.59	7.75	1.69	3.42	6.54	1.91	3	5	1.67	373	12	3.2%
	2nd Quarter	3.36	10.00	**2.98**	2.90	6.43	**2.22**	2	9	**4.50**	488	12	2.5%
	3rd Quarter	3.99	20.22	**5.07**	3.39	12.65	**3.73**	3	13	**4.33**	416	45	10.8%
	4th Quarter	4.68	13.27	**2.84**	3.47	8.48	**2.44**	3	10	**3.33**	490	11	2.2%
1982	1st Quarter	5.14	1.00	0.19	4.00	1.00	0.25	4	1	0.25	424	1	0.2%
	2nd Quarter	5.13	9.24	1.80	4.07	5.35	1.31	4	5	1.25	459	17	3.7%
	3rd Quarter	4.98	6.00	1.21	3.91	5.79	1.48	4	6	1.50	591	4	0.7%
	4th Quarter	5.01	27.50	**5.48**	4.08	27.50	**6.75**	4	27.5	**6.88**	497	2	0.4%
1983	1st Quarter	5.63	14.65	**2.60**	4.46	11.69	**2.62**	4	12	**3.00**	670	31	4.6%
	2nd Quarter	5.74	4.83	0.84	4.42	4.89	1.11	4	3.5	0.88	773	6	0.8%
	3rd Quarter	4.70	9.00	1.91	3.80	6.53	1.72	3	9	**3.00**	734	5	0.7%
	4th Quarter	5.43	-	-	4.29	-	-	4	-	-	785	0	NA

Table 6. Comparison of Contractor versus Coworker Records by Quarter at the Median, Arithmetic and Geometric Mean

Year	Quarter	Arithmetic Mean			Geometric Mean			Median			# of Available Records in HIS_20		
		Coworker	50 Series	Ratio	Coworker	50 Series	Ratio	Coworker	50 Series	Ratio	Coworker	50 Series	% of Total
1984	1st Quarter	5.26	3.00	0.57	3.96	3.00	0.76	4	3	0.75	735	1	0.1%
	2nd Quarter	6.69	5.00	0.75	4.35	4.16	0.96	4	4.5	1.13	809	22	2.7%
	3rd Quarter	5.73	70.32	**12.27**	4.44	12.18	**2.75**	4	8	2.00	824	19	2.3%
	4th Quarter	6.02	8.07	1.34	4.45	5.74	1.29	4	5	1.25	900	45	5.0%
1985	1st Quarter	8.04	12.33	1.53	4.96	12.21	**2.46**	4	13	**3.25**	1594	3	0.2%
	2nd Quarter	5.85	32.14	**5.49**	4.30	29.77	**6.93**	4	32	**8.00**	2112	44	2.1%
	3rd Quarter	3.51	19.65	**5.60**	3.23	13.90	**4.30**	3	19	**6.33**	2100	20	1.0%
	4th Quarter	4.30	5.95	1.38	3.55	6.46	1.82	3	3.5	1.17	1518	42	2.8%

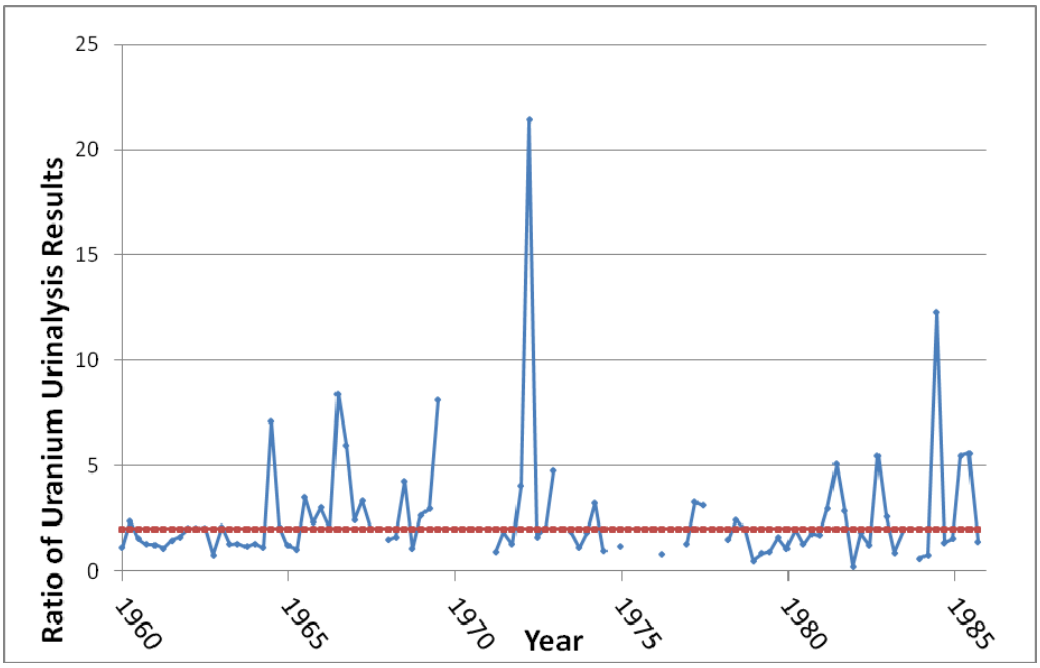

Figure 9. Ratio of the Quarterly Arithmetic Mean Urinalysis Values for the '50 Series' Records and the 'Coworker' Records

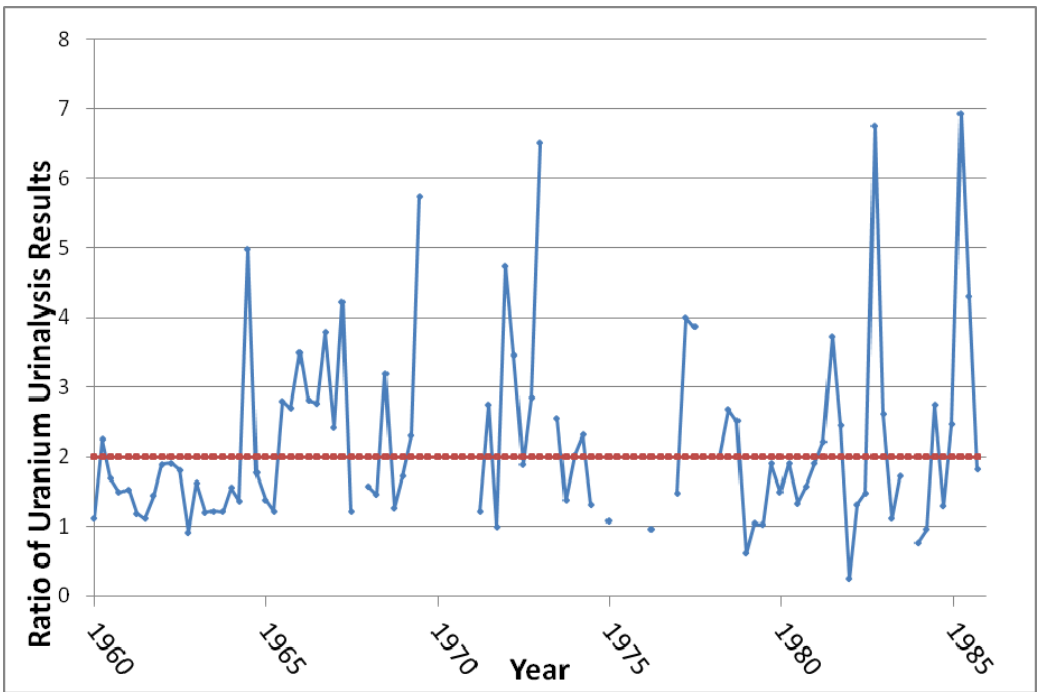

Figure 10. Ratio of the Quarterly Geometric Mean Urinalysis Values for the '50 Series' Records and the 'Coworker' Records

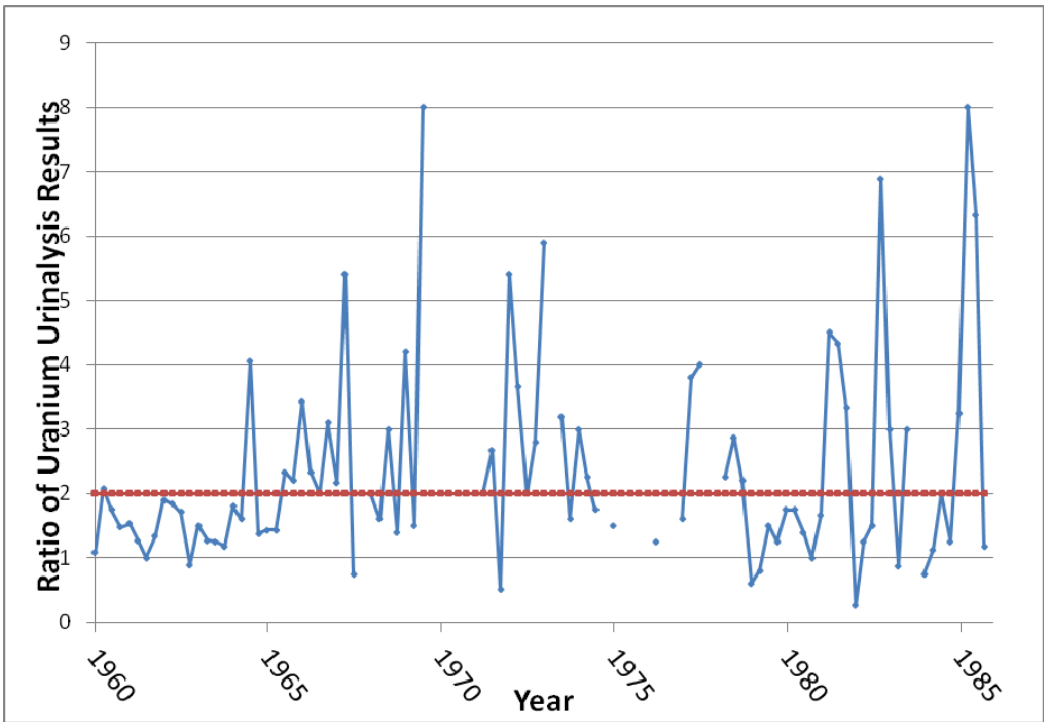

Figure 11. Ratio of the Quarterly Median Urinalysis Values for the '50 Series' Records and the 'Coworker' Records