Draft White Paper

REVIEW OF ORAUT-OTIB-0075: USE OF CLAIMANT DATASETS FOR COWORKER MODELING FOR CONSTRUCTION WORKERS AT SAVANNAH RIVER SITE

Contract Number 200-2009-28555

Prepared by

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

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

January 2010

Disclaimer

This document is made available in accordance with the unanimous desire of the Advisory Board on Radiation and Worker Health (ABRWH) to maintain all possible openness in its deliberations. However, the ABRWH and its contractor, SC&A, caution the reader that at the time of its release, this report is pre-decisional and has not been reviewed by the Board for factual accuracy or applicability within the requirements of 42 CFR 82. This implies that once reviewed by the ABRWH, the Board's position may differ from the report's conclusions. Thus, the reader should be cautioned that this report is for information only and that premature interpretations regarding its conclusions are unwarranted.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION AND SUMMARY OF FINDINGS

The Advisory Board on Radiation and Worker Health (ABRWH) has asked SC&A to perform a review of the Special Exposure Cohort petition (SEC-00103) for construction workers at Savannah River Site (SRS) and NIOSH's Evaluation Report (NIOSH 2008). SC&A has prepared a draft matrix of issues related to this SEC (SC&A 2009). The present report is a focused analysis that relates to issue number 16 in that matrix. This issue states that the use of all claimant data for building a coworker model for SRS construction workers is questionable.

NIOSH's statement regarding an internal dose coworker model in its Evaluation Report is as follows:

> *The majority of SRS workers was monitored for internal intake of radionuclides and has internal monitoring data. This point is reflected in the NOCTS claimant files for which 1467 of the 1798 construction worker claim files contained internal monitoring data. However, the possibility exists that some workers who should have been monitored were not, or that the data for some workers who were monitored has been misplaced. As a result, NIOSH is developing a co-worker model based on the claimant data in NOCTS. There are approximately 382,000 in vitro bioassay records available for analysis in NOCTS.* ***A separate study has been completed that established the principle that, under certain conditions, the data in NOCTS are representative of a site's population generally (ORAUT-OTIB-0075). All of the SRS NOCTS data has been entered into a database, and the co-worker model is in preparation.*** *In addition, ORAUT-OTIB-0052 indicated that construction trades workers had more plutonium bioassay measurements below the reporting limit compared with non-construction workers. ORAUT-OTIB-0052 also found that for the positive bioassays, the non-construction workers results were generally higher than construction trades workers.* [NIOSH 2008, p. 39] [Emphasis added.]

The present focused review relates to the two sentences that that we have indicated in bold. The NIOSH justification for this approach depends on two hypotheses that are implicitly connected in the above paragraph in the bolded sentences that follow each other:

(1) Claimant data are representative of the entire worker population.

(2) Given Item 1 above, a coworker model can be developed from SRS claimant data that will satisfy the requirements of 42 CFR 83 for dose reconstruction with sufficient accuracy for SRS construction workers during the requested SEC period from January 1, 1950, to December 31, 2007.

NIOSH has addressed the issue of the representativeness of claimant data for the entire worker population in *Use of Claimant Datasets for Coworker Modeling*, ORAUT-OTIB-0075, Rev. 00, May 5, 2009, cited hereafter as OTIB-0075. This review evaluates OTIB-0075 in the specific context of the SEC Petition for SRS, SEC-00103. This requires evaluating both of the hypotheses that NIOSH has made above. An important consideration in the second hypothesis is whether it applies to all types of construction workers in the various different phases of SRS operation. A critical link, which NIOSH has not made explicit, also needs to be addressed. Are the claimant data adequate to ensure a bounding dose estimate or a dose estimate more precise than that (i.e., dose reconstruction with sufficient accuracy) for all members of the proposed class, including those who were not monitored at all, or those who were not monitored for certain radionuclides or in certain periods?

It should be noted that NIOSH has not yet published the SRS coworker model based on claimant data that it proposes to use for SRS construction workers to demonstrate dose reconstruction with sufficient accuracy for all members of the proposed class. Hence, this report analyzes whether NIOSH's approach appears to be equal to the task of creating a coworker model, or whether additional data and elements are needed so far as the two hypotheses above are concerned.

In view of the above, this review of the study conducted by NIOSH to support their proposal addresses two separate but related questions:

(1) *Is a large (site-wide, but non-random) collection of available data from SRS claimants who were monitored in a given year representative of other large (site-wide and random) samples drawn from nearly complete coworker populations?*

OTIB-0075 compared the lognormal parameters estimated from a large sample of claimants in a given year with the parameters estimated from similar-sized samples of data from all workers on the site in that year. Attachments C, F, and I of OTIB-0075 contain a large number of scatter plots of the values of the lognormal distribution parameters obtained from the claimant dataset and from 1,000 independent samples of similar size drawn from the larger all-worker dataset at Y-12, Mound Laboratory, and SRS. According to NIOSH,

> *These plots are presented to support the idea that the claimant dataset is basically no different than a random draw from the complete dataset (p.1, Attachments C, F, and I to OTIB-0075).*

While the plots demonstrate that similar parameter estimates are obtained from the claimant dataset and the all-worker dataset samples, there is no formal statistical test of this apparent similarity with an assigned level of confidence. This core finding of OTIB-0075 is a statement of the law of large numbers. Given a sufficiently large sample size, estimates of population parameters will, on average, converge to the true values. The results of OTIB-0075 demonstrate that the parameter estimates are not very different. However, this SC&A analysis shows that this result does not confirm the adequacy of the proposed approach for the purpose of dose reconstruction of each individual claimant for the reasons presented below.

OTIB-0075 is based on the few complete datasets that are available in electronic form for all coworkers at three sites; uranium urine bioassay from workers at the Y-12 Plant for

1950 to 1988, plutonium urine bioassay at the Mound Laboratory for 1960 to 1990, and tritium data at SRS for 1991 to 2001. To amass a sufficiently large dataset for their purpose, NIOSH found it was necessary to aggregate the available claimant data for the entire site at an annual level. Use of this high degree of aggregation was necessary, because sufficient amounts of claimant data were presumably not available to support an analysis with detail, for example, by work area on the site or by job type.

Implicit in the NIOSH approach is the assumption that no further detail in the estimates is required for estimating missed doses of workers. This is a one-size-fits-all approach that ignores important differences among claimants who worked in different areas of the site doing different jobs. No detail by work area is provided in OTIB-0075, although a detailed examination by work area would be the next logical step in this type of analysis. It is not likely that the same conclusions would be demonstrated if the variety of work areas at SRS were analyzed individually. SC&A recognizes that collecting coworker data at this level of granularity might be difficult, because the amount of claimant data available in each work area in each year would be much smaller than the sample sizes used by NIOSH in their study of aggregated data for the entire site. Nevertheless, our analysis shows that such a level of granularity is needed.

(2) *Is the procedure proposed by NIOSH applicable to the SEC-00103 for the SRS construction worker claimants?*

Implicit in the NIOSH approach is the assumption that their proposal is applicable to all SRS claimants, including those in the construction crafts addressed in SEC-00103. In this approach, construction worker claimants with missed data in a given year would be assigned doses estimated from exposure data from all SRS claimants in that year, regardless of the occupation of the claimant. Estimates of missed doses for construction workers should be based on coworker data that are representative of construction workers. The NIOSH approach cannot be used if the claimant data are limited to claimants who were construction workers, due to the small number of construction worker claimants in each year. If NIOSH plans to use non-construction worker data for developing a coworker model for construction workers, they will need to demonstrate that the potential for internal exposure of non-construction workers is comparable or greater than that for all construction workers who are part of the proposed SEC class. As described below, the limited electronic data for non-construction workers appear to indicate that construction workers might have experienced higher internal exposures than non-construction workers in many cases.

This critical issue, not mentioned in the proposal by NIOSH, is addressed in this review through a detailed analysis of claimant data for construction and non-construction workers by job type, work area, and time period. Note that our analysis of this issue is limited by the same factors that limited NIOSH; only claimant data were available for this analysis. A more thorough analysis would be based on the complete coworker dataset. The small sample sizes that result when the claimant data are used in this detailed fashion demonstrate the inadequacy of the proposed approach to address detailed analyses. The findings of our analysis of claimant data show that there are important differences in exposure between construction workers and non-construction workers, and construction workers have different exposures than non-construction workers in many SRS work areas and time periods. Important differences in exposure are also evident when the claimant data for construction workers in each of the construction crafts are examined.

This report contains a brief general review of the OTIB-0075 analysis prepared by NIOSH, and further analyses to address the significance of OTIB-0075 for construction workers at SRS. OTIB-0075 examined internal exposure data at three sites; uranium at the Y-12 Plant from 1950 to 1988, plutonium at the Mound Laboratory from 1960 to 1990, and tritium at SRS from 1991 to 2001. The study reports comparisons of aggregate site-wide exposure by year for all types of workers at these facilities. The results of the OTIB-0075 study indicate that the annual distributions of site-wide exposures for claimants are similar to the annual distributions derived from similarly sized samples of site-wide exposures for all workers within the expected degree of statistical variation.

1.1 FINDINGS WITH SUMMARY OF ANALYSIS

1.1.1 Y-12 Claimants and All-Worker Uranium Data

This review begins with a comparison of the mean and standard deviations of the lognormal distributions derived for the claimant and complete (all-worker) uranium biosamples at the Y-12 Plant (OTIB-0075, Table 4-1). The means and standard deviations of the lognormal distributions in each year from 1950 to 1988 were compared using a linear regression model. Conclusions were based on hypothesis tests (t-tests) for the value of the regression coefficients. The hypothesis tests confirmed similarity of the estimated claimant and all-worker means and standard deviations at Y-12.

FINDING #1: At the Y-12 Plant, the complete (all-worker) and claimant datasets for uranium in urine from 1950 to 1988 show no significant difference at the annual level of aggregation. This finding confirms the conclusions reached in OTIB-0075 for uranium at the Y-12 Plant.

1.1.2 Mound Claimant and All-Worker Data

A similar comparison of the means and standard deviations of the lognormal distributions for the claimant and complete datasets for plutonium at Mound Laboratory (OTIB-0075, Table 6-2) was conducted using the regression model and hypothesis tests. At Mound, the comparisons for the mean and standard deviation do not show good agreement between the two datasets. The estimated regression line indicates that the mean for the all-worker dataset is much higher than the mean for the claimant dataset in the years when exposures are the highest. A coworker model based on claimant-only data would tend to underestimate typical exposures in years when exposures were high.

FINDING #2: At the Mound Laboratory, the complete (all-worker) and claimant datasets for plutonium in urine from 1960 to 1990 show significant differences at the annual level of

aggregation. This finding raises questions concerning the conclusions reached in OTIB-0075 for plutonium at the Mound Laboratory.

1.1.3 SRS Claimant and All-Worker Data, Tritium

At SRS, there are approximately 10,000 workers in the all-worker tritium dataset and 451 claimants. The lognormal distributions derived from the claimant and all-worker datasets for tritium at SRS cover only 11 years (OTIB-0075, Table 7-2). The regression results for all years from 1991 to 2001 are dominated by a single year with high exposure, 1991. When this year is omitted, the regressions shows no unduly influential data values from 1992 to 2001, and the complete and claimant datasets for annual tritium doses during this period show no significant difference at the annual level of aggregation.

FINDING #3: At SRS, the complete (all-worker) and claimant datasets for annual tritium doses from 1991 to 2001 show no significant difference at the annual level of aggregation, but the sample size is very small and the regression results were dominated by a single year with high exposure, 1991. If this year is omitted, the complete and claimant datasets for annual tritium doses period from 1992 through 2001 again show no significant difference at the annual level of aggregation.

1.1.4 SRS Data for Radionuclides Other than Tritium in ORAUT-OTIB-0075

The comparisons for the three sites above were based on the use of site-wide data for estimating both the claimant and all-worker exposure distributions. With respect to SRS, OTIB-0075 had access to data on only tritium in the later years of operations at the site after many of the production and processing facilities, such as nearly all production reactors, had ceased operation. Note that the production reactors were the facilities in which the SRS tritium was created.

FINDING #4: At SRS, OTIB-0075 includes data only for tritium from 1991 to 2001 in comparing the claimant population to that of all workers. No analysis of uranium or plutonium exposures at SRS was possible, because the available hardcopy data have not been reduced to electronic form. Similarly, no analysis of uranium or fission product exposures regarding the validity of the central hypothesis of OTIB-0075 for SRS could be done for any period. No analysis of tritium exposures before 1991 was done for the same reason. Furthermore, the tritium conclusion cannot be back-extrapolated in time, since the production and work conditions relating to tritium were different in earlier periods.

1.1.5 Proposed SRS Data Aggregation for All Claimants

In terms of representativeness, NIOSH has provided no justification that the use of site-wide datasets in the construction of a coworker model for SRS is representative of individual claimant exposures at large sites like SRS, with its long history of different activities in the variety of facilities on the site. In OTIB-0075, the tritium data for all claimants were treated as if they were all drawn from the same distribution, without regard to area or job type, or whether non-construction workers who constitute the bulk of the claimants are representative of construction workers in terms of tritium intakes. There is also no analysis showing that any conclusions for tritium are valid for other radionuclides.

FINDING #5: Data for the entire SRS were aggregated by year for the NIOSH analysis, with no detail by work area or by job type. The proposed NIOSH coworker model for SRS construction workers includes no analysis of these details.

1.1.6 Completeness of Y-12 Uranium Data used in ORAUT-OTIB-0075

In terms of representativeness, NIOSH has described the all-worker dataset as "complete." This term means only that NIOSH has used all the worker data that were available for the years covered. The dataset is not "complete" in the sense that it covers all workers. There were many workers at these sites who were not monitored, and many more workers who were infrequently monitored. OTIB-0075 (p. 10, footnote 7) states, "Out of 1,971 total claimants for Y-12, 731 have uranium urine bioassay results in the complete dataset and 1,240 do not (presumably because they were not monitored)."

FINDING #6: At Y-12, only 37% of all claimants (3 out of 8) have data in the "complete" Y-12 uranium urine bioassay coworker database for 1950 to 1988. This subset of 731 claimants with uranium bioassay data had a total of approximately 70,000 bioassays.

1.1.7 Y-12 Data Aggregation in the Coworker Model

Despite the lack of completeness, the all-worker uranium database at Y-12 is very large and covers almost 40 years of operations. Of the three sites examined, Y-12 has the most extensive all-worker dataset. Despite the large size of the all-worker and claimant datasets that were available for the uranium study at Y-12, NIOSH did not provide any detailed comparisons of the claimant and all-worker data by job type or by area of the site in OTIB-0075.

FINDING #7: Data for the entire Y-12 site were aggregated by year for the NIOSH analysis, with no detail by work area or by job type. The NIOSH approach includes no analysis of these details.

1.1.8 Aggregation of Mound Data

At Mound, the study period covers 30 years of operations, but the plutonium datasets used for the OTIB-0075 analysis are much smaller than at Y-12. The database contains 2,070 workers who submitted a total of 53,340 plutonium urine bioassay samples. The 225 claimants with bioassay data submitted 8,849 plutonium urine samples. Despite the relatively large size of the datasets available for comparison at Mound Laboratory, no details are provided by job type or by area of the site.

FINDING #8: Data for the entire Mound Laboratory were aggregated by year for the NIOSH analysis, with no detail by work area or by job type. The NIOSH approach includes no attention to these details.

1.1.9 Findings Specific to SRS

NIOSH's Evaluation Report for SEC-00103 indicates that, according to the analysis in OTIB-0075, "the data in NOCTS are representative of a site's population," and thus the NOCTS data will be used as the technical bases of the coworker model for SRS, including a coworker model for SRS construction workers (NIOSH 2008, pp. 70 and 72). However, the above analyses are not based on a comparison of construction worker claimants to non-construction worker claimants. In effect, OTIB-0075 does not have any analyses that would establish the validity of the hypothesis that all claimant data at any site, including SRS, are representative of construction worker data for that site for various periods and radionuclides. Furthermore, OTIB-0075 does not have any analysis that establishes that using all-worker or all-claimant data for particular job types and areas will result in a dose reconstruction that meets the requirements of sufficient accuracy under 42 CFR 83. The OTIB-0075 study provides only general analyses of all workers by year, with no differentiation by job type. In addition, the OTIB-0075 study only looked at tritium in the most recent years of operations at SRS.

To address these concerns, the remainder of this review contains an analysis of SRS claimant exposures by work area and job type. Due to the lack of all-worker data in electronic form at SRS, this review could only look at claimant exposures. We must proceed under an assumption that the NOCTS data are representative of all workers at SRS, even though OTIB-0075 only performed a limited test for tritium for the 1991–2001 period.

This review of claimant exposures addresses both non-construction worker claimants and construction worker claimants. The advantages of using claimant data for this portion of the analysis are that the job types and work areas are known for many of the claimants, and the data cover all decades of operation at SRS. The review examined five different sources of exposure; tritium, plutonium, uranium, enriched uranium, and fission products.

This review contains three sets of analyses by area of the site:

(1) A comparison by decade of exposures of non-construction workers by SRS work area to all non-construction worker data in NOCTS

(2) A comparison by SRS work area of construction worker exposures to all non-construction workers in NOCTS

(3) A comparison of construction worker exposures by SRS work area to all construction workers in the NOCTS database

In the first set of analyses by work area, non-construction worker claimant exposures are compared by decade with aggregated exposures over all work areas. A ratio equal to the 84^{th} percentile for each work area divided by the 84^{th} percentile for all work areas is used in this comparison. A similar ratio of the geometric standard deviations (GSD) was also calculated. The purpose of this comparison is to demonstrate that non-construction workers in different work areas have different levels of exposures. If large differences in the 84^{th} percentile or GSD are found by work area, then the NIOSH coworker model, which assigns exposures estimated from aggregate claimant data for all work areas combined, would not be claimant favorable for claimants in some specific work areas.

FINDING #9: At SRS, the 84^th^ percentile of exposures to tritium, plutonium, uranium, and other radionuclides for non-construction workers in specific work areas show considerable differences from the 84^th^ percentile of exposures to non-construction workers site-wide. Similar results are observed for the corresponding ratio of the GSDs.

The second set of analyses by area provides a comparison of construction worker exposures by work area of the site with non-construction worker exposures aggregated over all work areas. A ratio equal to the 84^{th} percentile for construction worker claimants in each work area divided by the 84^{th} percentile for data from non-construction workers in all work areas is used in this comparison. A similar ratio of the GSDs was also calculated. The purpose of this comparison is to demonstrate that the NIOSH proposal to use non-construction worker claimant data from all work areas for estimating missed doses to construction workers will underestimate the dose for some construction worker claimants and overestimate the dose to other construction worker claimants, in some cases by considerable amounts, for instance by a factor of two or more. If large differences in the 84^{th} percentile or GSD are found, then assigning non-construction worker claimant data in the coworker model to construction workers, as proposed by NIOSH, would not be claimant favorable for some work areas and periods.

FINDING #10: At SRS, the 84^{th} percentile of exposures to tritium, plutonium, and other radionuclides for construction workers in specific work areas show considerable differences from the 84^{th} percentile of exposures to all construction workers site-wide. Similar results are observed for the corresponding ratio of the GSDs.

The third set of analyses by area contains comparisons of construction worker exposures by work area with construction worker exposures aggregated over all work areas. A ratio equal to the 84^{th} percentile for construction worker claimants in each work area divided by the 84^{th} percentile for construction workers in all work areas is used in this comparison. A similar ratio of the GSDs was also calculated. The purpose of this comparison is to show that sizeable differences occur between work areas for construction worker claimants. It should be noted that data for construction worker exposure to uranium, enriched uranium, and fission products are very sparse, preventing the calculation of ratios in many decades. In general, the discrepancies for tritium and plutonium are found to be larger than those observed in the comparison for non-construction workers by work area, as discussed above in the first set of analyses.

FINDING #11: At SRS, the 84^{th} percentile of exposures to tritium and plutonium for construction workers in specific work areas show large differences from the 84^{th} percentile of site-wide exposures to construction workers. Similar results are observed for the corresponding ratio of the GSDs. In many cases, there are insufficient data for construction workers to make a comparison for uranium, enriched uranium, and fission products.

The review ends with two analyses of SRS construction worker claimant exposures for tritium by construction craft. A ratio equal to the 84^{th} percentile for construction worker claimants in each craft divided by the 84^{th} percentile for construction workers in all construction crafts is used in the first analysis. A similar ratio of the GSD was also calculated. This comparison provides a measure of the differences in exposure among construction workers in different crafts for the SRS radionuclide studied by NIOSH in OTIB-0075.

FINDING #12: At SRS, the 84th percentile of exposures to tritium for construction workers in specific crafts shows large differences from the 84th percentile of exposures to all construction workers. Similar results are observed for the corresponding ratio of the GSDs.

In the second analysis by construction craft, a ratio equal to the 84th percentile for construction worker claimants in each craft divided by the 84th percentile for all non-construction workers is used. A similar ratio of the GSD was also calculated. This ratio measures how well site-wide non-construction worker data perform when estimating construction worker exposures in different crafts. This ratio is affected both by the differences in exposure among the construction crafts and the differences between construction workers and non-construction workers. Only tritium was examined in the comparisons by construction craft, due to lack of sufficient data for other nuclides.

FINDING #13: At SRS, the 84th percentile of exposures to tritium for construction workers in specific crafts shows large differences from the 84th percentile of site-wide exposures for non-construction workers. Similar results are observed for the corresponding ratio of the GSDs.

2.0 REVIEW OF THE STUDY CONDUCTED BY NIOSH

To verify the representativeness of using available data from claimants in lieu of actual coworker data (i.e., data sorted by specific job category, location, and time period), NIOSH looked at three cases where essentially complete coworker datasets were available in electronic form:

Y-12 Plant	Uranium urine bioassay	1950–1988
Mound Laboratory	Plutonium urine bioassay	1960–1990
Savannah River Site (SRS)	Tritium dose	1991–2001

2.1 COMPARISON OF CLAIMANT AND COMPLETE DATASETS FOR URANIUM AT THE Y-12 PLANT

NIOSH presents a summary of the results of their study of the annual uranium in urine samples at the Y-12 Plant in Table 4-1 of OTIB-0075. The table contains the lognormal distribution parameters estimated for the claimant and complete (all-worker) datasets in each year from 1950 to 1988. To obtain these estimates, all samples were combined into a single dataset for each year, with no differentiation by work area or job type.

Figure 2-1 displays a time series plot comparing the mean uranium concentrations in urine for each dataset. The arithmetic mean (expected value) and standard deviation of the lognormal distributions were calculated from the parameter values shown in Table 4-1 of ORAUT-0075 using the standard formulas (Battelle 2007, Table 2.2). The mean of the lognormal distribution is used in this review to compare the expected values of the two distributions. The expected values are approximately twice as high as the median concentrations shown in Figure 4-3 of OTIB-0075, and slightly lower than the 84th percentiles shown in Figure 4-4 of OTIB-0075. The claimant dataset has a lower mean in the earliest and latest years, and a higher mean in 1984. The outlier in 1984 is also obvious in the figure on page 18 of Appendix C to OTIB-0075. Examination of the regression plot in the figure on page 18 of Appendix B to OTIB-0075 shows that this high slope appears to overestimate the exposures in the upper tail of the distribution of claimant samples in this year.

A scatter plot of the mean uranium concentrations for the claimant versus the complete datasets is shown in Figure 2-2. Each year appears as a single point in this figure, with the complete (all-worker) annual mean plotted on the horizontal axis and the claimant annual mean plotted on the vertical axis. The dashed line in the figure at 45 degrees is the line of perfect equality. Data points falling on this line have equal values for the complete and claimant means. The solid line in the figure is the best-fitting regression line for the plotted data points. The estimated slope and y-intercept of the regression line may be compared to the ideal values of 1 and 0, respectively, using a hypothesis test derived from the regression statistics. The hypothesis test is based on the standard error of estimation of the slope and intercept. The hypothesis is rejected when the probability level (p-level) for the test is less than 0.05, meaning that there is less than a 5% chance that the intercept or slope would differ by this much or more from its target value of 0 or 1, respectively, due to the magnitude of the error in its estimation. The results of the hypotheses tests are shown in the upper portion of Table 2-1. The hypotheses that the intercept is 0 and the slope is 1 are accepted for the mean of the uranium samples at Y-12.

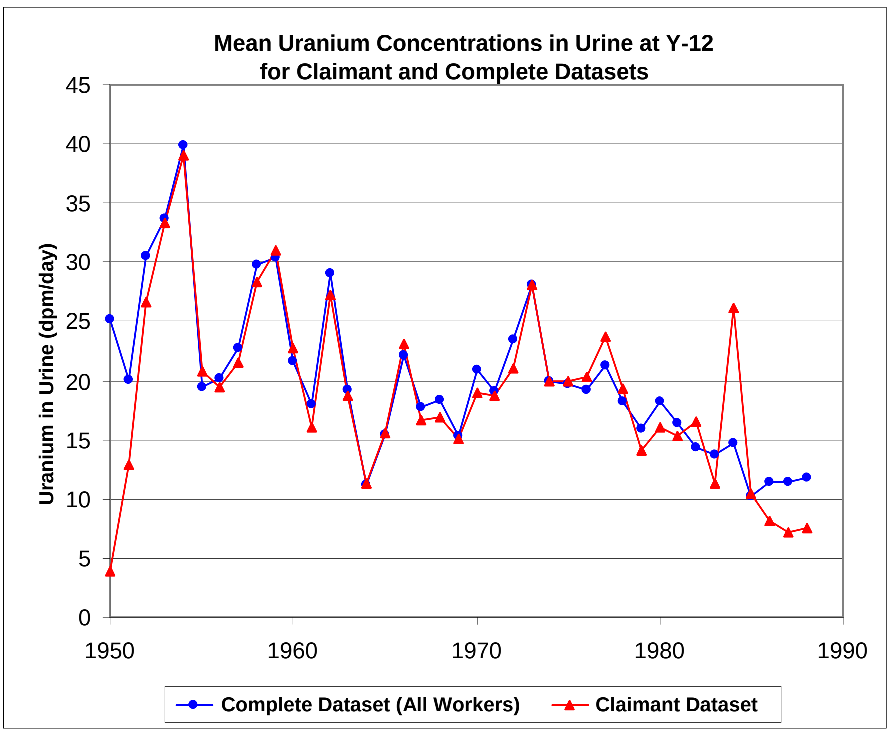

Figure 2-1: Mean Uranium Concentrations in Urine at Y-12 for Claimant and Complete Datasets

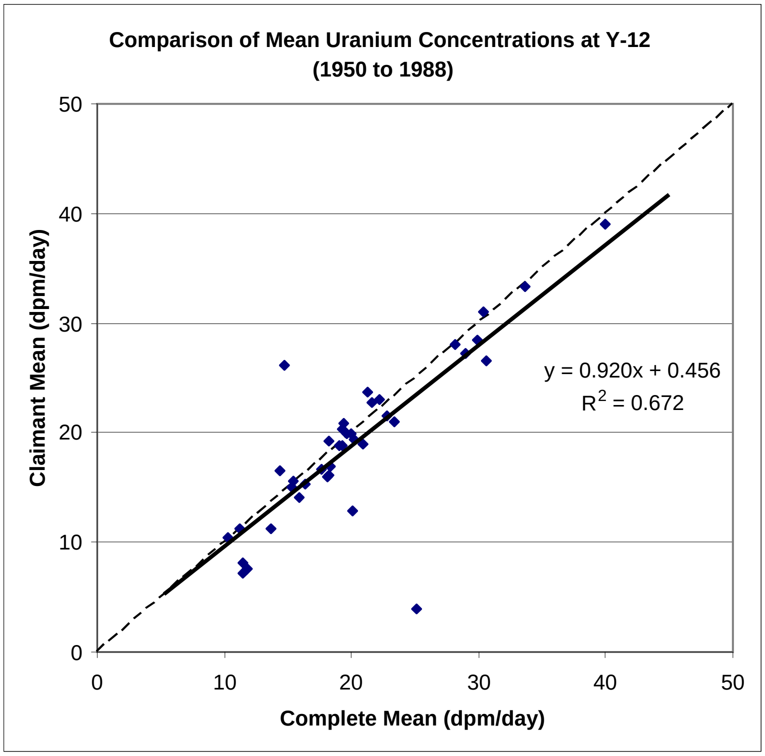

Figure 2-2: Comparison of Mean Uranium Concentrations at Y-12 (1950 to 1988)

Table 2-1: Summary of Regression Comparisons of Complete (All-Worker) and Claimant-Only Distributions for Uranium at the Y-12 Plant

Years	n	Lognormal Distribution Parameter	Regression Coefficient	Estimated Coefficient	Standard Error of Estimate	Hypothesis Tested	t-statistic for Test	p-level Pr{|X|>|t|}	Hypothesis Test Result
1950	39	Mean	Intercept	0.456	2.245	Intercept=0?	0.203	0.840	Accept
to			Slope	0.920	0.106	Slope=1?	-0.757	0.454	Accept
1988			R^2	0.672					
		Standard Deviation	Intercept	8.822	14.697	Intercept=0?	0.600	0.552	Accept
			Slope	0.826	0.243	Slope=1?	-0.717	0.478	Accept
			R^2	0.238					

Figure 2-3 shows a time series plot comparing the standard deviation of the lognormal distributions in each year for each dataset. The claimant dataset also has a lower standard deviation in the earliest and latest years, and a higher standard deviation in the outlier year 1984. A scatter plot of the standard deviation of the uranium concentrations for the claimant versus the complete datasets is shown in Figure 2-4. The estimated value for the slope and y-intercept of the regression line in this figure and the standard error of each estimate for uranium at Y-12 are shown in the lower part of Table 2-1. The estimated slope and y-intercept of the regression line are compared to the ideal values of 1 and 0, respectively, using the t-test. The results of these hypotheses tests are shown in Table 2-1. The hypotheses that the intercept is 0 and the slope is 1 are accepted for the standard deviation of uranium samples at Y-12. The conclusion is that the complete (all-worker) and claimant datasets for uranium in urine at the Y-12 Plant show no significant statistical differences at the annual level of aggregation; samples from all work areas and all job types are combined.

FINDING #1: At the Y-12 Plant, the complete (all-worker) and claimant datasets for uranium in urine from 1950 to 1988 show no significant difference at the annual level of aggregation. This finding confirms the conclusions reached in OTIB-0075 for uranium at the Y-12 Plant.

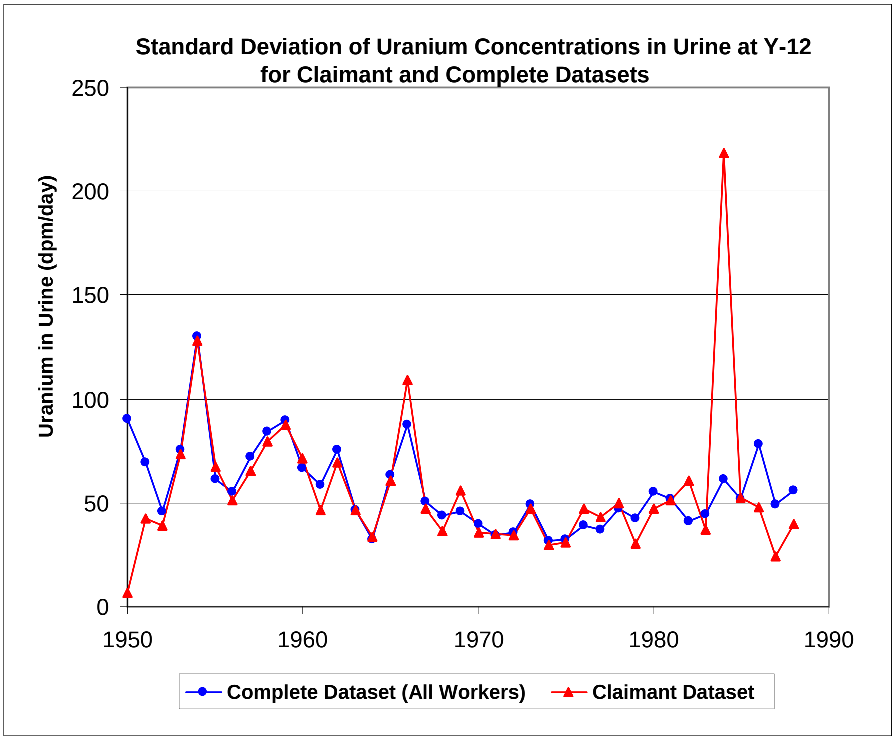

Figure 2-3: Standard Deviation of Uranium Concentrations in Urine at Y-12 for Claimant and Complete Datasets

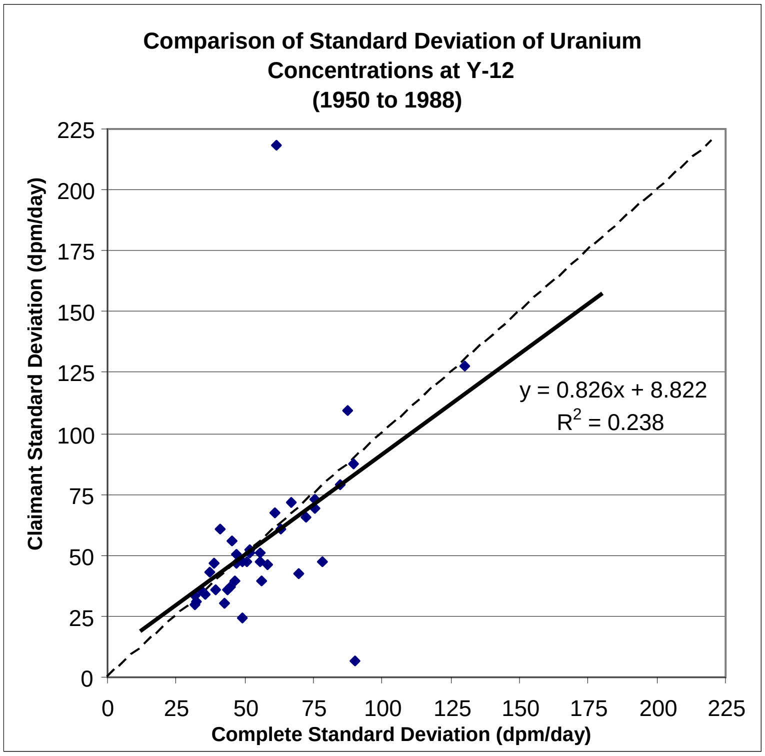

Figure 2-4: Comparison of Standard Deviation of Uranium Concentrations at Y-12 (1950 to 1988)

2.2 COMPARISON OF CLAIMANT AND COMPLETE DATASETS FOR PLUTONIUM AT MOUND LABORATORY

NIOSH presents a summary of the results of their study of the annual plutonium in urine samples at the Mound Laboratory in Table 6-2 of OTIB-0075. The table shows the lognormal distribution parameters estimated for the claimant and complete (all-worker) datasets in each year from 1960 to 1990. All samples were combined into a single dataset for each year, with no differentiation by work area or job type. Figure 2-5 shows a time series plot comparing the mean plutonium concentrations in urine for each dataset. The claimant dataset has a lower mean in the early years and a higher mean in the last 6 years. The claimant dataset underestimates the expected exposure of the average worker from 1960 to 1964, and overestimates exposures after 1984.

A scatter plot of the mean plutonium concentrations for the claimant versus the complete datasets is shown in Figure 2-6. The dashed line in the figure at 45 degrees is the line of perfect equality. At Mound, the estimated regression line lies far below the line of perfect equality, indicating that the mean for the complete dataset is much higher than the mean for the claimant dataset in the years when exposures are the highest.

Figure 2-7 shows a time series plot comparing the standard deviation of the lognormal distributions in each year for each dataset. The complete (all-worker) dataset has a higher standard deviation than the claimant dataset in many of the earlier years, but a lower standard deviation than the claimant dataset in the latest years.

A scatter plot of the standard deviation of the plutonium concentrations for the claimant versus the complete datasets is shown in Figure 2-8. The dashed line in the figure at 45 degrees is the line of perfect equality. Again, the estimated regression line lies far below the line of perfect equality, indicating that the standard deviation for the complete dataset is higher than the mean for the claimant dataset in the earliest years when exposures are the highest.

The estimated value for the slope and y-intercept of the regression lines in Figures 2-7 and 2-8 and the standard error of each estimate for plutonium at the Mound Laboratory are shown in Table 2-2. The estimated slope and y-intercept of the regression line are compared to the ideal values of 1 and 0, respectively, using the t-test. The results of these hypotheses tests are also shown in Table 2-2. The hypotheses that the intercept is 0 and the slope is 1 are rejected in all cases. The conclusion is that the complete (all-worker) and claimant datasets for annual plutonium in urine concentrations at the Mound Laboratory show statistically significant differences at the annual level of aggregation after combining samples from all work areas and all job types.

FINDING #2: At the Mound Laboratory, the complete (all-worker) and claimant datasets for plutonium in urine from 1960 to 1990 show significant differences at the annual level of aggregation. This finding raises questions concerning the conclusions reached in OTIB-0075 for plutonium at the Mound Laboratory.

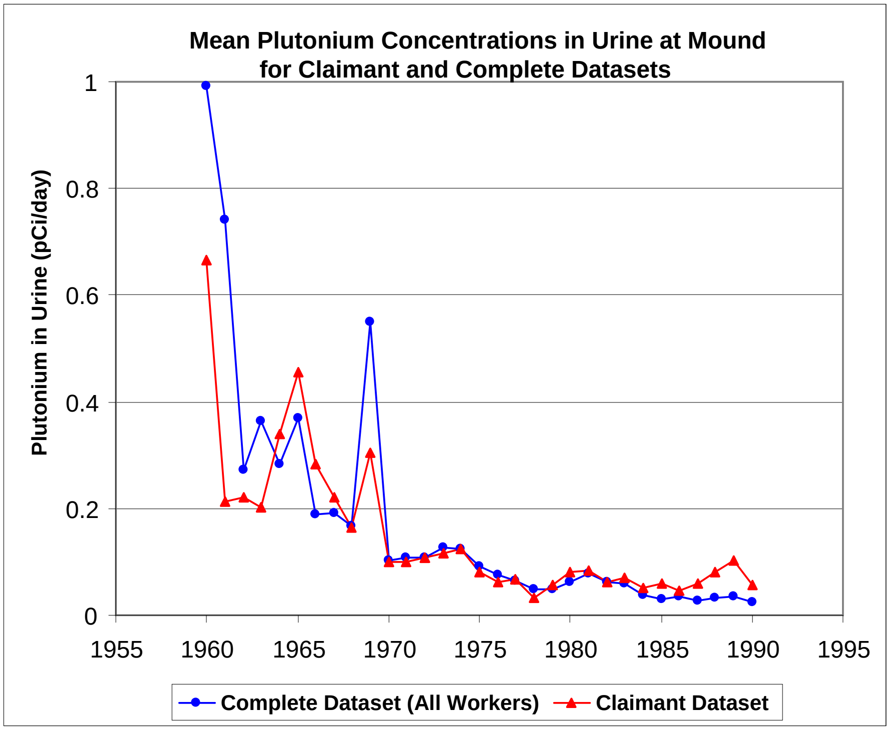

Figure 2-5: Mean Plutonium Concentrations in Urine at Mound for Claimant and Complete Datasets

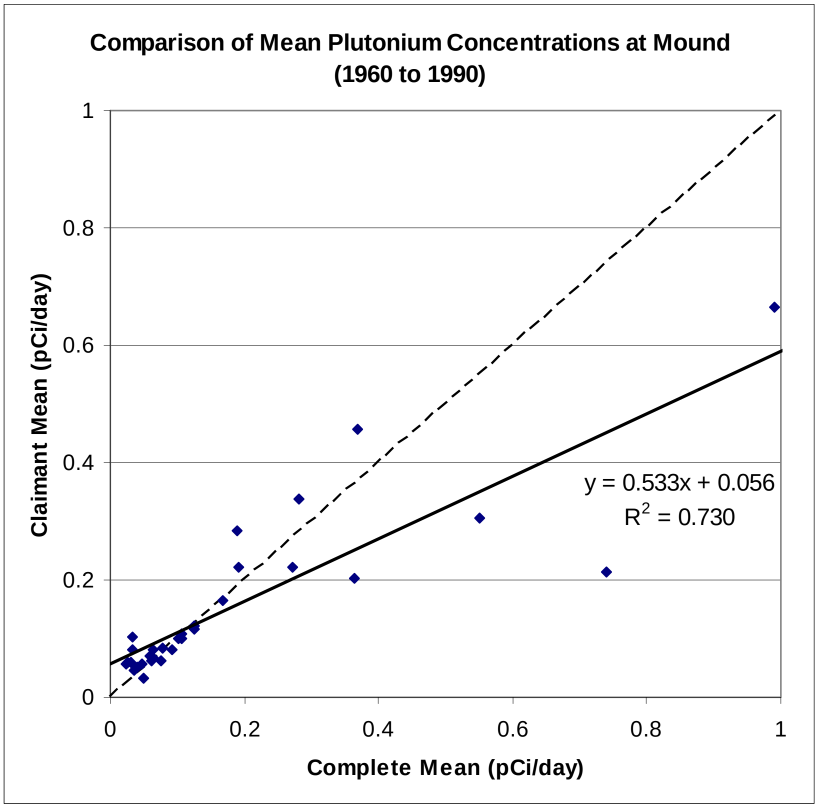

Figure 2-6: Comparison of Mean Plutonium Concentrations at Mound (1960 to 1990)

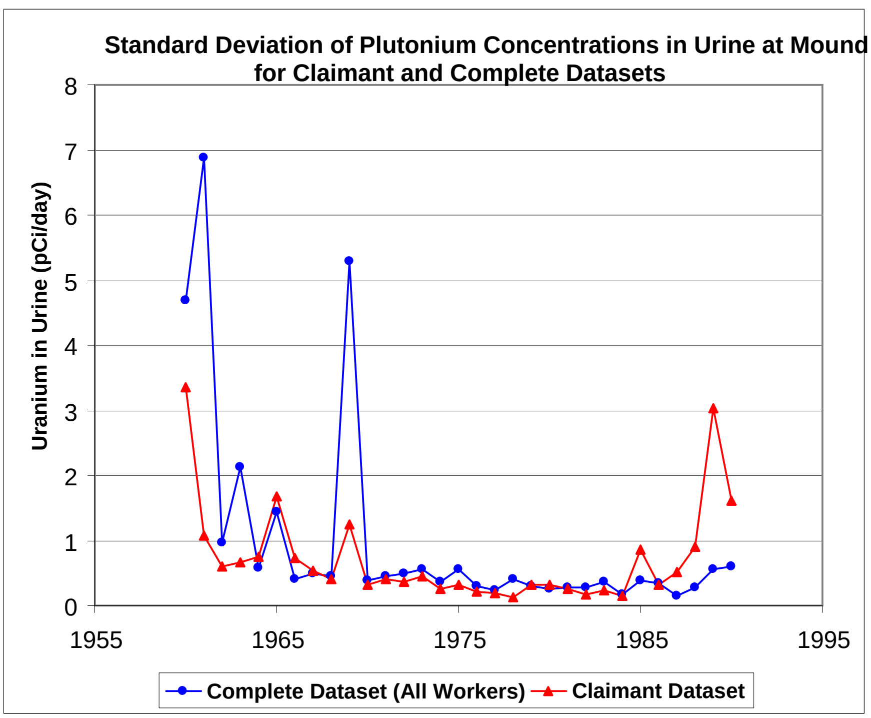

Figure 2-7: Standard Deviation of Plutonium Concentrations in Urine at Mound for Claimant and Complete Datasets

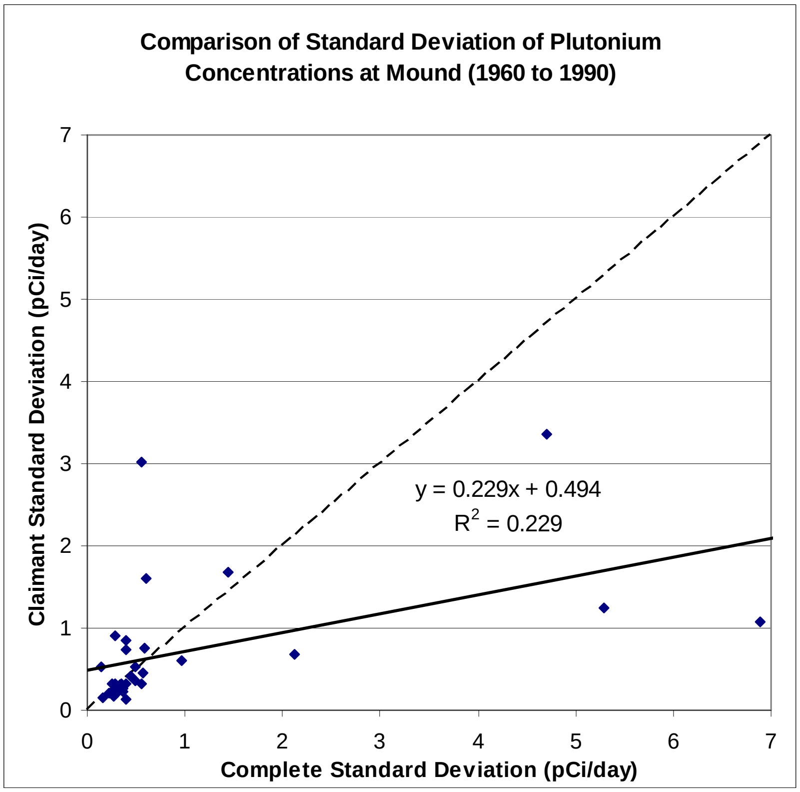

Figure 2-8: Comparison of Standard Deviation of Plutonium Concentrations at Mound (1960 to 1990)

Table 2-2: Summary of Regression Comparisons of Complete (All-Worker) and Claimant-Only Distributions for Plutonium at Mound Laboratory

Years	n	Lognormal Distribution Parameter	Regression Coefficient	Estimated Coefficient	Standard Error of Estimate	Hypothesis Tested	t-statistic for Test	p-level Pr{|X|>|t|}	Hypothesis Test Result
1960 to 1990	31	Mean	Intercept	0.056	0.017	Intercept=0?	3.309	0.003	Reject
			Slope	0.533	0.060	Slope=1?	-7.754	0.000	Reject
			R^2	0.730					
		Standard Deviation	Intercept	0.494	0.146	Intercept=0?	3.378	0.002	Reject
			Slope	0.229	0.078	Slope=1?	-9.889	0.000	Reject
			R^2	0.229					

2.3 COMPARISON OF CLAIMANT AND COMPLETE DATASETS FOR TRITIUM AT SRS

The SRS analysis used tritium dose estimates for the years from 1991 to 2001, rather than tritium urine bioassay concentrations. The tritium doses were calculated from the tritium urine bioassay dataset extracted from the SRS HPRED13 database, which is considered complete for the period of 1990 onward. The reason presented by NIOSH for analyzing this particular all-worker dataset at SRS is that the data were readily available in electronic form.

NIOSH presents a summary of the results of their study of the annual dose from tritium at SRS in Table 7-2 of OTIB-0075. The table shows the lognormal distributions estimated for the claimant and complete datasets in each year. All samples were combined into a single dataset for each year, with no differentiation by work area or job type. Figure 2-9 shows a time series plot comparing the mean annual tritium dose for each dataset. The claimant and complete (all-worker) datasets are very similar in all years.

A scatter plot of the mean annual tritium dose for the claimant versus the complete datasets at SRS is shown in Figure 2-10. The regression line is quite near the dashed line at 45 degrees, and the relatively high R^2 indicates good agreement between the two datasets during this time period. However, the sample size is small and nearly all values are at 3 to 4 mrem, with a single outlier at 6 mrem. The single outlier in 1991 almost entirely determines the slope of the regression line in this case.

Figure 2-11 shows a time series plot comparing the standard deviation of the lognormal distributions in each year. The claimant and complete (all-worker) datasets are very similar in all years except 2000. A scatter plot of the standard deviation of the plutonium concentrations for the claimant versus the complete datasets is shown in Figure 2-12. The regression line is quite near the dashed line at 45 degrees, and the relatively high R^2 indicates good agreement between the two datasets during this time period. However, the sample size is small and nearly all values are at 1 to 3 mrem, with a single outlier at 6 mrem. Again, the single outlier in 1991 almost entirely determines the slope of the regression line.

The estimated value for the slope and y-intercept of the regression line in Figure 2-12 and the standard error of estimate for the mean and standard deviation of tritium doses at SRS are shown in the upper portion of Table 2-3. The estimated slope and y-intercept of the regression line are compared to the ideal values of 1 and 0, respectively, using the t-test. The results of these hypotheses tests also are shown in Table 2-3. The hypotheses that the intercept is 0 and the slope is 1 are accepted in all cases. The conclusion is that the complete (all-worker) and claimant datasets for annual tritium doses at SRS show no statistically significant differences at the annual level of aggregation, combining samples from all work areas and all job types. However, the sample size at SRS is very small, and results are dominated by a single outlier year.

A second comparison of the claimant and all-worker tritium datasets at SRS was conducted omitting the outlier year of 1991. Regressions for comparing the mean and the standard deviations in the years from 1992 to 2001 are shown in Figures 2-13 and 2-14, respectively.

These regressions show no unduly influential data values from 1992 to 2001, and the regression lines fall near the line of equality. The t-test results in the lower portion of Table 2-3 indicate that the hypotheses of intercept equal to 0 and slope equal to 1 are accepted for mean and the standard deviation.

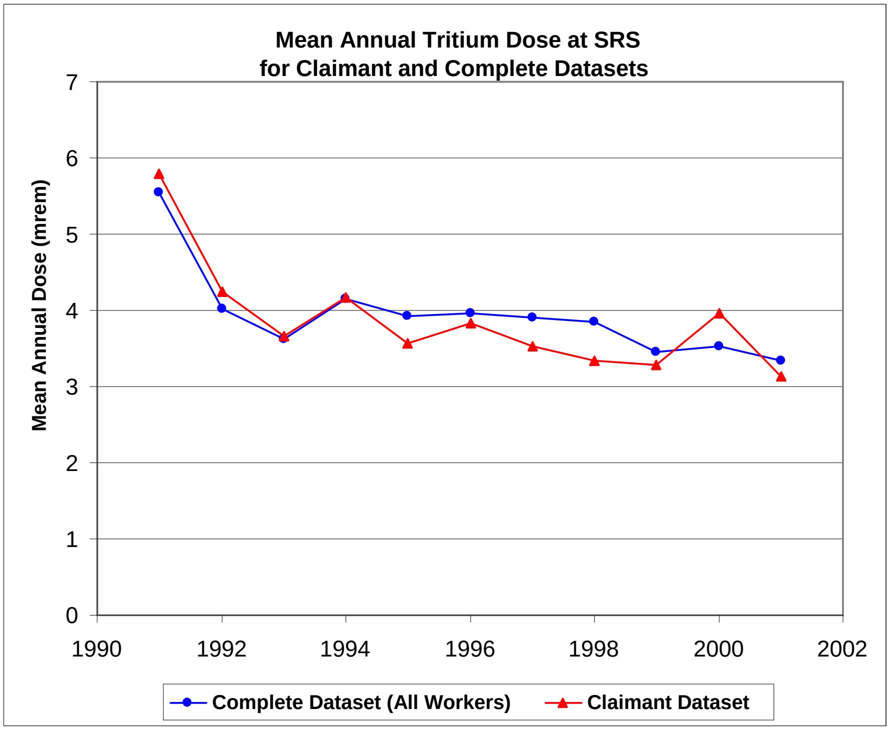

Figure 2-9: Mean Annual Tritium Dose at SRS for Claimant and Complete Datasets

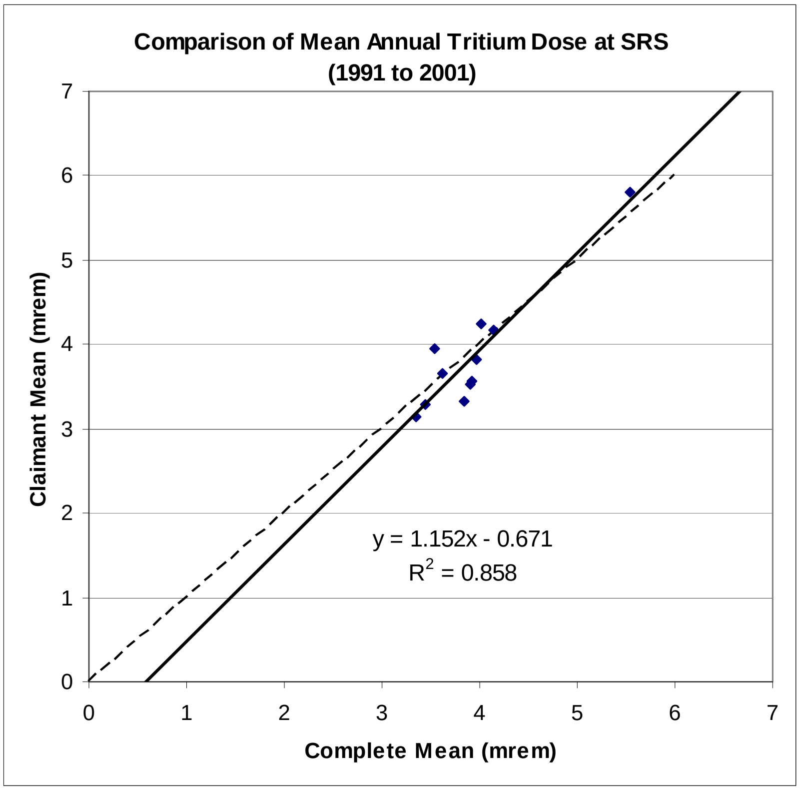

Figure 2-10: Comparison of Mean Annual Tritium Dose at SRS (1991 to 2001)

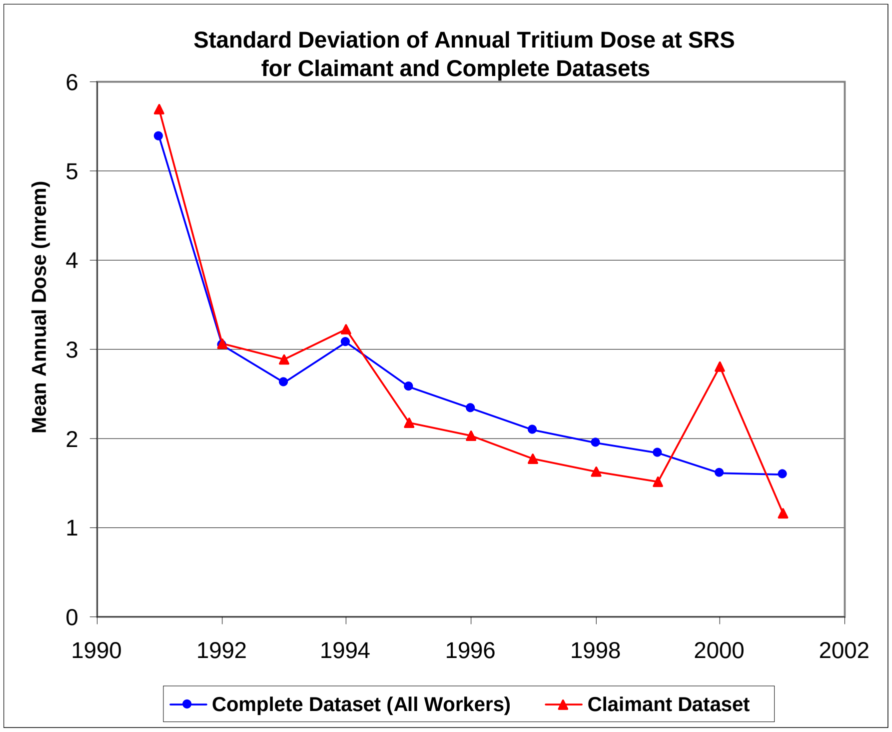

Figure 2-11: Standard Deviation of Annual Tritium Dose at SRS for Claimant and Complete Datasets

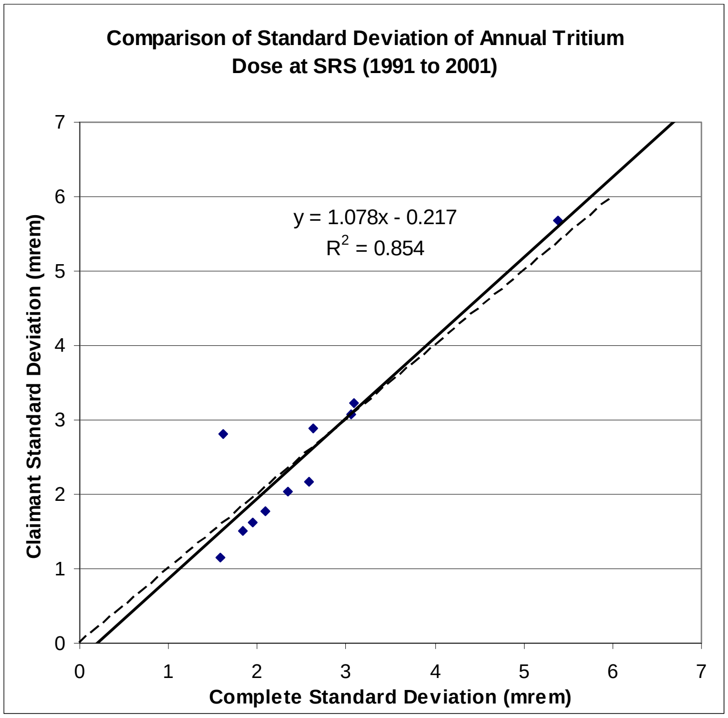

Figure 2-12: Comparison of Standard Deviation of Annual Tritium Dose at SRS (1991 to 2001)

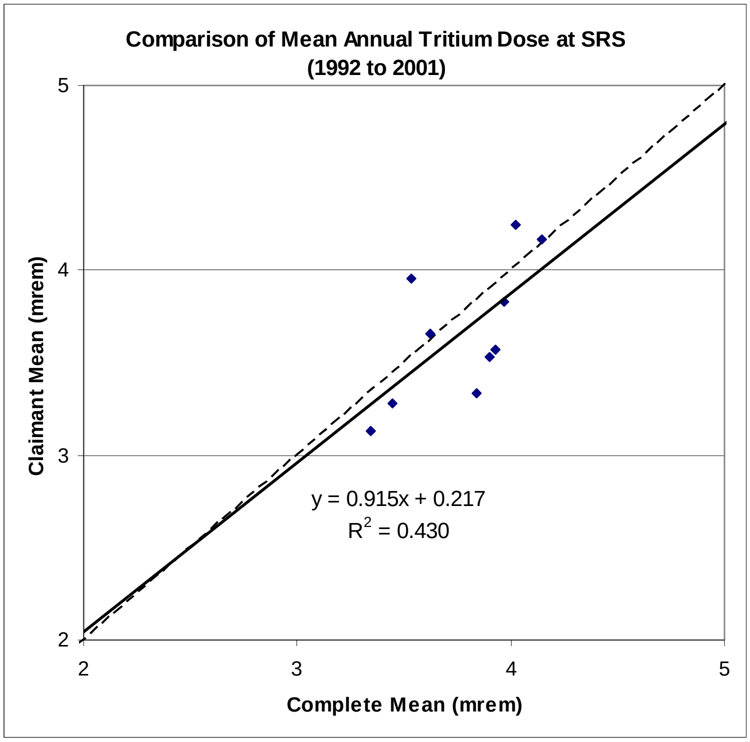

Figure 2-13: Comparison of Mean Annual Tritium Dose at SRS (1992 to 2001)

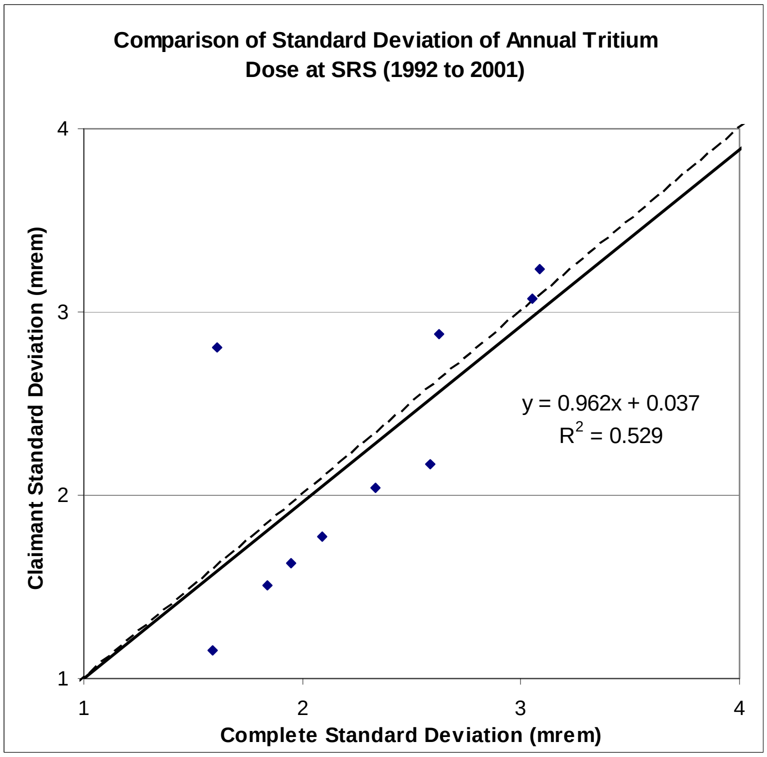

Figure 2-14: Comparison of Standard Deviation of Annual Tritium Dose at SRS (1992 to 2001)

Table 2-3: Summary of Regression Comparisons of Complete (All-Worker) and Claimant-Only Distributions for Tritium at SRS

Years	n	Lognormal Distribution Parameter	Regression Coefficient	Estimated Coefficient	Standard Error of Estimate	Hypothesis Tested	t-statistic for Test	p-level Pr{|X|>|t|}	Hypothesis Test Result
1991 to 2001	11	Mean	Intercept	-0.671	0.622	Intercept=0?	-1.079	0.309	Accept
			Slope	1.152	0.156	Slope=1?	0.973	0.356	Accept
			R^2	0.858					
		Standard Deviation	Intercept	-0.217	0.410	Intercept=0?	-0.530	0.609	Accept
			Slope	1.078	0.149	Slope=1?	0.526	0.611	Accept
			R^2	0.854					
1992 to 2001	10	Mean	Intercept	0.217	1.409	Intercept=0?	0.15	0.881	Accept
			Slope	0.915	0.372	Slope=1?	-0.23	0.825	Accept
			R^2	0.430					
		Standard Deviation	Intercept	0.037	0.750	Intercept=0?	0.05	0.962	Accept
			Slope	0.962	0.321	Slope=1?	-0.12	0.909	Accept
			R^2	0.529					

FINDING #3: At SRS, the complete (all-worker) and claimant datasets for annual tritium doses from 1991 to 2001 show no significant difference at the annual level of aggregation, but the sample size is very small and the regression results are dominated by a single year with high exposure, 1991. If this year is omitted, the complete and claimant datasets for annual tritium doses period from 1992 through 2001 show no significant difference at the annual level of aggregation

In the particular case of the SRS site, the OTIB-0075 study only addressed tritium exposures in the late years of operations at the site. Figure 2-11 shows evidence of a continuing exponential decline in mean annual tritium doses to all workers during this time period, indicating a residual nature of the tritium contamination. During essentially the whole period studied, many of the production and processing facilities, such as production reactors, had ceased operation. Note that the production reactors were the facilities in which the SRS tritium was created.

3.0 OVERVIEW COMMENTS ON OTIB-0075

The tritium data that were available in electronic form for the SRS site represent only a small fraction of the coworker exposure data that are available in hardcopy for this site. The entire exposure dataset at SRS includes a large amount of uranium and plutonium coworker exposure data that were not available in electronic form. No comparison of claimant and general worker exposures to uranium or transuranics is possible, because NIOSH has not yet assembled the complete dataset of SRS worker exposures into an electronic database.

At SRS, the potentially available coworker exposure database is large, but it is not available electronically. It is possible that the use of all the available data could support separate analyses of coworker exposures by quarter, work area (H Canyon versus F Canyon, etc.), and job type. Use of aggregated collections of claimant data in lieu of such detailed coworker data results in a great loss of occupational and area detail. This loss of critical information is not mentioned in OTIB-0075, which assumes that all claimants working at SRS in a given year are interchangeable, regardless of job type or work area. No consideration is given by NIOSH to the fact that the estimates derived using a coworker model based on all claimant data taken together would be not be claimant favorable for many sub-groups of claimants at the site. The study, at best, demonstrates that the estimates would be, **on average**, in the same ballpark for tritium in a limited period. In this case, the term "on average" means that for some groups of claimants, the estimates derived using this proposal will be too low, and for other groups of claimants, the estimates will be too high. This is not a claimant-favorable approach to dose estimation, because it ignores the known differences between work areas and job types that would become evident if the hardcopy data for all SRS workers in all years were available for analysis.

FINDING #4: At SRS, OTIB-0075 includes data only for tritium from 1991 to 2001 in comparing the claimant population to that of all workers. This is a very partial and incomplete basis for any overall conclusion about the relationship of claimant data to all-worker data. Analysis for other radionuclides, including uranium, plutonium, and fission products, can only be done if the available hardcopy data are reduced to electronic form. The same applies to tritium data prior to 1991. In all these cases, the validity of the central hypothesis of OTIB-0075 for SRS cannot be checked until the necessary hardcopy data are put into electronic form.

FINDING #5: Data for the entire SRS in OTIB-0075 were aggregated by year for the NIOSH analysis, with no detail by work area or by job type. The proposal for a NIOSH coworker model includes no analysis of these details.

With regard to the Y-12 Plant, NIOSH has an electronic coworker uranium urine bioassay dataset available for the years 1950 to 1988. This dataset was developed by the Oak Ridge Institute for Science and Engineering (ORISE) Center for Epidemiologic Research (CER) for use in epidemiology studies (Watkins et al. 1993) and has undergone detailed verification of its integrity.[1] A member of the complete dataset is referred to as a worker. The uranium bioassay database contains approximately 470,000 bioassays from over 7,500 workers. The subset of claimants with uranium bioassay data comprises approximately 10% of the workers and approximately 15% of the bioassays in the complete coworker database.

This dataset has been named as a "complete" coworker dataset. However, in regard to the claimant data at this site, NIOSH states the following.

[1] Note that the procedure used by Oak Ridge to prepare and validate a uranium exposure dataset in electronic form at Y-12 is precisely what will be required at SRS if the current NIOSH proposal is deemed not to be a claimant-favorable approach for coworker dose estimation.

> *Out of 1,971 total claimants for Y-12, 731 have uranium urine bioassay results in the complete dataset and 1,240 do not (presumably because they were not monitored).*

Note that only 731 out of 1,971 claimants (37%) had data in the “complete” coworker database. For the claimants with data, 67,923 uranium urine samples were found in the coworker database. The median claimant had 46 samples over the 39-year monitoring period; a little more than 1 assay per year.

FINDING #6: At Y-12, only 37% of all claimants (3 out of 8) have data in the "complete" Y-12 uranium urine bioassay coworker database for 1950 to 1988. This subset of 731 claimants with uranium bioassay data had a total of approximately 70,000 bioassays.

FINDING #7: Data for the entire Y-12 site were aggregated by year for the NIOSH analysis, with no detail by work area or by job type. The NIOSH coworker model includes no analysis of these details.

At the Mound Laboratory, the plutonium urine bioassay dataset PURECON provided “complete” coworker data for the years 1960 to 1990, with 225 claimants identified in the database. No information is provided on the fraction of all Mound claimants represented by the claimants with data in the complete coworker database. The database contains 2,070 workers who submitted a total of 53,340 plutonium urine bioassay samples. The 225 claimants with bioassay data submitted 8,849 plutonium urine samples. The median claimant submitted 24 samples over the 31-year monitoring period.

At the Mound Laboratory, the complete coworker plutonium bioassay database contains approximately 53,000 bioassays from over 2,000 workers. The subset of 225 claimants with plutonium bioassay data comprises approximately 11% of the workers and approximately 17% of the bioassays in the complete coworker database. The fraction of all claimants who were found to have data in the complete database is not reported.

FINDING #8: Data for the entire Mound Laboratory were aggregated by year for the NIOSH analysis, with no detail by work area or by job type. The NIOSH coworker model includes no attention to these details.

None of the above analyses compares construction worker claimants to non-construction worker claimants. In effect, OTIB-0075 does not have any analysis that would establish the validity of the hypothesis that all claimant data at any site, including SRS, are representative of construction worker data for that site for various periods and radionuclides.

4.0 ANALYSIS OF SRS CLAIMANT EXPOSURES BY WORK AREA AND JOB TYPE

Because much of the SRS sample data have not been transferred from its paper files to an electronic file, NIOSH is proposing to utilize the NIOSH OCAS Claims Tracking System (NOCTS) as its source of coworker data. NOCTS is a database of sample results for all Energy Employee Occupational Illness Compensation Program Act (EEOICPA) claimants. The NOCTS SRS sample results are stored on the O-drive in the files "Non-CW Coworker Data.xls" and "CW Coworker Data Test.xls." In this evaluation, the data from "Non-CW Coworker Data.xls" and "CW Coworker Data Test.xls" were used to compare the 84th percentile sample results of construction workers to non-construction workers for the entire SRS, as well as for specific areas within the SRS. Comparisons were made for tritium, plutonium, uranium, enriched uranium, and fission products, since those were the radionuclides with the most non-construction worker sample results. Specifically, we have not analyzed several other radionuclides of interest, including americium-241, curium-244, californium-252, and neptunium-237. There are very scant data in NOCTS for construction workers for these radionuclides during the main operational period of nuclear materials production up to and including 1988, except for just under a hundred samples for americium or "americium-curium," almost all of which are for the 1970s and 1980s, and the vast majority of them were taken from [redact].

Assumptions made for this evaluation include the following:

- Samples were determined to be unusable and not included if they (1) do not have a valid year, (2) do not have valid units, (3) have a zero result, or (4) contain data that would make it impossible to perform the calculations.

- No calculation (n/c) was performed if there were less than 100 usable non-construction worker sample results available for any combination of radionuclide, time period, and area. Because there are fewer construction worker samples, no calculation (n/c) was performed if there were less than 10 usable construction worker sample results available.

- In the O-drive files, plutonium results are reported as Pu, Pu-238/239, Pu-238, and Pu-239. All of these results were included in the plutonium calculations, but the Pu and Pu-238/239 (mostly pre-1981) results were divided by 2 to be consistent with the Pu-238 and Pu-239 results (mostly 1981 and later).

- All results were converted to units of μCi/L for tritium and dpm/L for the other radionuclides. This assumption differs from how NIOSH handles units when developing their coworker data, which were in units of dpm/day for other radionuclides.

The results of this SC&A evaluation of the NOCTS data are shown in two series of tables, one for non-construction worker claimants and one for construction worker claimants. Due to the large number of tables, all summary data tables are presented in the appendices. Table A-1 in Appendix A contains the number of tritium sample results from SRS non-construction worker claimants by work area and decade from the 1950s to the 2000s. The number of samples ranges from 1 to over 16,000 samples in a given year. The 84th percentile of tritium exposure in each work area and decade is shown in Table A-2. Tables B-1 and B-2 in Appendix B show similar results for construction worker claimants. The number of samples from construction worker claimants is much smaller, ranging from 1 to over 1,600. Note there are also fewer work areas with samples from construction worker claimants (7) than for non-construction worker claimants (13).

Tables A-3 and A-4 in Appendix A show similar results for plutonium bioassay samples from non-construction worker claimants. There are fewer work areas with non-construction worker claimant plutonium samples. The number of samples ranges from 2 to over 1,800 samples per decade. Tables B-3 and B-4 in Appendix B show similar results for the construction worker claimants.

Tables A-5 and A-6 show the results for non-construction worker uranium bioassay samples, Tables A-7 and A-8 for enriched uranium, and Tables A-9 and A-10 for fission products. Similar results for construction worker claimants are shown for uranium in Tables B-5 and B-6, for enriched uranium in Tables B-7 and B-8, and for fission products in Tables B-9 and B-10.

4.1 COMPARISON OF NON-CONSTRUCTION WORKER EXPOSURES BY WORK AREA

A summary of the 84th percentile estimates for non-construction worker claimants contained in the tables of Appendix A is presented in Table 4-1. This table contains the ratio of 84th percentile for non-construction workers in the specified work area over the 84th percentile for non-construction workers in all work areas (first row of data in Tables A-2, A-4, A-6, A-8 and A-10). The five types of exposures are shown in the table. The purpose of this table is to demonstrate that non-construction workers in different work areas have different levels of exposures, and hence should not be assigned exposures estimated from claimant data for all work areas combined.

Some entries in Table 4-1 are less than 1 and some are greater than 1. When the ratio is less than 1, the estimated missed dose would be claimant favorable, higher than typical exposures in that work area. But when the ratio is greater than 1, the estimated missed dose would not be claimant favorable, lower than typical exposures in that work area. The degree to which the numbers in Table 4-1 differ from 1.0 is a measure of the error expected if the NIOSH proposal of using aggregated NOCTS claimant data were used to assign missed doses to non-construction worker claimants.

In the case of tritium in the 1950s in Table 4-1, all the ratios shown exceed unity. This is due to the large number of workers with missing work area information in NOCTS in the 1950s, as shown near the bottom of Table A-1.

Table 4-1: Ratio of 84th Percentile for Non-Construction Workers in Specified Work Areas over 84th Percentile for Non-Construction Workers in All Work Areas

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Tritium			
C-Area	5.45	1.67	1.00	1.00	0.50	n/c
F-Area	4.05	n/c	n/c	n/c	n/c	n/c
H-Area	n/c	0.17	0.50	0.50	0.50	0.56
K-Area	1.82	1.00	1.50	1.30	1.50	n/c
L-Area	1.91	1.67	n/c	0.25	0.50	n/c
P-Area	3.64	1.33	1.00	1.00	2.00	n/c
R-Area	2.73	1.33	n/c	n/c	n/c	n/c
			Plutonium			
A-Area	n/c	0.74	0.06	1.00	n/c	n/c
F-Area	0.87	0.74	0.47	1.70	n/c	n/c
H-Area	1.30	2.91	14.98	1.00	n/c	n/c
			Uranium			
F-Area	n/c	1.44	1.00	1.00	n/c	n/c
M-Area	n/c	1.00	1.00	1.00	n/c	n/c
			Enriched Uranium			
M-Area	n/c	n/c	1.82	1.00	n/c	n/c
			Fission Products			
F-Area	n/c	1.00	n/c	1.00	n/c	n/c
H-Area	n/c	1.00	n/c	1.00	n/c	n/c

n/c: Not calculated

A bar plot of the tritium ratios in Table 4-1 comparing the level of non-construction worker exposures in specific areas to aggregate exposures of non-construction workers over all areas is shown in Figure 4-1. Horizontal lines are drawn at a ratio of 1. The largest deviations from 1 are labeled with the value of the ratio. Other than in the 1950s, when there were few samples with identified work areas, the largest deviations from 1 occur in the 1990s, with a ratio of 2.0.

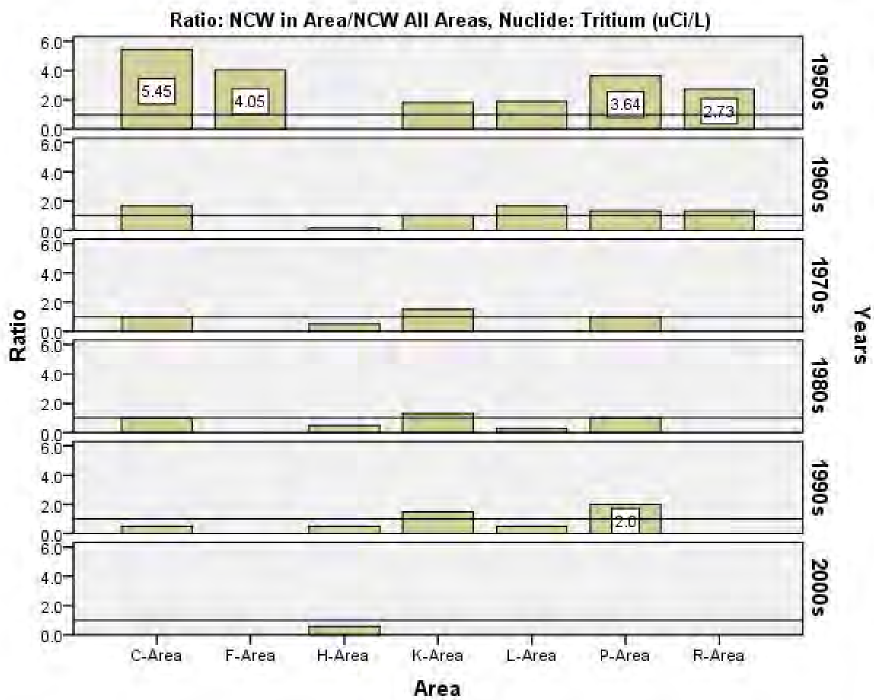

Figure 4-1: Ratio of 84th Percentile of Tritium Samples from Non-Construction Workers (NCW) in Specified Work Areas over 84th Percentile of Tritium Samples from Non-Construction Workers in All Work Areas, by Decade

Table 4-2 contains the ratio of the GSD for non-construction workers in the specified work area over the GSD for non-construction workers in all work areas. The GSD, calculated as the ratio of the 84th percentile over the 50th percentile, is always greater than or equal to 1. The GSD is a measure of the spread of the distribution of bioassays in the specified area, while the 50th and 84th percentiles are measures of the level of the distribution. When the median for the work area is equal to the median for all work areas, the ratio of the corresponding GSDs will be the same as the ratio of the 84th percentiles shown in Table 4-1.

A plot of the GSD ratios for tritium shown in Table 4-2 is presented in Figure 4-2. The horizontal line in each plot is drawn at a value of 1.0. The GSD of the non-construction workers in Areas C, F, K, L, P, and R exceeds the GSD for non-construction workers in all areas combined. Again, this is due to the large number of workers with missing work area information in NOCTS in the 1950s, as shown near the bottom of Table A-1.

Table 4-2: Ratio of GSD for Non-Construction Workers in Specified Work Areas over GSD for Non-Construction Workers in All Work Areas

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Tritium			
C-Area	2.73	0.83	1.00	1.00	0.50	n/c
F-Area	2.03	n/c	n/c	n/c	n/c	n/c
H-Area	n/c	0.17	1.00	0.50	0.50	0.56
K-Area	1.82	1.00	1.50	0.65	0.75	n/c
L-Area	1.91	0.42	n/c	0.25	0.50	n/c
P-Area	3.64	0.33	1.00	0.63	1.00	n/c
R-Area	2.73	0.67	n/c	n/c	n/c	n/c
			Plutonium			
A-Area	n/c	0.74	0.06	1.00	n/c	n/c
F-Area	0.87	0.74	0.47	1.70	n/c	n/c
H-Area	1.30	2.91	14.98	1.00	n/c	n/c
			Uranium			
F-Area	n/c	1.44	1.00	0.23	n/c	n/c
M-Area	n/c	1.00	4.43	1.00	n/c	n/c
			Enriched Uranium			
M-Area	n/c	n/c	1.21	1.00	n/c	n/c
			Fission Products			
F-Area	n/c	1.00	n/c	1.00	n/c	n/c
H-Area	n/c	1.00	n/c	1.00	n/c	n/c

n/c: Not calculated

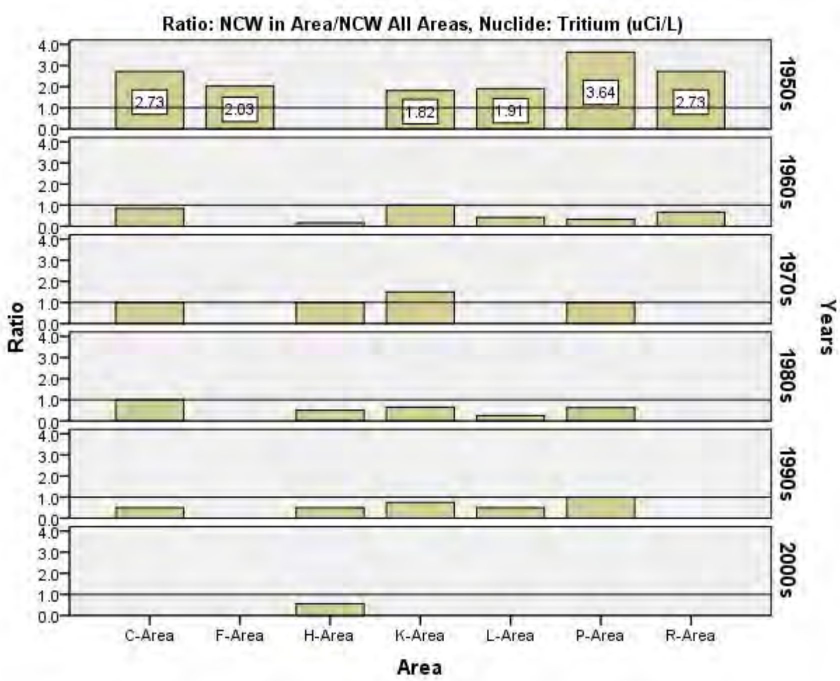

Figure 4-2: Ratio of GSD of Tritium Samples from Non-Construction Workers (NCW) in Specified Work Areas over GSD of Tritium Samples from Non-Construction Workers in All Work Areas, by Decade

A plot for the ratio of the 84th percentile of plutonium bioassays in the specified work area over the 84th percentile for all work areas combined is shown in Figure 4-3. Several large ratios are observed in the P-Area in the 1960s and 1970s. The 84th percentile of non-construction worker exposure in P-Area exceeded the 84th percentile of plutonium exposure for all non-construction worker claimants by a factor of 15 in the 1970s, and by almost a factor of 3 in the 1960s.

Table 4-2 contains ratios of the GSD of plutonium bioassays in the specified work area over the GSD in all work areas. A plot of these ratios is shown in Figure 4-4. When the ratio of the GSDs exceeds 1, the distribution of samples from non-construction workers in the specified work area has a wider spread than the distribution for non-construction workers in all work areas. The GSD ratios in H-Area show large discrepancies in the 1960s and 1970s.

Table 4-1 also contains ratios of the 84th percentile of uranium bioassays from non-construction workers in the specified work area over the 84th percentile for non-construction workers in all work areas combined. A plot of these ratios is shown in Figure 4-5. The ratios are all close to 1, indicating good agreement in the 84th percentiles. The ratio of the GSD of uranium bioassays in the specified work area over the GSD in all work areas is plotted in Figure 4-6. A large ratio of over a factor of 4 is observed for the GSD in M-Area in the 1970s.

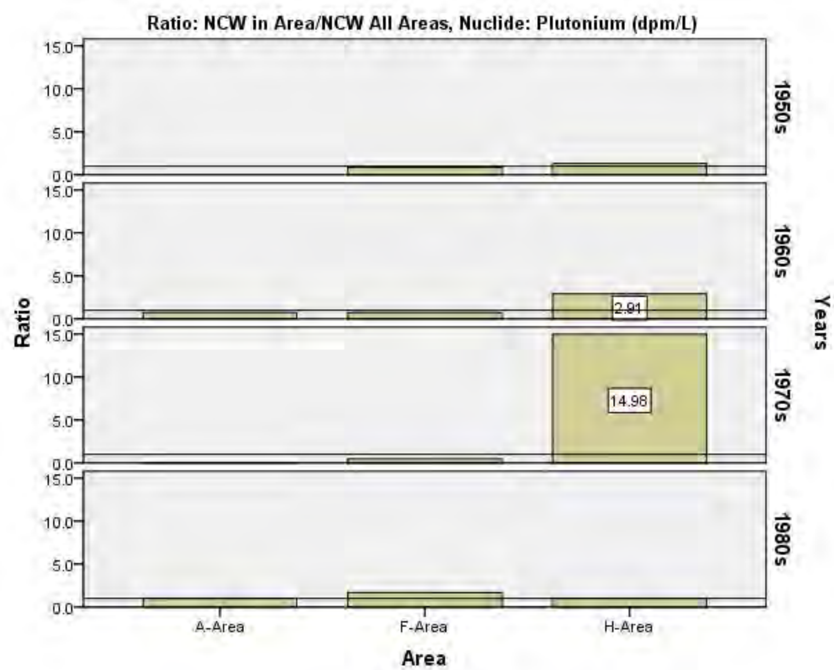

Figure 4-3: Ratio of 84th Percentile of Plutonium Samples from Non-Construction Workers (NCW) in Specified Work Areas over 84th Percentile of Plutonium Samples from Non-Construction Workers in All Work Areas, by Decade

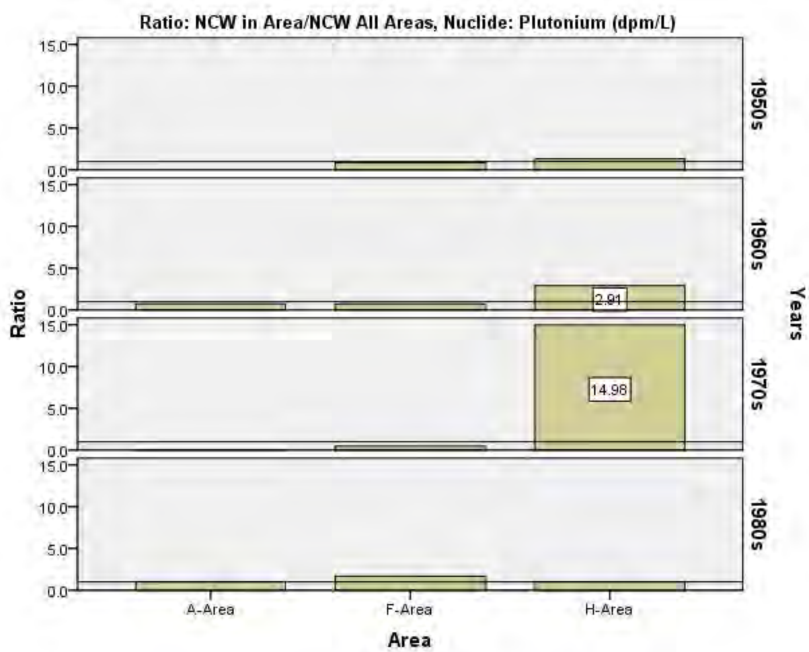

Figure 4-4: Ratio of GSD of Plutonium Samples from Non-Construction Workers (NCW) in Specified Work Areas over GSD of Plutonium Samples from Non-Construction Workers in All Work Areas, by Decade

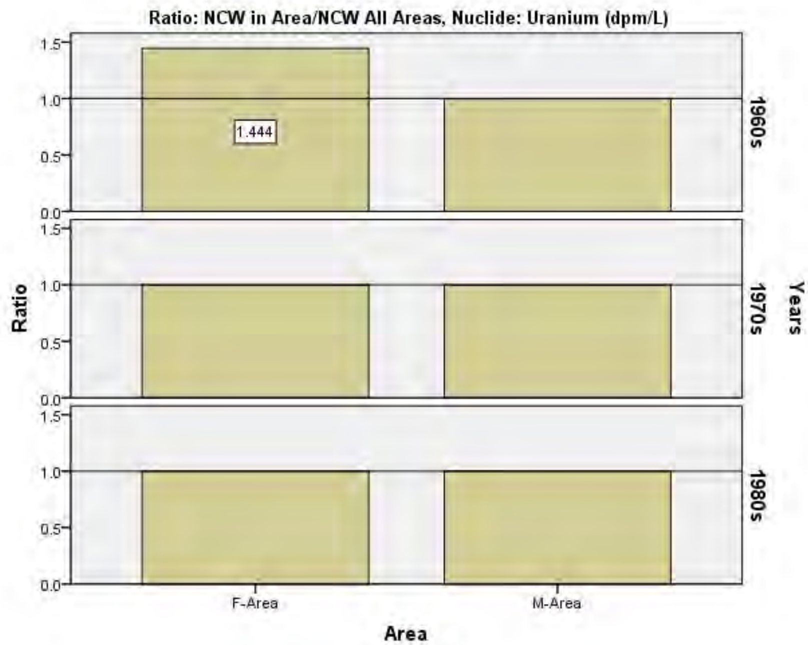

Figure 4-5: Ratio of 84th Percentile of Uranium Samples from Non-Construction Workers (NCW) in Specified Work Areas over 84th Percentile of Uranium Samples from Non-Construction Workers in All Work Areas, by Decade

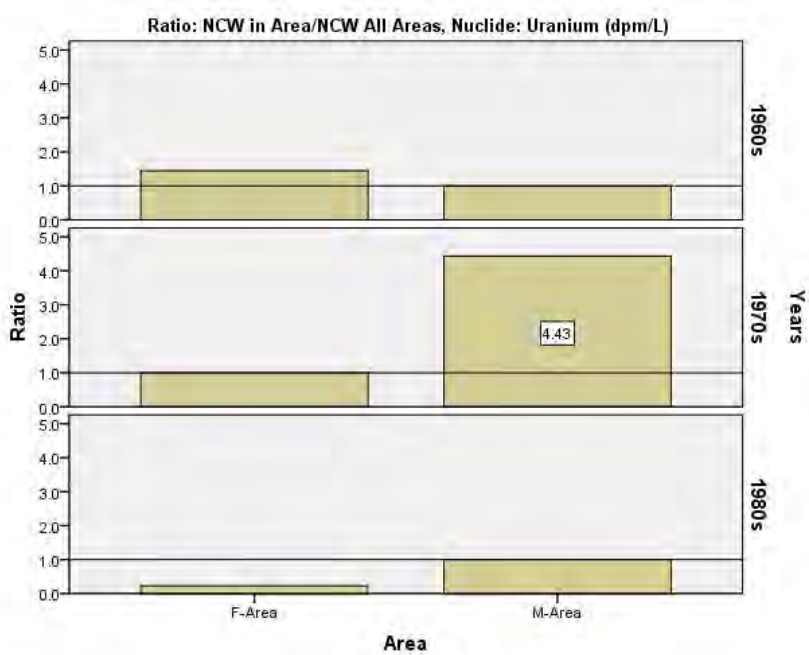

Figure 4-6: Ratio of GSD of Uranium Samples from Non-Construction Workers (NCW) in Specified Work Areas over GSD of Uranium Samples from Non-Construction Workers in All Work Areas, by Decade

FINDING #9: At SRS, the 84th percentile of exposures to tritium, plutonium, uranium, and other radionuclides for non-construction workers in specific work areas show considerable differences from the 84th percentile of exposures to non-construction workers site-wide. Similar results are observed for the corresponding ratio of the GSDs.

4.2 COMPARISON OF CONSTRUCTION WORKER AND NON-CONSTRUCTION WORKER EXPOSURES

A comparison of the 84th percentile estimates for non-construction worker and construction worker claimants in the tables of Appendices A and B, respectively, is presented in Table 4-3. This table shows the ratio of the 84th percentile for construction workers in the specified work area divided by the 84th percentile for non-construction workers in all work areas. This ratio has the same denominator that was used for the ratios in Table 4-1 (first row of data in Tables A-2, A-4, A-6, A-8, and A-10). The purpose of Table 4-3 is to show that the NIOSH proposal to use non-construction worker claimant data for estimating missed doses to construction workers will underestimate the dose for some construction worker claimants and overestimate the dose to other construction worker claimants, in some cases by a large amount.

A bar plot of the tritium ratios in Table 4-3 comparing construction worker exposures in specific areas to aggregate exposures for non-construction worker over all areas is shown in Figure 4-7. Horizontal lines are drawn at a ratio of 1. The plot shows that the 84th percentile for construction worker claimants in specified work areas exceeds the 84th percentile for non-construction workers by factors of 2.5 to 5 in many work areas in the 1950s, in K-Area and P-Area in the 1090s, and in H-Area in the 2000s. The NIOSH proposal would not be claimant favorable for construction worker claimants who worked in these areas.

Table 4-4 contains the ratio of the GSD for biosamples from construction workers in the specified work area over the GSD for non-construction workers in all work areas. When the ratio of the GSDs exceeds 1, the distribution of samples from construction workers in the specified work area has a wider spread than the distribution for non-construction workers in all work areas. The GSDs differ by large factors in Areas F, K, and P in the 1950s, and in H-Area in the 2000s.

A plot for the ratio of the 84th percentiles of plutonium exposure for the construction worker and non-construction worker claimants is shown in Figure 4-9. Large ratios are observed in F-Area and P-Area in the 1980s, ranging from 1.7 to 2.0. The NIOSH proposal would not be claimant favorable for construction worker claimants who worked in these areas.

Table 4-4 contains the ratio of the GSD of plutonium bioassays from construction workers in the specified work area over the GSD for non-construction workers in all work areas. These ratios are plotted in Figure 4-10. Very low ratios are noted in the 1970s for Areas A, F and H. These low ratios are due to the relatively high mean and GSD of the plutonium samples for non-construction workers in H-Area in this decade, as shown in Figures 4-3 and 4-4.

A plot for the ratio of the 84th percentile of uranium bioassays from construction workers in the specified work area over the 84th percentile for non-construction workers in all work areas combined is shown in Figure 4-11. Several large ratios are observed in F-Area in the 1970s and M-Area in the 1960s. Table 4-4 shows the ratio of the GSD of uranium bioassays in the specified work area over the GSD in all work areas. A plot of these ratios is shown in Figure 4-12. Again, large ratios are observed in F-Area in the 1970s and M-Area in the 1960s.

FINDING #10: At SRS, the 84th percentile of exposures to tritium, plutonium, and other radionuclides for construction workers in specific work areas show considerable differences from the 84th percentile of exposures to all non-construction workers site-wide. Similar results are observed for the corresponding ratio of the GSDs.

Table 4-3: Ratio of 84th Percentile for Construction Workers in Specified Work Areas over 84th Percentile for Non-Construction Workers in All Work Areas

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Tritium			
C-Area	2.73	2.00	1.00	1.00	0.25	n/c
F-Area	3.04	n/c	n/c	n/c	n/c	n/c
H-Area	n/c	0.17	0.25	0.50	0.25	3.33
K-Area	4.55	1.00	1.00	1.50	2.50	n/c
L-Area	0.91	2.00	n/c	0.25	1.00	n/c
P-Area	5.45	2.00	1.00	1.10	3.00	n/c
R-Area	0.45	1.67	n/c	n/c	n/c	n/c
			Plutonium			
A-Area	n/c	1.43	0.12	1.00	n/c	n/c
F-Area	0.74	1.43	0.12	1.70	n/c	n/c
H-Area	1.00	1.43	0.23	2.03	n/c	n/c
			Uranium			
F-Area	n/c	1.49	3.34	1.00	n/c	n/c
M-Area	n/c	2.00	0.23	0.23	n/c	n/c
			Enriched Uranium			
M-Area	n/c	n/c	0.17	0.96	n/c	n/c
			Fission Products			
F-Area	n/c	1.00	n/c	1.00	n/c	n/c
H-Area	n/c	1.00	n/c	1.00	n/c	n/c

n/c: Not calculated

Table 4-4: Ratio of GSD for Construction Workers in Specified Work Areas over GSD for Non-Construction Workers in All Work Areas

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Tritium			
C-Area	1.36	0.50	1.00	1.00	0.25	n/c
F-Area	3.04	n/c	n/c	n/c	n/c	n/c
H-Area	n/c	0.17	0.50	0.50	0.25	3.33
K-Area	3.03	1.00	1.00	1.25	1.25	n/c
L-Area	0.91	0.50	n/c	0.25	0.50	n/c
P-Area	5.45	0.50	1.00	0.69	0.50	n/c
R-Area	0.45	0.83	n/c	n/c	n/c	n/c
			Plutonium			
A-Area	n/c	0.74	0.06	0.52	n/c	n/c
F-Area	0.35	0.74	0.06	0.87	n/c	n/c
H-Area	0.47	0.74	0.12	1.05	n/c	n/c
			Uranium			
F-Area	n/c	1.49	3.34	1.13	n/c	n/c
M-Area	n/c	2.00	1.00	0.23	n/c	n/c
			Enriched Uranium			
M-Area	n/c	n/c	0.17	0.96	n/c	n/c
			Fission Products			
F-Area	n/c	1.00	n/c	1.00	n/c	n/c
H-Area	n/c	1.00	n/c	1.00	n/c	n/c

n/c: Not calculated

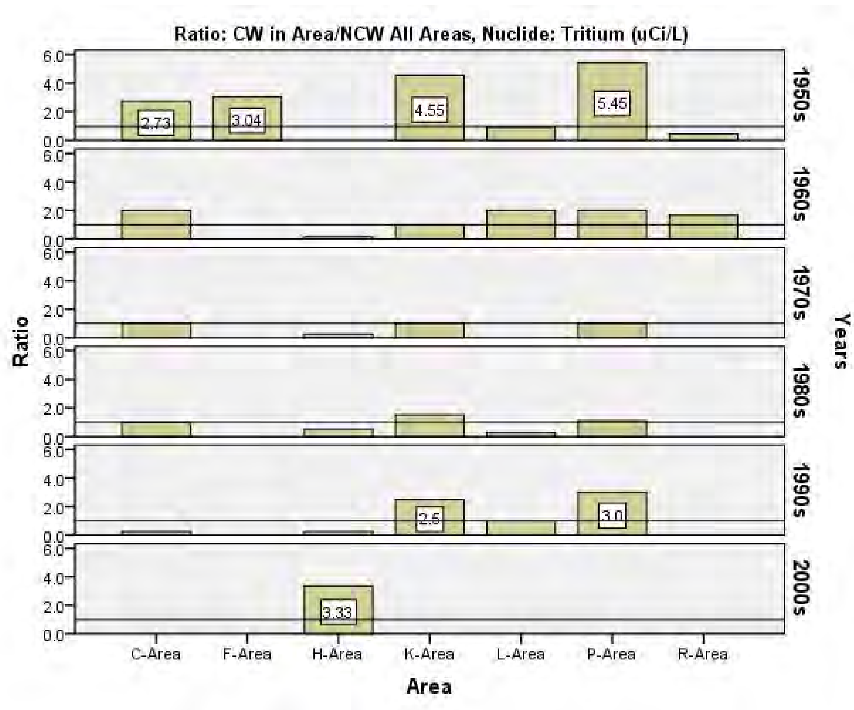

Figure 4-7: Ratio of 84th Percentile of Tritium Samples from Construction Workers (CW) in Specified Work Areas over 84th Percentile of Tritium Samples from Non-Construction Workers (NCW) in All Work Areas, by Decade

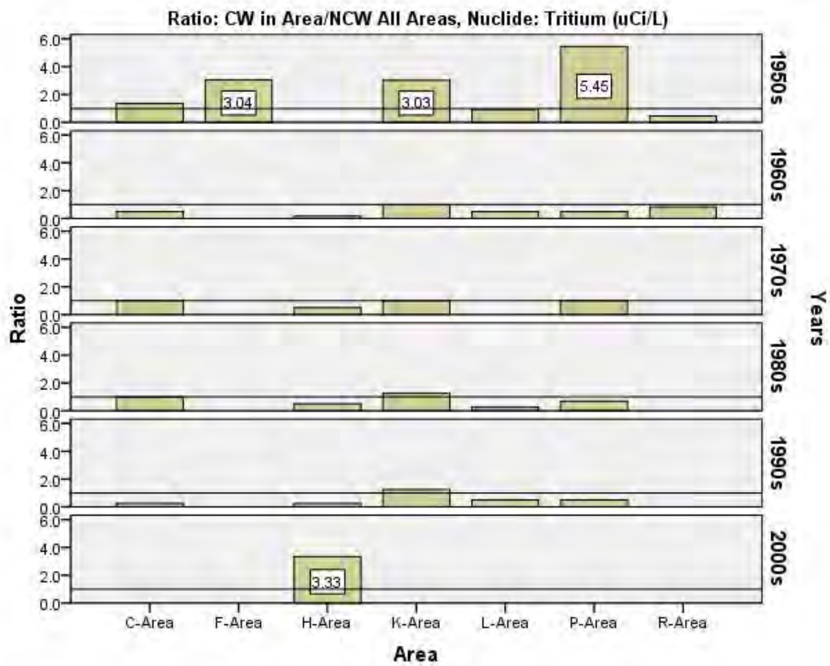

Figure 4-8: Ratio of GSD of Tritium Samples from Construction Workers (CW) in Specified Work Areas over GSD of Tritium Samples from Non-Construction Workers (NCW) in All Work Areas, by Decade

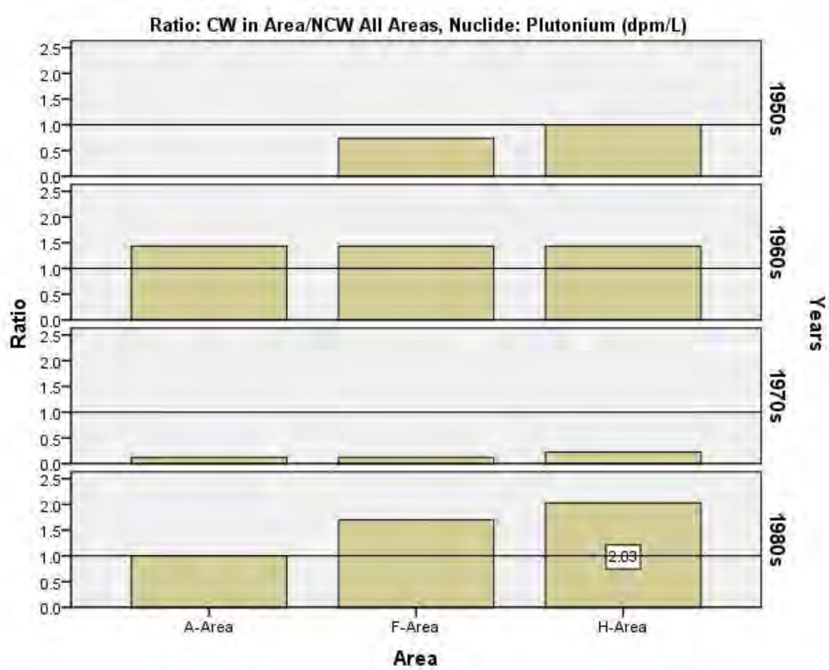

Figure 4-9: Ratio of 84th Percentile of Plutonium Samples from Construction Workers (CW) in Specified Work Areas over 84th Percentile of Plutonium Samples from Non-Construction Workers (NCW) in All Work Areas, by Decade

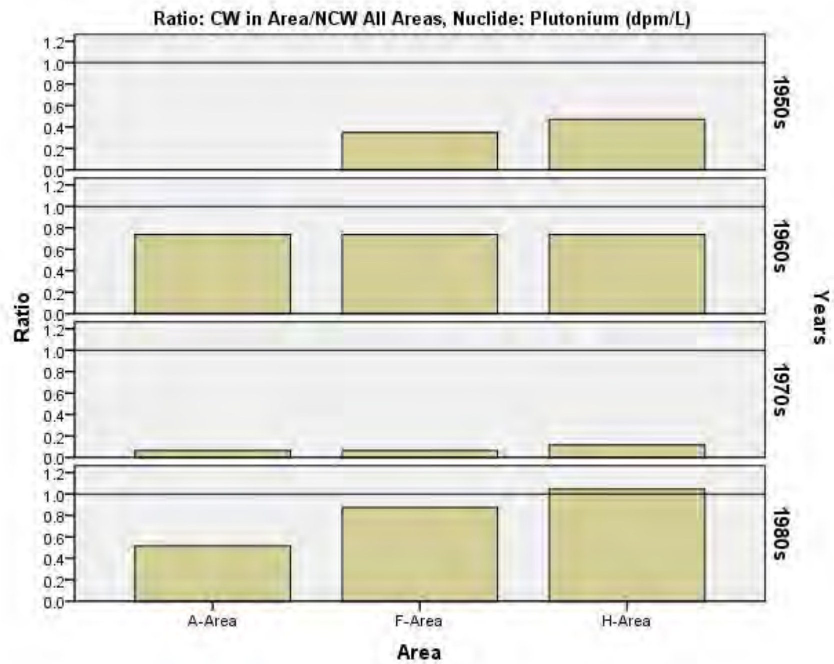

Figure 4-10: Ratio of GSD of Plutonium Samples from Construction Workers (CW) in Specified Work Areas over GSD of Plutonium Samples from Non-Construction Workers (NCW) in All Work Areas, by Decade

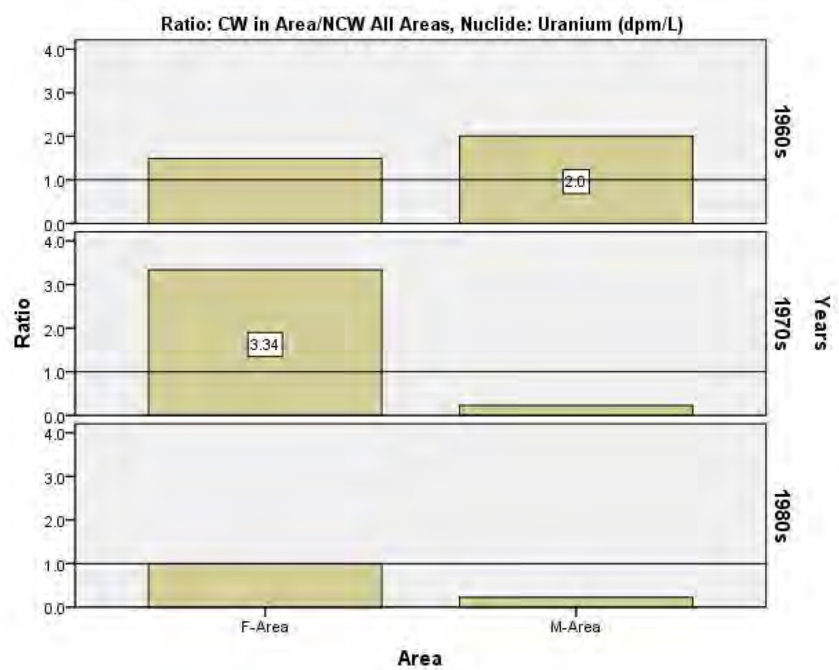

Figure 4-11: Ratio of 84th Percentile of Uranium Samples from Construction Workers (CW) in Specified Work Areas over 84th Percentile of Uranium Samples from Non-Construction Workers (NCW) in All Work Areas, by Decade

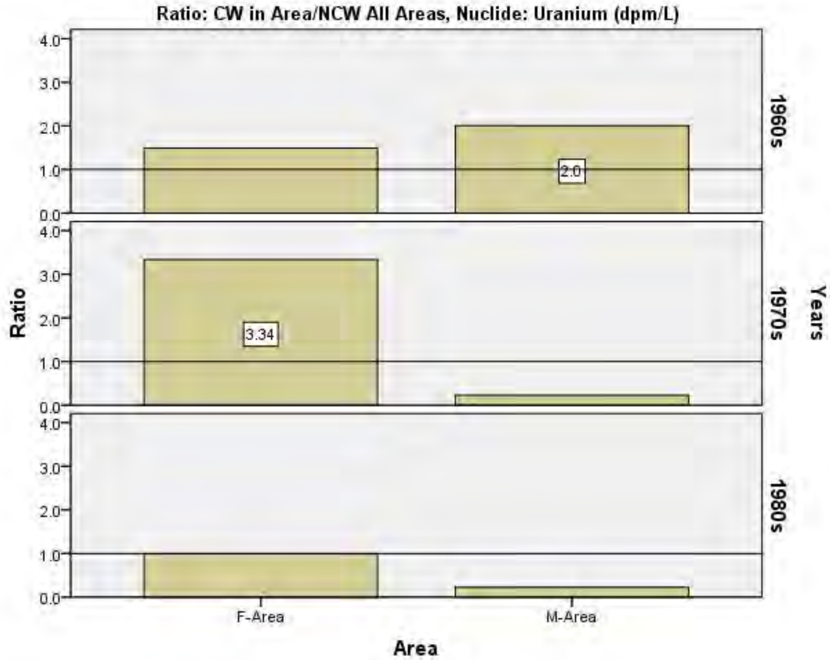

Figure 4-12: Ratio of GSD of Uranium Samples from Construction Workers (CW) in Specified Work Areas over GSD of Uranium Samples from Non-Construction Workers (NCW) in All Work Areas, by Decade

4.3 COMPARISON OF CONSTRUCTION WORKER EXPOSURES BY AREA

Table 4-5 shows the ratio of 84th percentile for construction workers in the specified work areas divided by the 84th percentile for construction workers in all work areas (first row of data in Tables B-2, B-4, B-6, B-8 and B-10). The purpose of this table is to show that sizeable differences occur between work areas for construction worker claimants if site-wide claimant data from construction workers were used to estimate missed doses. It should be noted that data for construction worker exposure to uranium, enriched uranium, and fission products are sparse, preventing the calculation of ratios in many decades. In general, the discrepancies for tritium and plutonium are found to be larger than those observed in a similar comparison for non-construction workers in Tables 4-1 and 4-2.

A plot of the tritium 84th percentile ratios in Table 4-5 comparing construction worker exposures in specific areas to aggregate exposures for construction workers over all areas is presented in Figure 4-13. The plot shows that the 84th percentile for construction worker claimants in specified work areas exceeds the 84th percentile for all construction workers in K-Area and P-Area in the 1950s. The NIOSH proposal would not be claimant favorable in these areas if the coworker model for construction workers included site-wide data from construction worker claimants.

Table 4-6 contains the ratio of the GSD for tritium samples from construction workers in the specified work area over the GSD for construction workers in all work areas. When the ratio of the GSDs exceeds 1, the distribution of samples from construction workers in the specified work area has a wider spread than the distribution for construction workers in all work areas. The GSD ratios for tritium are shown in Figure 4-14. The GSD for construction worker claimants in specified work areas exceeds the 84th percentile for all construction workers in F-Area, K-Area and P-Area in the 1950s.

A plot of the plutonium ratios in Table 4-5 comparing construction worker exposures in specific areas to aggregate exposures for construction workers over all areas is shown in Figure 4-15. The plot shows that the 84th percentile for construction worker claimants in specified work areas exceeds the 84th percentile for all construction workers in H-Area in the 1950s, 1970s, and 1980s.

Table 4-6 contains the ratio of the GSD of plutonium bioassays from construction workers in the specified work area over the GSD for construction workers in all work areas. These ratios are plotted in Figure 4-16. Most ratios are near 1, except for H-Area in the 1970s.

A plot for the ratio of the 84th percentile of uranium bioassays from construction workers in the specified work area over the 84th percentile for construction workers in all work areas combined is presented in Figure 4-17. A large ratio of the 84th percentiles is observed in F-Area in the 1980s, exceeding a factor of 4. Table 4-6 also contains the ratio of the GSD of uranium bioassays in the specified work area over the GSD in all work areas. The GSD ratios are graphed in Figure 4-18. Again, a large ratio is observed in F-Area in the 1980s, exceeding a factor of 5.

FINDING #11: At SRS, the 84th percentile of exposures to tritium and plutonium for construction workers in specific work areas show considerable differences from the 84th percentile of site-wide exposures to construction workers. Similar results are observed for the corresponding ratio of the GSDs. In many cases, there are insufficient data for construction workers to make a comparison for uranium, enriched uranium and fission products.

Table 4-5: Ratio of 84th Percentile for Construction Workers in Specified Work Areas over 84th Percentile for Construction Workers in All Work Areas

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Tritium			
C-Area	1.76	1.20	1.00	1.00	0.13	n/c
F-Area	1.96	n/c	n/c	n/c	n/c	n/c
H-Area	n/c	0.10	0.25	0.50	0.13	1.11
K-Area	2.94	0.60	1.00	1.50	1.25	n/c
L-Area	0.59	1.20	n/c	0.25	0.50	n/c
P-Area	3.53	1.20	1.00	1.10	1.50	n/c
R-Area	0.29	1.00	n/c	n/c	n/c	n/c
			Plutonium			
A-Area	n/c	1.00	1.00	0.59	n/c	n/c
F-Area	1.00	1.00	1.00	1.00	n/c	n/c
H-Area	1.35	1.00	1.85	1.20	n/c	n/c
			Uranium			
F-Area	n/c	0.74	1.67	4.43	n/c	n/c
M-Area	n/c	1.00	0.11	1.00	n/c	n/c
			Enriched Uranium			
M-Area	n/c	n/c	1.00	0.53	n/c	n/c
			Fission Products			
F-Area	n/c	1.00	n/c	1.00	n/c	n/c
H-Area	n/c	1.00	n/c	1.00	n/c	n/c

n/c: Not calculated

Table 4-6: Ratio of GSD for Construction Workers in Specified Work Areas over GSD for Construction Workers in All Work Areas

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Tritium			
C-Area	0.88	0.60	1.00	1.00	0.25	n/c
F-Area	1.96	n/c	n/c	n/c	n/c	n/c
H-Area	n/c	0.20	0.50	0.50	0.25	1.11
K-Area	1.96	1.20	1.00	1.25	1.25	n/c
L-Area	0.59	0.60	n/c	0.25	0.50	n/c
P-Area	3.53	0.60	1.00	0.69	0.50	n/c
R-Area	0.29	1.00	n/c	n/c	n/c	n/c
			Plutonium			
A-Area	n/c	1.00	1.00	0.59	n/c	n/c
F-Area	1.00	1.00	1.00	1.00	n/c	n/c
H-Area	1.35	1.00	1.85	1.20	n/c	n/c
			Uranium			
F-Area	n/c	0.74	0.38	5.01	n/c	n/c
M-Area	n/c	1.00	0.11	1.00	n/c	n/c
			Enriched Uranium			
M-Area	n/c	n/c	1.00	0.71	n/c	n/c
			Fission Products			
F-Area	n/c	1.00	n/c	1.00	n/c	n/c
H-Area	n/c	1.00	n/c	1.00	n/c	n/c

n/c: Not calculated

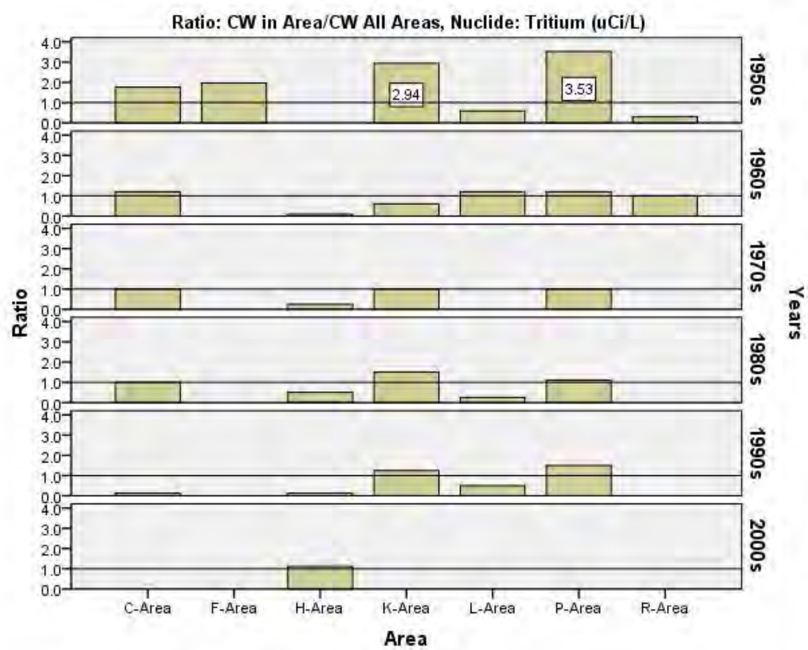

Figure 4-13: Ratio of 84th Percentile of Tritium Samples from Construction Workers (CW) in Specified Work Areas over 84th Percentile of Tritium Samples from Construction Workers in All Work Areas, by Decade

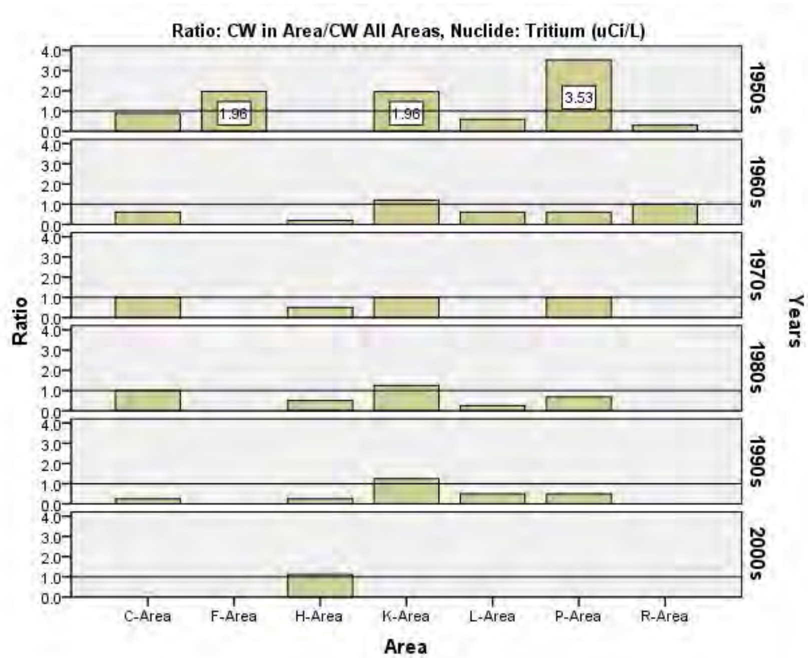

Figure 4-14: Ratio of GSD of Tritium Samples from Construction Workers (CW) in Specified Work Areas over GSD of Tritium Samples from Construction Workers in All Work Areas, by Decade

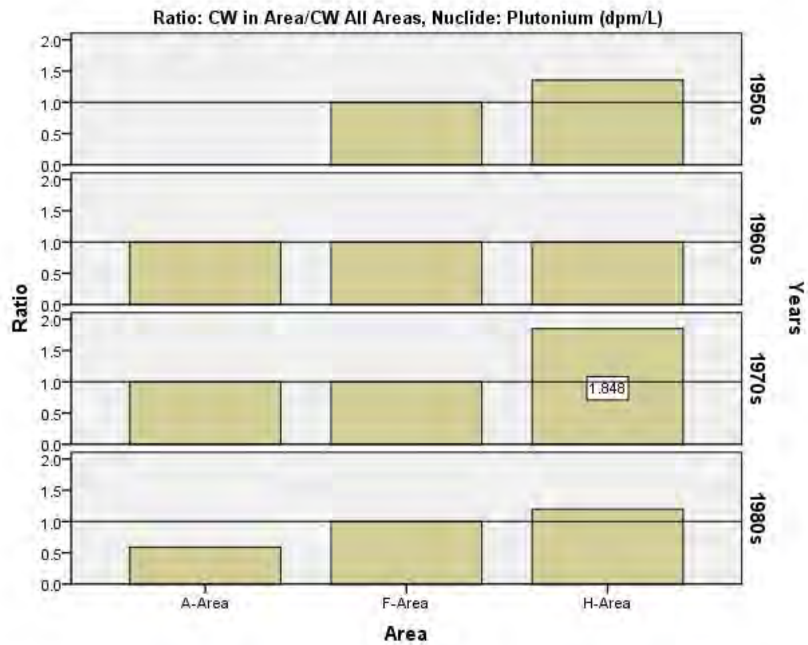

Figure 4-15: Ratio of 84th Percentile of Plutonium Samples from Construction Workers (CW) in Specified Work Areas over 84th Percentile of Plutonium Samples from Construction Workers in All Work Areas, by Decade

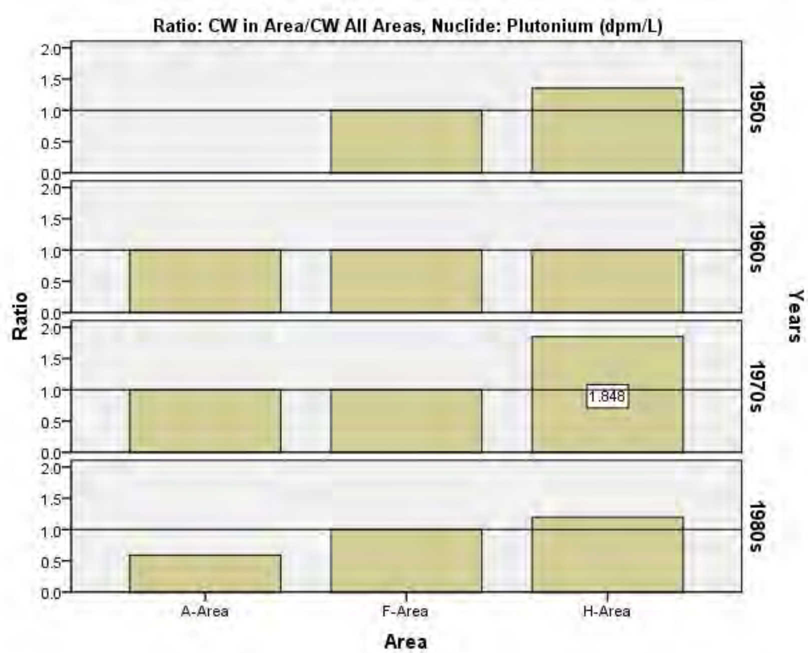

Figure 4-16: Ratio of GSD of Plutonium Samples from Construction Workers (CW) in Specified Work Areas over GSD of Plutonium Samples from Construction Workers in All Work Areas, by Decade

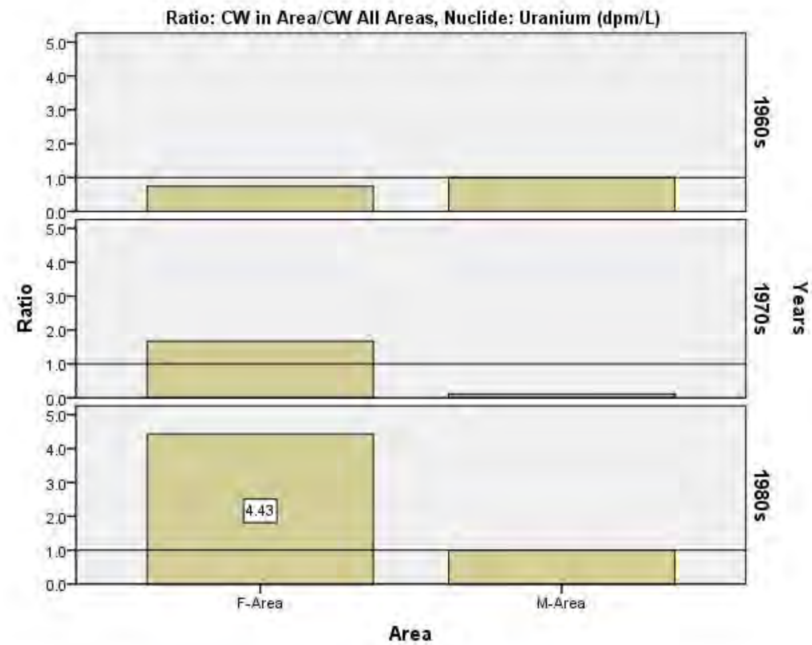

Figure 4-17: Ratio of 84th Percentile of Uranium Samples from Construction Workers (CW) in Specified Work Areas over 84th Percentile of Uranium Samples from Construction Workers in All Work Areas, by Decade

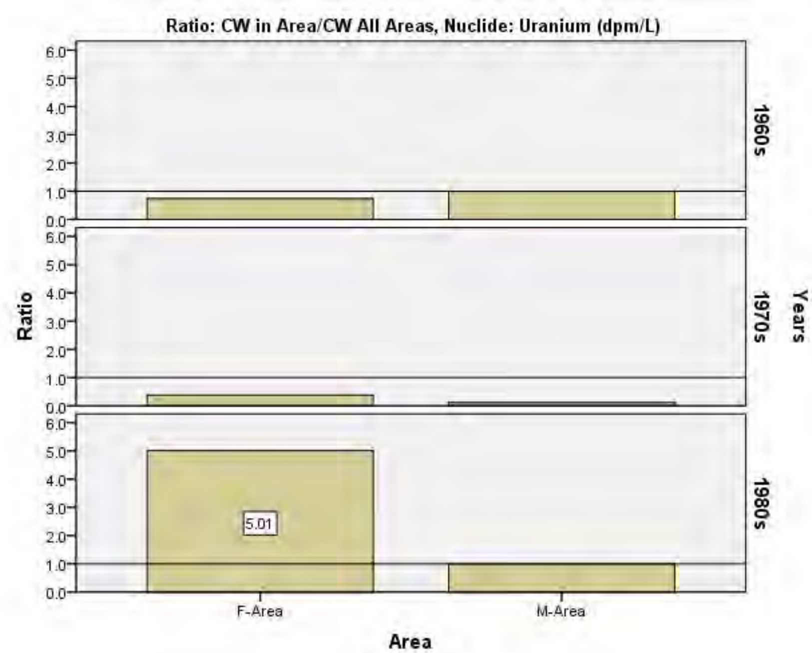

Figure 4-18: Ratio of GSD of Uranium Samples from Construction Workers (CW) in Specified Work Areas over GSD of Uranium Samples from Construction Workers in All Work Areas, by Decade

5.0 ANALYSIS OF SRS CONSTRUCTION WORKER CLAIMANT EXPOSURE BY CRAFT

In addition to the variability of construction worker and non-construction workers bioassay samples by year and work area, the bioassay samples from construction workers also vary across the construction crafts. Table 5-1 shows the ratio of 84th percentile of tritium exposure for construction workers in the specified crafts divided by the 84th percentile for construction workers in all crafts. Tritium is the radionuclide examined by NIOSH for SRS in OTIB-0075. This ratio has the same denominator that was used in Tables 4-5 and 4-6. This ratio is a measure of the differences in exposure among construction workers in different crafts. Figure 5-1 shows a bar plot of the ratios in Table 5-1. Pipefitters have higher exposures than other crafts in all but the most recent decades. However, in the 1990s and 2000s, general construction workers had higher exposures than the pipefitters.

Table 5-1: Ratio of 84th Percentile of Tritium Samples from Construction Workers in Specified Craft over 84th Percentile of Tritium Samples from Construction Workers in All Crafts

Craft	1950s	1960s	1970s	1980s	1990s	2000s
			Tritium			
Electrician	1.18	0.60	1.00	0.90	0.75	n/c
Pipefitter	1.18	1.40	2.00	1.30	1.25	0.19
Laborer	0.59	0.80	0.66	0.40	0.75	n/c
Iron Worker	1.07	0.40	n/c	n/c	0.50	n/c
Carpenter	0.59	1.00	1.00	1.00	1.00	n/c
Construction	0.29	1.20	0.50	0.60	1.75	1.15

n/c: Not calculated

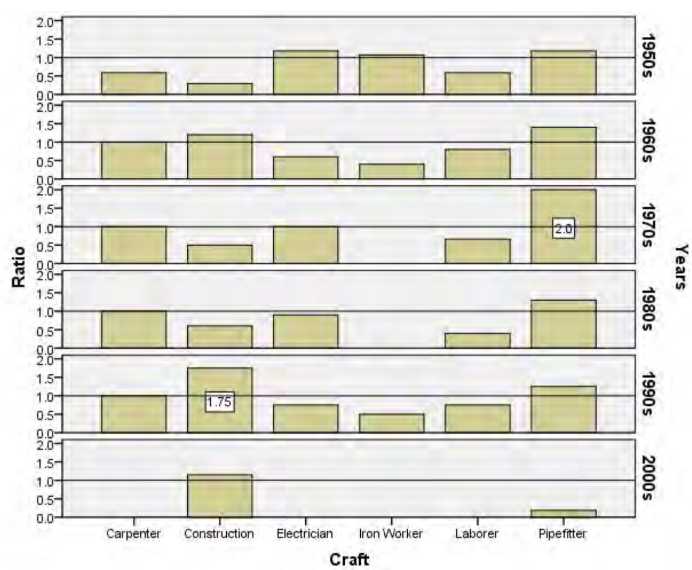

Figure 5-1: Ratio of 84th Percentile of Tritium Samples from Construction Workers in Specified Crafts over 84th Percentile of Tritium Samples from Construction Workers in All Construction Crafts, by Decade

The ratio of the GSD for tritium samples from construction workers in the specified work area over the GSD for construction workers in all work areas is shown in Table 5-2. When the ratio of the GSDs exceeds 1, the distribution of samples from construction workers in the specified craft has a wider spread than the distribution for construction workers in all crafts. The plot of the GSD ratios in Figure 5-2 is very similar to the plot in Figure 5-1. An additional high ratio is observed for carpenters in the 1990s.

Table 5-2: Ratio of GSD of Tritium Samples from Construction Workers in Specified Craft over GSD of Tritium Samples from Construction Workers in All Crafts

Craft	1950s	1960s	1970s	1980s	1990s	2000s
			Tritium			
Electrician	1.18	1.20	1.00	0.90	0.75	n/c
Pipefitter	1.18	0.70	2.00	1.08	1.25	0.19
Laborer	0.59	0.80	1.32	0.40	0.75	n/c
Iron Worker	1.07	0.80	n/c	n/c	0.50	n/c
Carpenter	0.59	0.50	1.00	1.00	2.00	n/c
Construction	0.29	0.60	1.00	0.60	1.75	0.57

n/c: Not calculated

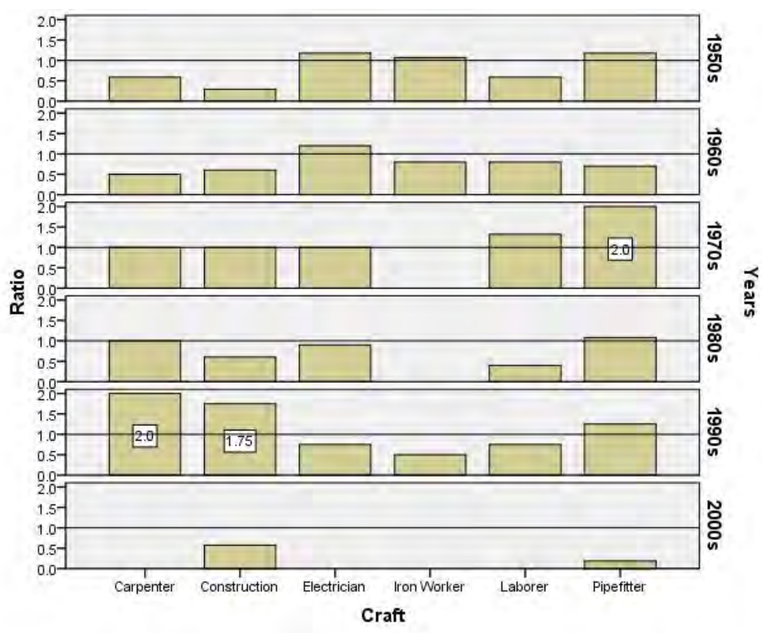

Figure 5-2: Ratio of GSD of Tritium Samples from Construction Workers in Specified Crafts over GSD of Tritium Samples from Construction Workers in All Construction Crafts, by Decade

FINDING #12: At SRS, the 84th percentiles of exposures to tritium for construction workers in specific crafts show considerable differences from the 84th percentile of exposures to all construction workers. Similar results are observed for the corresponding ratio of the GSDs.

Table 5-3 shows the ratio of 84th percentile for construction workers in the specified work area over the 84th percentile for non-construction workers in all work areas combined. This ratio has the same denominator that was used in Tables 4-3 through 4-6. This ratio measures how well site-wide non-construction worker data perform in estimating construction worker exposures in different crafts. This ratio is affected both by the differences in exposure among the construction crafts shown in Table 4-1 and the differences between construction workers and non-construction workers shown in Table 4-2.

Figure 5-3 shows a bar plot of the differences between the 84th percentiles for each construction craft and the 84th percentile derived from site-wide non-construction worker data. Included in this plot at the left is the same ratio for all construction workers combined. Differences ranging from a factor of 2 to 3 are observed for most construction crafts. The NIOSH proposal would not be claimant favorable for construction workers in these crafts if site-wide data from non-construction worker claimants were used to estimate exposures for construction workers.

Table 5-3: Ratio of 84th Percentile of Tritium Samples from Construction Workers in Specified Crafts over 84th Percentile of Tritium Samples from All Non-Construction Workers

Craft	1950s	1960s	1970s	1980s	1990s	2000s
			Tritium			
All Crafts	1.55	1.67	1.00	1.00	2.00	3.00
Electrician	1.82	1.00	1.00	0.90	1.50	n/c
Pipefitter	1.82	2.33	2.00	1.30	2.50	0.56
Laborer	0.91	1.33	0.66	0.40	1.50	n/c
Iron Worker	1.65	0.67	n/c	n/c	1.00	n/c
Carpenter	0.91	1.67	1.00	1.00	2.00	n/c
Construction	0.45	2.00	0.50	0.60	3.50	3.44

n/c: Not calculated

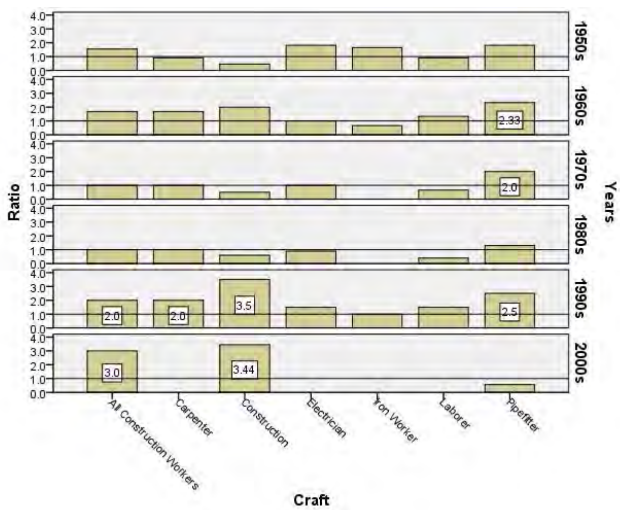

Figure 5-3: Ratio of 84th Percentile of Tritium Samples from Construction Workers in Specified Crafts over 84th Percentile of Tritium Samples from All Non-Construction Workers, by Decade

The ratio of the GSD for tritium samples from construction workers in the specified work area over the GSD for non-construction workers in all work areas is shown in Table 5-4. The plot of the GSD ratios in Figure 5-4 is very similar to Figure 5-3, but at a slightly lower level.

Table 5-4: Ratio of GSD of Tritium Samples from Construction Workers in Specified Crafts over GSD of Tritium Samples from All Non-Construction Workers

Craft	1950s	1960s	1970s	1980s	1990s	2000s
			Tritium			
All Crafts	1.55	0.83	1.00	1.00	1.00	3.00
Electrician	1.82	1.00	1.00	0.90	0.75	n/c
Pipefitter	1.82	0.58	2.00	1.08	1.25	0.56
Laborer	0.91	0.67	1.32	0.40	0.75	n/c
Iron Worker	1.65	0.67	n/c	n/c	0.50	n/c
Carpenter	0.91	0.42	1.00	1.00	2.00	n/c
Construction	0.45	0.50	1.00	0.60	1.75	1.72

n/c: Not calculated

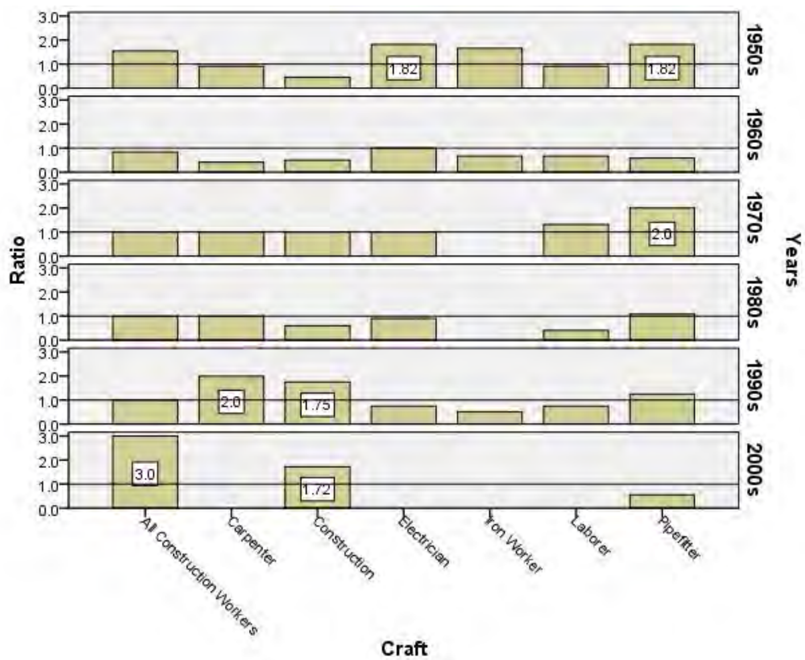

Figure 5-4: Ratio of GSD of Tritium Samples from Construction Workers in Specified Crafts over GSD of Tritium Samples from All Non-Construction Workers, by Decade

FINDING #13: At SRS, the 84th percentiles of exposures to tritium for construction workers in specific crafts show considerable differences from the 84th percentile of site-wide exposures for non-construction workers. Similar results are observed for the corresponding ratio of the GSDs.

6.0 OVERALL CONCLUSIONS

Our overall conclusions can be divided into two parts. The first relates to the hypothesis that OTIB-0075 seeks to demonstrate—that claimant data are representative of all-worker data. The second relates to the SRS construction worker SEC—whether the claimant database as compiled from NOCTS provides a satisfactory basis for a coworker model that would meet the requirements of dose reconstruction with sufficient accuracy.

6.1 CONCLUSIONS REGARDING ORAUT-OTIB-0075

We examined all three datasets in OTIB-0075. Our conclusions are as follows:

(1) The uranium dataset for Y-12 conforms to the OTIB-0075 hypothesis of claimant data representativeness.

(2) The data for Mound indicate significant differences between claimant and all-worker plutonium bioassay data.

(3) The SRS tritium data cover a very narrow period from 1990 to 2001. These data show no significant differences at the annual level of aggregation, but the sample size is very small and the regression results were dominated by a single year with high exposure, 1991. If this year is omitted, the complete and claimant datasets for annual tritium doses from the period 1992 through 2001 again show no significant differences at the annual level of aggregation.

6.2 SRS CONSTRUCTION WORKER COWORKER MODEL

Our conclusion regarding the use of the SRS NOCTS data compiled by NIOSH for use as the basis for a coworker model to demonstrate the ability to reconstruct dose with sufficient accuracy is as follows:

(1) A conclusion that the claimant data from the 1990s for tritium are representative of the claimant population can, at best, be applied to that radionuclide and that period. This conclusion cannot be back-extrapolated to other periods. Even within this period, there are differences between construction workers disaggregated by craft and non-construction workers.

(2) There are considerable differences in exposures between job types and areas, even when data are aggregated by decade. This applies to all non-construction workers, as well as construction workers, when compared to others in the same group.

(3) The data indicate that construction workers in some areas and periods had greater exposure potential than all non-construction workers.

We have not analyzed certain radionuclides, like americium, neptunium-237, curium-244, and californium-252, since NOCTS data for construction workers are too scant for an analysis.

The overall conclusion of this analysis for the SRS coworker model is that, contrary to NIOSH's proposal in its Evaluation Report (NIOSH 2008), the NOCTS claimant dataset is inadequate for dose reconstruction with sufficient accuracy for SRS construction workers. A more complete compilation of the data and analyses by area, radionuclide, and job type are necessary to determine whether dose reconstruction with sufficient accuracy is feasible for SRS construction workers.

7.0 REFERENCES

42 CFR 83. *Procedure for Designating Classes of Employees as Members of the Special Exposure Cohort under the Energy Employees Occupational Illness Compensation Program Act of 2000*. On the web at http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&tpl=/ecfrbrowse/Title42/42cfr83_main_02.tpl

Battelle 2007. *Default Assumptions and Methods for Atomic Weapons Employer Dose Reconstructions,* Rev 0. Battelle PNWD, Battelle-TIB-5000. April 2, 2007.

NIOSH 2008. *SEC Petition Evaluation Report: Petition SEC 00103*. National Institute of Occupational Safety and Health, November 14, 2008.

ORAUT-OTIB-0075. *Use of Claimant Datasets for Coworker Modeling*, Rev. 00, Oak Ridge Associated Universities Team, Cincinnati, Ohio. May 5, 2009. Cited in the text as OTIB-0075 for short.

SC&A 2009. *Issues Matrix for the Savannah River Site SEC Petition and Petition Evaluation Report*, S. Cohen & Associates, Vienna, Virginia, September 2009.

Watkins, J.P., J.L. Reagan, D.L. Cragle, E.L. Frome, C.M. West, D.J. Crawford-Brown, and W.G. Tankersley, 1993. *Data Collection, Validation, and Description for the Oak Ridge Nuclear Facilities Mortality Study*, ORISE 93/J-42, Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee. October 1993. [SRDB Ref ID:10133]

APPENDIX A: SAMPLE SIZE AND 84TH PERCENTILES OF NON-CONSTRUCTION WORKER BIO-SAMPLES

Table A-1: Number of Tritium Samples from Non-Construction Workers in Specified Work Areas

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Tritium			
All Areas	19,821	53,027	50,166	46,294	17,550	1,041
C-Area	1,611	11,505	12,113	8,141	736	[redact]
D-Area	502	1,481	1,594	2,678	823	[redact]
F-Area	422	124	68	24	69	[redact]
G-Area	[redact]	[redact]	635	91	70	[redact]
H-Area	517	13,592	16,302	11,063	7,524	691
K-Area	563	5,829	8,100	9,832	5,412	25
L-Area	967	6,072	[redact]	4,096	1,309	[redact]
M-Area	10	12	20	10	34	[redact]
P-Area	784	6,117	10,515	9,799	1,125	[redact]
R-Area	1,541	5,369	[redact]	[redact]	[redact]	[redact]
T-Area	[redact]	[redact]	[redact]	[redact]	291	[redact]
U-Area	[redact]	568	[redact]	[redact]	[redact]	[redact]
CS-Area	81	998	604	[redact]	[redact]	[redact]
BG - Background	[redact]	118	[redact]	[redact]	[redact]	[redact]
None Listed	12,338	1,078	69	489	22	266
Other	484	161	135	59	128	38

Table A-2: 84th Percentile of Tritium Samples from Non-Construction Workers in Specified Work Areas (µCi/L)

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Tritium			
All Areas	1.1	3	2	1	0.2	0.09
C-Area	6	5	2	1	0.1	n/c
D-Area	2	3	3	0.8	0.3	n/c
F-Area	4.46	0.5	n/c	n/c	n/c	n/c
G-Area	n/c	n/c	0.5	n/c	n/c	n/c
H-Area	0.5	0.5	1	0.5	0.1	0.05
K-Area	2	3	3	1.3	0.3	n/c
L-Area	2.1	5	n/c	0.25	0.1	n/c
M-Area	n/c	n/c	n/c	n/c	n/c	n/c
P-Area	4	4	2	1	0.4	n/c
R-Area	3	4	n/c	n/c	n/c	n/c
T-Area	n/c	n/c	n/c	n/c	0.05	n/c
U-Area	n/c	2	n/c	n/c	n/c	n/c
CS-Area	n/c	0.5	0.5	n/c	n/c	n/c
BG - Background	n/c	0.50	n/c	n/c	n/c	n/c

n/c: Not calculated

Table A-3: Number of Plutonium Samples from Non-Construction Workers in Specified Work Areas

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Plutonium			
All Areas	2,017	4,512	5,096	3,346	3,139	334
A-Area	174	526	619	348	46	[redact]
F-Area	965	2,557	1,732	1,215	102	[redact]
H-Area	683	1,104	1,825	748	88	[redact]
K-Area	[redact]	[redact]	43	70	[redact]	[redact]
M-Area	[redact]	41	208	60	[redact]	[redact]

Table A-4: 84th Percentile of Plutonium Samples from Non-Construction Workers in Specified Work Areas (dpm/L)

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Plutonium			
All Areas	0.02	0.02	0.27	0.03	0.03	0.02
A-Area	0.01	0.02	0.02	0.03	n/c	n/c
F-Area	0.02	0.02	0.13	0.06	0.05	n/c
H-Area	0.03	0.07	4.00	0.03	n/c	n/c
K-Area	n/c	n/c	n/c	n/c	n/c	n/c
M-Area	n/c	n/c	0.02	n/c	n/c	n/c

n/c: Not calculated

Table A-5: Number of Uranium Samples from Non-Construction Workers in Specified Work Areas

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Uranium			
All Areas	1,533	2,679	3,030	553	31	[redact]
A-Area	224	265	282	69	[redact]	[redact]
F-Area	585	1,936	1,855	292	[redact]	[redact]
H-Area	189	94	30	[redact]	[redact]	[redact]
M-Area	435	288	599	132	22	[redact]

Table A-6: 84th Percentile of Uranium Samples from Non-Construction Workers in Specified Work Areas (dpm/L)

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Uranium			
All Areas	0.24	0.25	1.67	1.67	n/c	n/c
A-Area	0.12	0.25	1.67	n/c	n/c	n/c
F-Area	0.23	0.36	1.67	1.67	n/c	n/c
H-Area	0.20	n/c	n/c	n/c	n/c	n/c
M-Area	0.30	0.25	1.67	1.67	n/c	n/c

n/c: Not calculated

Table A-7: Number of Enriched Uranium Samples from Non-Construction Workers in Specified Work Areas

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Enriched Uranium			
All Areas	18	1,170	1,639	1,244	417	[redact]
A-Area	[redact]	81	130	56	[redact]	[redact]
F-Area	[redact]	352	173	54	11	[redact]
H-Area	10	492	201	290	29	[redact]
M-Area	[redact]	216	1,003	726	32	[redact]

Table A-8: 84th Percentile of Enriched Uranium Samples from Non-Construction Workers in Specified Work Areas (dpm/L)

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Enriched Uranium			
All Areas	n/c	0.33	2.00	1.00	0.67	n/c
A-Area	n/c	n/c	0.33	n/c	n/c	n/c
F-Area	n/c	0.33	0.50	n/c	n/c	n/c
H-Area	n/c	0.33	0.33	0.67	n/c	n/c
M-Area	n/c	3.17	3.65	1.00	n/c	n/c

n/c: Not calculated

Table A-9: Number of Fission Product Samples from Non-Construction Workers in Specified Work Areas

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Fission Products			
All Areas	981	1,816	147	1,137	[redact]	[redact]
A-Area	163	274	[redact]	88	[redact]	[redact]
F-Area	452	940	22	110	[redact]	[redact]
H-Area	279	458	17	126	[redact]	[redact]
M-Area	[redact]	27	[redact]	13	[redact]	[redact]

Table A-10: 84th Percentile of Fission Product Samples from Non-Construction Workers in Specified Work Areas (dpm/L)

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Fission Products			
All Areas	20	33.33	740	740	n/c	n/c
A-Area	20	33.33	n/c	n/c	n/c	n/c
F-Area	20	33.33	n/c	740	n/c	n/c
H-Area	20	33.33	n/c	740	n/c	n/c
M-Area	n/c	n/c	n/c	n/c	n/c	n/c

n/c: Not calculated

APPENDIX B: SAMPLE SIZE AND 84TH PERCENTILES OF CONSTRUCTION WORKER BIO-SAMPLES

Table B-1: Number of Tritium Samples from Construction Workers in Specified Work Areas

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Tritium			
All Areas	1,203	6,687	1,355	4,519	3,499	61
C-Area	45	1,141	434	571	43	[redact]
F-Area	71	[redact]	[redact]	[redact]	[redact]	[redact]
H-Area	[redact]	1,087	288	419	625	35
K-Area	76	1,432	343	1,650	1,147	[redact]
L-Area	126	1,155	[redact]	957	664	[redact]
P-Area	97	1,219	273	859	956	[redact]
R-Area	91	480	[redact]	[redact]	[redact]	[redact]
None Listed	598	70	[redact]	27	[redact]	16
Other	93	98	[redact]	31	58	[redact]

Table B-2: 84th Percentile of Tritium Samples from Construction Workers in Specified Work Areas (µCi/L)

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Tritium			
All Areas	1.7	5	2	1	0.4	0.27
C-Area	3	6	2	1	0.05	n/c
F-Area	3.34	n/c	n/c	n/c	n/c	n/c
H-Area	n/c	0.5	0.5	0.5	0.05	0.3
K-Area	5	3	2	1.5	0.5	n/c
L-Area	1	6	n/c	0.25	0.2	n/c
P-Area	6	6	2	1.1	0.6	n/c
R-Area	0.50	5	n/c	n/c	n/c	n/c

n/c: Not calculated

Table B-3: Number of Plutonium Samples from Construction Workers in Specified Work Areas

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Plutonium			
All Areas	47	201	161	398	489	44
A-Area	[redact]	17	44	13	[redact]	[redact]
F-Area	25	69	53	112	[redact]	[redact]
H-Area	11	28	27	63	[redact]	[redact]
CS-Area	[redact]	46	15	38	12	[redact]

Table B-4: 84th Percentile of Plutonium Samples from Construction Workers in Specified Work Areas (dpm/L)

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Plutonium			
All Areas	0.02	0.03	0.03	0.06	0.03	0.02
A-Area	n/c	0.03	0.03	0.03	n/c	n/c
F-Area	0.02	0.03	0.03	0.06	n/c	n/c
H-Area	0.02	0.03	0.06	0.07	n/c	n/c
CS-Area	n/c	0.03	0.03	0.07	0.11	n/c

n/c: Not calculated

Table B-5: Number of Uranium Samples from Construction Workers in Specified Work Areas

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Uranium			
All Areas	26	39	111	61	[redact]	[redact]
A-Area	[redact]	[redact]	[redact]	[redact]	[redact]	[redact]
F-Area	[redact]	14	61	13	[redact]	[redact]
H-Area	[redact]	[redact]	[redact]	[redact]	[redact]	[redact]
M-Area	10	21	48	44	[redact]	[redact]

Table B-6: 84th Percentile of Uranium Samples from Construction Workers in Specified Work Areas (dpm/L)

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Uranium			
All Areas	0.18	0.50	3.33	0.38	n/c	n/c
A-Area	n/c	n/c	n/c	n/c	n/c	n/c
F-Area	n/c	0.37	5.56	1.67	n/c	n/c
H-Area	n/c	n/c	n/c	n/c	n/c	n/c
M-Area	n/c	0.50	0.38	0.38	n/c	n/c

n/c: Not calculated

Table B-7: Number of Enriched Uranium Samples from Construction Workers in Specified Work Areas

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Enriched Uranium			
All Areas	[redact]	[redact]	22	49	95	[redact]
A-Area	[redact]	[redact]	[redact]	[redact]	[redact]	[redact]
F-Area	[redact]	[redact]	[redact]	[redact]	[redact]	[redact]
H-Area	[redact]	[redact]	[redact]	[redact]	[redact]	[redact]
M-Area	[redact]	[redact]	15	33	[redact]	[redact]

Table B-8: 84th Percentile of Enriched Uranium Samples from Construction Workers in Specified Work Areas (dpm/L)

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Enriched Uranium			
All Areas	n/c	n/c	0.33	1.80	0.67	n/c
A-Area	n/c	n/c	n/c	n/c	n/c	n/c
F-Area	n/c	n/c	n/c	n/c	n/c	n/c
H-Area	n/c	n/c	n/c	n/c	n/c	n/c
M-Area	n/c	n/c	0.33	0.96	n/c	n/c

n/c: Not calculated

Table B-9: Number of Fission Product Samples from Construction Workers in Specified Work Areas

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Fission Products			
All Areas	19	70	17	327	[redact]	[redact]
A-Area	[redact]	[redact]	[redact]	11	[redact]	[redact]
F-Area	[redact]	35	[redact]	60	[redact]	[redact]
H-Area	[redact]	19	[redact]	48	[redact]	[redact]
M-Area	[redact]	[redact]	[redact]	10	[redact]	[redact]

Table B-10: 84th Percentile of Fission Product Samples from Construction Workers in Specified Work Areas (dpm/L)

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Fission Products			
All Areas	25.88	25.00	740	652.54	n/c	n/c
A-Area	n/c	n/c	n/c	740	n/c	n/c
F-Area	n/c	26.63	n/c	649.53	n/c	n/c
H-Area	n/c	22.29	n/c	577.46	n/c	n/c
M-Area	n/c	n/c	n/c	n/c	n/c	n/c

n/c: Not calculated

APPENDIX C: SAMPLE SIZE AND 84TH PERCENTILES OF CONSTRUCTION WORKER TRITIUM BIO-SAMPLES BY CRAFT

Table C-1: Number of Tritium Samples from Construction Workers in Specified Construction Crafts

Craft	1950s	1960s	1970s	1980s	1990s	2000s
			Tritium			
All Crafts	1,203	6,687	1,355	4,519	3,499	61
Electrician	377	2,591	771	1,386	1,096	[redact]
Pipefitter	266	1,645	238	1,301	1,256	34
Laborer	90	448	24	316	268	[redact]
Iron Worker	33	406	[redact]	[redact]	137	[redact]
Carpenter	35	523	98	647	132	[redact]
Construction	402	1,074	215	863	610	26

Table C-2: 84th Percentile of Tritium Samples from Construction Workers in Specified Construction Crafts (µCi/L)

Work Area	1950s	1960s	1970s	1980s	1990s	2000s
			Tritium			
All Crafts	1.7	5	2	1	0.4	0.27
Electrician	2	3	2	0.9	0.3	n/c
Pipefitter	2	7	4	1.3	0.5	0.05
Laborer	1	4	1.32	0.4	0.3	n/c
Iron Worker	1.82	2	n/c	n/c	0.2	n/c
Carpenter	1	5	2	1	0.4	n/c
Construction	0.50	6	1.00	0.60	0.70	0.31

n/c: Not calculated