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8.0 DATA COMPLETENESS EVALUATION

The Advisory Board's criteria for evaluation of SEC petitions include several that relate to the data underlying dose reconstruction (ABRWH, January 2006).[1] These criteria fall under the general rubric of the "credibility and validity of the dataset." The intent of these criteria relates to NIOSH's ability to perform dose reconstructions:

> *For each petition evaluation, NIOSH will typically review the available exposure data for that site and then focus on a few key sets of exposure data (including exposure sources) to determine if those data at that site are adequate for completing individual dose reconstructions for all members of the class.* [ABRWH, January 2006]

The Board elaborated on the meaning of the term "credibility and validity of the dataset" by specifying the following criteria:

- "*1. Pedigree of the Data" This includes determining* ".the relation of the exposure monitoring to documented activities at the site during that time period" and ensuring that "secondary sources of data …are consistent with the original data set…."
- "*2. Methodology*" This includes an evaluation of "*the documented methodology for the data set including whether reliable corrective estimation procedures have been applied and are appropriate*."
- "*3. Relation to Other Sources of Information" This includes a demonstration that "the data are appropriate for… estimating the maximum plausible dose for any member of the class*."
- "*4. Internal Consistency*" of the dataset.
- "*5. Representativeness" of the dataset including considerations of the various periods, areas, types of work and processes, source terms, and adequacy of data to be "representative of the highest exposed individuals within the class*."

[1] Report of the Working Group on Special Exposure Cohort Evaluation, draft dated January 16, 2006, approved by the Board at its January 24-26, 2006 meeting in Oak Ridge, TN.

The procedures approved by the Board for its contractor in evaluating SEC petitions and in reviewing NIOSH's Evaluation Reports on SEC petitions also involve an investigation of the completeness of the internal and external dose datasets that NIOSH proposes to use for dose reconstruction for any member of the class. (SC&A June 12, 2006, p. 24).[2]

The review of NIOSH's Evaluation Report by the Board's Working Group and the Board's involved detailed investigations of various aspects of the credibility and validity of the dataset. NIOSH also did a considerable amount of work investigating the issue in the process.

Initial inquiries focused on the completeness of the HIS-20 electronic database and its relationship to the underlying data. Comparison of the database with information in logbooks and claimant files revealed that the HIS-20 database was not complete and that workers whose employment ended prior to 1977 may not be represented in it. Another database, the CER database, was also found to be incomplete. NIOSH, in response, stated that it would rely on individual dose records in DOE files as the principal source of data for individual dose reconstruction and on the HIS-20 electronic database for co-worker models. As a result, the issue of the completeness of the data in the DOE files arose, since that is the primary data on which NIOSH is relying for individual dose reconstruction. This section examines the issue of the completeness of individual dose data as reflected in Rocky Flats claimant files.

This completeness investigation was necessitated by the fact that there is no complete compilation of dosimetry data that reflects essentially all the data in the DOE files. Gaps in data – that is, periods when there were no measurements whatsoever – indicate a need for methods to fill those gaps. These gaps are essentially different from zeros in the data records that reflect measurements below the detectable limit that can be filled in various ways, including by using the Limit of Detection (LoD) or LoD/2 or some value in between. Co-worker models may be needed if gaps are significant or if whole groups of workers were not monitored at certain facilities or in certain periods or both.

SC&A conducted a broad investigation of the completeness of Rocky Flats external and internal monitoring data in claimants' DOE files, using minimal criteria for completeness, to ascertain whether substantial gaps that needed to be filled in exist. This broad investigation is to be distinguished from a more detailed evaluation that would, for instance, involve a review of each badging cycle for external dose.

SC&A conducted two types of completeness evaluations. The first was to examine external and internal dose data in DOE responses in the records of 32 randomly selected claimants. The second consisted of examining the DOE responses in the records of 20 claimants that were judged by Rocky Flats in the 1990s to have high cumulative radiation doses. The randomly selected cases allow a picture to be developed about the general extent of the gaps in Rocky Flats worker records. This investigation does not tell us why those gaps exist. It only alerts one to their existence and approximate extent. An examination of the records of claimants with high cumulative exposures allows a preliminary view of whether there is a basis to fill in the gaps in

[2] SC&A, *Board Procedures for Review of Special Exposure Cohort Petitions and Petition Evaluation Reports,* June 12, 2006.

dosimetry data in the rest of the workers population, should such gaps be found to exist. In each case, the investigation of gaps related to the data that are in DOE files for a particular claimant. SC&A also did a preliminary evaluation of the job records of the 20 claimants with high cumulative exposures in order to ascertain whether a pattern existed for certain gaps in the external dose records. This evaluation does not cover external dose gaps in 1969, which are discussed under a separate heading.

The 32 random claims were selected in three waves. An initial set of 4 was chosen from among Rocky Flats dose reconstructions already audited by SC&A. These were among the cases randomly selected by NIOSH and presented to the Board, which selected the cases from across the weapons complex to be audited. The next eight (Wave 2) were obtained by picking the first Rocky Flats case with more than five years from 1-999 claimant numbers on the NIOSH R Drive, then one from the 1,000 to 1,999 group, one from the 2,000 to 2,999 group, until there were a total of 8 cases. A preliminary analysis was conducted to determine whether the gaps indicated were sufficient to warrant a further inquiry. Finally, the last 20 (Wave 3) were selected using a randomized search procedure, with the added limitations that:

- Two periods, 1951-1963 and 1964-1992, be represented among those selected so that they could be studied separately. This is because Rocky Flats integrated its security and film badge in that year. This made the earlier period a statistically different distribution – and indeed, data on the fraction of workers monitored in the first period indicate a fairly steady increase with the years from start-up through the early 1960s. The data show a sudden jump in the fraction of employees badged in 1964. See Table 8.1, which is taken from a NIOSH paper on Rocky Flats badging practices, which is reproduced, in full, in Attachment 27.
- Each claimant file selected represents a claimant who worked at Rocky Flats for at least five years.
- The sampling was done without regard to whether dose reconstruction had been completed or not. Only files pulled by NIOSH from the dose reconstruction process (17 out of 1,165) were excluded from the sampling.

The sampling procedure for selecting the 20 cases is described in Attachment 28.

The total of 32 cases was designed to provide a reliable picture of the gaps in Rocky Flats workers' DOE records. Table 8.1, which catalogs the proportion of workers badged at Rocky Flats, by year, shows that we should expect larger gaps in the 1951-1963 period for external dose than in the 1964-1992 period. Note that the frequency of monitoring declined again beginning in 1992. This was the year that production ended and the transition to decommissioning of Rocky Flats began. Decommissioning was formally started in 1993.

Table 8.1. Percent Badged.

Year	Badged	Year	Badged	Year	Badged	Year	Badged	Year	Badged	Year	Badged
1951		1961	77%	1971	94%	1981	96%	1991	91%	2001	73%
1952	5%	1962	78%	1972	94%	1982	96%	1992	82%	2002	72%
1953	33%	1963	75%	1973	94%	1983	97%	1993	80%	2003	56%
1954	34%	1964	93%	1974	98%	1984	96%	1994	65%	2004	40%

1955	43%	1965	93%	1975	97%	1985	98%	1995	65%	2005	25%
1956	53%	1966	96%	1976	96%	1986	97%	1996	67%		
1957	61%	1967	95%	1977	97%	1987	98%	1997	79%		
1958	63%	1968	91%	1978	98%	1988	98%	1998	83%		
1959	63%	1969	74%	1979	98%	1989	98%	1999	83%		
1960	71%	1970	90%	1980	97%	1990	96%	2000	80%		
Source: ORAU analysis of RFP claimant files											

Source: NIOSH paper *Badging Practices at Rocky Flats*, no date, transmitted to SC&A on December 7, 2006.

Figure 8.1 shows the data in Table 8.0 in graphical form.

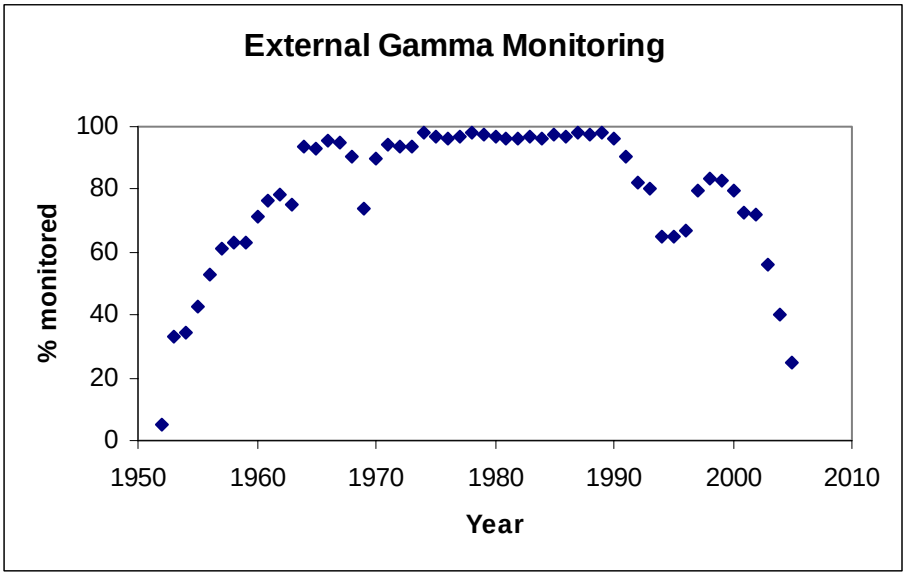

Figure 8.1: Proportion of workers monitored for external dose at Rocky Flats
Source: NIOSH paper *Badging Practices at Rocky Flats*, no date, transmitted to SC&A on December 7, 2006.

The DOE dose records of the 32 claimants were divided into two periods, 1951-1963 and 1964 to 1992. This is to account for the fact that a combined ID and film badge was issued in 1964, which resulted in almost all workers being badged (but not all – see below). In addition, separate tables were created for external dose (deep gamma) and internal dose. If, in any year, there were no external dose records at all (even zeros), but only blanks, that year was counted as a gap in external dose data. (The term "gap" is used equivalently to mean a blank in the records or no measurement indicated in the record. It does not include zeros in the record, which are counted as measurements at less than the limit of detection.) Note that counting a year as one that has data does not affirm that there are complete data within that year – that is, it does not make a statement one way or another whether there is a record for each badge cycle. Similarly, for internal dose data, a year counted as a gap in the data is one in which there was no bioassay (urine or fecal) record and no in vivo count. If there was a data point for any one of these categories in a given year, it was not counted as a year without data. Gaps for partial years at the start of employment and at the end of employment were not counted. (The initial and final year data were rounded to zero, half year or full year as follows: – 0 to 2 months = zero, 3 to 8 months = half year, nine months or more = full year). SC&A also compiled cumulative data on the data gaps. In these cumulative compilations partial initial and final years were counted according to the rounding scheme described.

In addition to the analysis of 32 cases randomly selected, a sample of 20 cases from among those judged in the 1990s to have the highest cumulative doses (internal committed dose equivalent plus external deep dose) was examined to assess completeness of records for those workers. The exposure assessment was carried out by ORAU in the 1990s as a retrospective. This part of the completeness evaluation has particular relevance for development of co-worker models.[3]

8.1 EXTERNAL DOSE – RANDOM SAMPLE

Table 8.2 shows the analysis for the external dose records for the 32 claimants in the random sample.

Table 8.2: Rocky Flats External Dose Data Completeness Analysis – Random Samples

Period	#of workers	# with gap of 1 yr or more (Note 1)	% workers with gaps of 1 yr or more (Note 1)	Cumulative years employed	Cumulative gap -- years	% cumulative gap
1951-1963	14	4	29%	76.5	16.0	21%
1964-1992	30	10 (Note 2)	33%	368	37.0 (Note 3)	10%

Notes: 1. First or last partial year gaps not counted in this column.
2. Of the 10 employees with gaps of one year or more in 1964-1992, four had gaps only in 1992
3. 1969 gaps data may be for part of the year or the full year. 1969 data gaps are not counted as full year gaps in this compilation. The 1969 issue is briefly addressed below and more fully elsewhere in this report.
4. A gap is recorded for the year if there are no film badge or TLD data at all for that year. Zero entries are counted as positive indications of recorded data. Only blank records are included in the compilation of the gaps.

The percentage cumulative gap in the external dose data was greater in the 1951-1963 period than in the 1964-1992 period. This result confirms the data compilation by NIOSH presented in Table 8.1 above, which shows that a significant proportion of workers were not badged in early period. The proportion of badged workers went from 5% in 1952 to a high of 78% in 1962. Overall, about 21% of the cumulative years worked by the 14 employees had no external dose records (partial years counted as 0 or 0.5 years, as noted above).

The proportion of workers with at least a one-year gap was about the same in the two periods (about 30%). However, the high value for the latter period is largely due to the transition year of 1992. Four of the ten workers with a gap of at least one year had a gap only in 1992. An investigation into job types may yield insight into the reasons. If one leaves out these four, 20% of the workers with a gap of at least one year in their external dose records. As noted, this analysis does not include partial year gaps. It just requires that one record be present in a given year for that year to be excluded from the compilation of data gaps. It is therefore a minimal criterion of completeness for external dose data. Issues related to dose reconstruction are discussed in the section on highly exposed workers.

[3] The detailed compilations of the claimant data are not included in this draft report. They may contain Privacy Act information. They spreadsheets have been sent to the CDC for evaluation as to Privacy-Act-related content.

We found several records with gaps for all or part of 1969. This also reflects the cumulative data compilation of monitoring frequency provided by NIOSH and discussed above. However, a specific problem appears to affect 1969 external dose data. In that year, Rocky Flats management decided not to read the film badges of workers on a three-month badge cycle. This was stated in the March 1969 monthly Status report:

> *Quarterly badges for the non-Pu areas will no longer e read routinely, except for a few higher dose risk groups. The film will be changed as usual, but will not be read unless circumstances warrant.* [Piltingsrud 1969][4]

It is not clear whether and when this policy was rescinded. Not reading film badges that were issued and then handed in appears to SC&A to be a questionable practice and even apparently surprised NIOSH/ORAU consultant and Rocky Flats dose expert Roger Falk (see Attachment 29, for the notes of SC&A's interview with him).

SC&A notes here that there was also a problem of blank external dosimetry records before 1969 and after the start of the integration of the ID badge and the film badge in 1964; it continued after 1970. For instance, one of the workers in the random sample of 32 had external dosimetry gaps (blanks) from 1963 to 1973 (inclusive). Despite the universal badging policy supposedly in effect at the time due to the integrated ID-film badge, NIOSH stated that he/she was not issued a badge (November 6, 2006 Working Group meeting transcript, pp. 76-79). It is not clear how NIOSH differentiated this from non-reading of issued badges. In any case, this practice likely relates to workers judged to not to have high exposure potential; it could create complications for some groups of workers for estimating dose (see discussion below and in the analysis of the 1969 external dose records).

8.2 RANDOM SAMPLE – INTERNAL DOSE

Table 8.3 shows the summary data for the 32-claimant random sample for internal dose data.

Table 8.3: Rocky Flats Internal Dose Data Completeness Analysis – Random Samples (Note 1)

Period	#of workers	# with gap of 1 yr or more (Note 2)	% workers with gaps of 1 yr or more (Note 2)	Cumulative years employed	Cumulative gap -- years	% cumulative gap
1951-1963	14	4	29%	76.5	9.0	12%
1964-1992	30	22	73%	368.0	122.5	33%

Notes: 1. A gap for a full year is recorded if there are no bioassay data (urine or fecal) and if there are no in vivo data. A single measurement in any of these categories is counted as a year with data. This approach cannot be directly related to dose reconstruction feasibility but provides a modest test of data availability for internal dose.
2. First or last partial year gaps data not counted in this column.

[4] C.W. Piltingsrud, *Status Report – Dosimetry – March 1969*, April 8, 1969.

Surprisingly, nearly three-fourths of the workers in the random sample had at least one year of no internal dose measurements in the 1964-92 period, though the total cumulative working years with no internal dose records was about one-third. There were smaller internal dose measurement gaps in the early period. The issues raised by these gaps as they concern internal dose reconstruction are discussed in the section on highly exposed workers.

8.3 SAMPLE OF HIGHLY EXPOSED WORKERS

As noted, SC&A also analyzed the DOE files of 20 Rocky Flats claimants who were assessed as having high cumulative exposure in a retrospective analysis done in the 1990s. That analysis categorized workers into groups, numbers "1" through "4", with "1" representing the lowest cumulative exposures (CDE internal plus external and "4" representing the highest exposures). SC&A chose 10 claimants from Group 4 and 10 from Group 3 for analysis. The selection was made as follows. SC&A asked NIOSH to provide the full lists of claimants in Group 3 and Group 4. NIOSH provided a list of 22 Group 4 claimants. SC&A selected the first five and last five from this list. For Group 3, NIOSH sent a list of 35 claimant numbers. SC&A selected approximately every third one from this list until it had a total of 10.

There were no full-year gaps in internal dose data for this group of 20 workers. This applies to both periods. The early period includes 63 cumulative years of employment in the 1950s. On the face of it, there would appear to be a sound database for beginning an analysis of the feasibility of one or more co-worker model for all members of the class through 1992. SC&A has not performed such an analysis. However, SC&A recommends that the analysis should include a review of the data related to workers with high cumulative exposure. This would allow NIOSH to examine the job types represented to determine if they include all the ones with high internal exposure potential relative to the various source terms present at Rocky Flats, or if the exposures for the job types that are represented bound those that are not represented for various periods where production operations changed, or other factors, such as materials brought in or processed, changed. Further, it is important to verify whether the available data are sufficient to reconstruct doses due to incidents, especially when exposure was to materials of high or medium solubility. Specifically, in view of the large proportion of workers (nearly three-fourths) in the random sample who had a gap of at least one year in their internal dose records, it is essential that an analysis of job types of Group 3 and Group 4 workers be done relative to the workers who have gaps in their data, before a co-worker model can be deemed to be suitably claimant favorable.

The picture regarding external dose is somewhat different. There are essentially full-year gaps in external dose data records for this group of 20 claimants from 1960 onward. However, there are considerable gaps for the 1951-1959 period, notably for claimants in Group 3. Specifically, about 62% of the cumulative employment years for Group 3 workers were lacking any external dose data in this period; the total for Group 4 was 19%. Most of the gaps relate to the initial years of employment.

The gaps in the 1950s most likely reflect the partial external dose monitoring for Rocky Flats workers, discussed above. SC&A sought an explanation for these gaps from Roger Falk, during an interview with him as a site expert, and he responded as follows:

> *They may have started work in a non-radiation area or in a lower job classification. Rocky Flats was a coveted place to work. What I have observed and known to have happened was that anyone would apply for a low-level job, such as Janitor, and work their way up into better positions as he proved himself. I don't know if it happened in the cases that you looked at.* [Attachment 29]

SC&A did a preliminary analysis of the job cards of both Group 3 and Group 4 workers in order to determine whether any pattern emerged in a screening analysis. It appears that most of the full-year data gaps in the 1950s are associated with work in Production Plant B, where uranium (DU and EU) was processed. There were also some gaps in Building 81, the QC lab, and the "pipe shop." There were no full-year gaps external dose data (as defined above) in Production Plant C, where plutonium was processed. SC&A confirmed Dr. Falk's observation that many workers started as janitors or laborers and worked their way up. However, the progression was rather rapid, and the data gaps do not relate mainly to the period of employment in non-radiological jobs. On the contrary, they are mainly in the years when the employees in question were in radiological areas, mainly in Production Plant B. A review of the job cards therefore provides a reasonable explanation for the gaps in the data. The remaining question relates to the relationship of the gaps to creating a co-worker model.

Uranium-238 has a much higher potential for shallow dose than plutonium-239/240, due to the beta-emitting decay products of uranium-238 -- thorium-234 and protactinium-234m. Further, uranium foundry operations resulted in separation of these two decay products, which flowed to the surface of the uranium. In those operations, beta dose rates was as high as 2,000 to 3,000 mrad/hour on castings of DU in the early years, which is an order of magnitude higher than equilibrium contact beta dose from uranium metal (Putzier 1982, pp. 74-75 of the pdf file). Contamination of workplace surfaces with dust high in Th-234 and Pa-234m could result in very high and non-uniform skin doses. Since shallow dose measurements from later years may not be reflective of early radiological conditions, it may be difficult to use later data to retrospectively estimate shallow dose or even deep dose for uranium workers. Concentrated, non-equilibrium areas of contamination with Th-234 and Pa-234m not shielded by massive uranium metal could also lead to higher deep exposure rates from the various gamma photons associated with these radionuclides (131 KeV, 1.9 Mev, 63 KeV, 92 Kev). One way of approaching the problem would be to examine whether there are sufficient data from the non-plutonium areas in the periods of high exposure potential (such as the early period) that would allow the creation of a co-worker model that would meet the test of 42 CFR 83 for dose reconstruction sufficient accuracy.

The possible use of data from plutonium areas for co-worker models could also be investigated. However, it cannot be assumed a priori that those areas exceeded the dose to workers in the uranium foundry or similar work areas in all periods. We note in this context that, according to NIOSH, americium-241 was not present in appreciable amounts in plutonium at Rocky Flats in the 1950s (see Chapter 6 on Internal Dose, sections on Other Radionuclides). Am-241 was presumably the main source of external gamma dose in the plutonium areas in Rocky Flats. On the other hand, early plutonium buttons from Savannah River Site had high surface contamination with fission products leading to high external dose rates in some areas in the initial period of receipts from SRS (Putzier 1982). In view of these facts, a comparative analysis

of the external exposure potential in Production Plant B compared to Production Plant C is necessary before data from the latter can be applied to shallow or deep gamma dose to fill the data gaps in worker external dose records.

Finding regarding external dose co-worker model for the 1950s: Significant gaps in external dose data for the 1950s were identified, as discussed above. The main issues therefore center on the nature of the gaps in relation to monitored workers and whether they can be filled by appropriate dose reconstruction procedures or coworker models. The gaps appear to be associated with work in non-plutonium areas. A comparative analysis along the lines suggested above is needed for the 1950s in order to determine whether the available data are adequate to yield a scientifically robust, claimant favorable co-worker model for the 1950s. NIOSH has not made the type of detailed analysis that would be needed to establish the feasibility of filling in the data gaps for all workers in the class, including workers such as uranium foundry workers in the 1950s. Lacking such an analysis, SC&A cannot come to a definitive conclusion regarding the feasibility of dose reconstruction with sufficient accuracy for all members of the class for external dose, notably beta dose. This is not to say that it cannot be done, but that it will require considerable work to demonstrate it. (The data gaps in 1969 are analyzed elsewhere in this report.)

Conclusion regarding internal dose co-worker model: Since the internal dose data for highly exposed workers do not show annual gaps, it is likely that the gaps in internal dose can be filled by one or more suitable co-worker models designed to appropriately reflect job types and periods of employment.

8.4 OTHER ISSUES REGARDING COMPLETENESS OF DOSE DATA

During the Working Group's deliberations, NIOSH stated that subcontractors were not necessarily badged even in the period when the ID badge and film badged were integrated into one device. The data provided by NIOSH and quoted above confirms that the proportion of monitored workers did not reach 100 percent at any time, but stayed a few percent below that throughout the period of production. Subcontractor workers, as with any RFP workers in the 1964-1991 period, were required to be monitored when they entered radiological areas. (Working Group meeting transcript, pp. 74-78).

Conclusion regarding unbadged subcontractor workers: While NIOSH has provided no documentation to confirm that the requirements for subcontractor workers to be badged when they entered radiological areas were uniformly followed, SC&A has found no evidence to the contrary. Specifically, we have not found any systemic violation of the policy that would have resulted in unbadged subcontractor workers going into areas with radiological exposure potential. The NIOSH statement was made at the Working Group meeting during a discussion of the dose record of a prime contractor worker who had an 11-year external dose gap. Ten years of that – 1964-1973 (inclusive) – was in the universal badging period after 1964 when the ID and film badges were integrated into a single device. SC&A also notes that between 1964 and 1991, the proportion of unbadged workers was small in almost all years (less than 10 percent and generally in the 2% to 6% range – see Table 8.1 above). Some verification of enforcement

would be desirable to ensure that unbadged subcontractors did not work in radiological areas. One possible verification procedure might relate to clean up after fires, such as those in 1965 and 1969. An investigation of the problem of not issuing badges to prime contractor workers not thought to have exposure potential or not reading issued badges is also needed to characterize their exposure potential (see separate discussion of the increase in zero external dose entries in 1969).

Overall conclusions regarding completeness

SC&A has carried out an extensive analysis of the issue of completeness of dosimetry data in DOE files, which are stated by NIOSH to be the primary basis for dose reconstruction for individual claimants. This included a random sample of 32 claimant files and a selected sample of 20 files of claimants who were assessed by Rocky Flats in the 1990s to have high cumulative exposure (external plus CDE internal). This investigation has provided SC&A with the basis to come to some firm conclusions about some aspects of the gaps in Rocky Flats data. The caveat "some" is related to the fact that we used minimal completeness criteria – it required a gap in measurements for a full year for that year to be included in the incomplete-year total. Intra-year gaps were not considered; nor were the data evaluated according to radionuclide source terms. Our overall conclusions for the period 1951-1992 are as follows:

- There are substantial gaps in external dose data for the 1950s. The investigation of the high cumulative exposure cases indicates that these gaps are likely related to work in Plant B and some other areas not related to plutonium processing facilities. It might be possible to fill in the gaps using data from Rocky Flats and other sites (for uranium external shallow and deep dose), provided that additional analysis as regards claimant favorability relating to actual working conditions is carried out. However, no firm conclusion is possible at the present time since NIOSH has not done the requisite analysis, including, for instance, about the shallow dose exposure conditions in uranium foundry operations in the 1950s.
- There are large gaps in internal dose data, notably for the 1964-1992 period, during which almost three-fourths of the workers had gaps of at least one year in internal dose measurements. About one-third of the cumulative years of employment had no measurements in the 1964-1992 period. These observations relate to the random sample.
- The bioassay data for the highly exposed workers have essentially no gaps for full years. Since the internal dose data for highly exposed workers do not show annual gaps in any period to 1992, it is likely that the gaps in internal dose can be filled by one or more suitable co-worker models designed to appropriately reflect job types and periods of employment.