MEMORANDUM

TO: Metals and Controls Corporation Work Group
FROM: SC&A, Inc.
DATE: September 17, 2018
SUBJECT: Response to NIOSH White Paper on M&C dated April 23, 2018

Introduction

This memorandum presents SC&A's review of the National Institute for Occupational Safety and Health (NIOSH) white paper, *Metals and Controls Corp. Subsurface Exposure Model*, dated April 23, 2018. Since this is a review of a white paper addressing subjects intended to support Advisory Board on Radiation and Worker Health (Advisory Board) deliberations regarding the granting or denial of a Special Exposure Cohort (SEC) petition, as opposed to a site profile review, the main questions addressed in this review emphasize whether there are scientifically sound and claimant-favorable data and information that can be used to support an SEC determination, and not whether the specific scientific methods and assumptions employed can be improved. These subjects are generally reserved for site profile reviews and entail a much more detailed analysis of the models and assumptions and the specific data used as input to the models. Nevertheless, where feasible, this report also addresses what is often referred to as site profile issues.

SC&A agrees with the description of the material provided in the paper's introduction, including the summary of the results of the worker interviews conducted on October 24–26, 2017, and the description of the November 8, 2017, teleconference. It is noteworthy that the Introduction refers to newly found monitoring data obtained on February 6, 2018, and February 13, 2018, that was collected by Creative Pollution Solutions (CPS) in the early to mid-1990s in support of characterizing the radiological condition at the facility prior to initiating and during site remediation. These data are directly applicable to the characterization of the subsurface environment in the 1990s and are being used in support of dose reconstructions associated with M&C maintenance and refurbishment activities during the residual period. SC&A reviewed these data and confirmed that we also made use of these data to assess their usefulness and applicability. As discussed in more detail below, although we believe that the data can be used to reconstruct subsurface exposures to Metals and Controls Corporation (M&C) workers, we do not agree with the methods and assumption used in the white paper to reconstruct these doses.

Inside Building 10

Evidence suggests that in Building 10 portions of the concrete floors were removed, subsurface gravel and dirt were removed, and maintenance and repurposing activities periodically took

place during the residual period. Some of this work involved cutting and replacing subsurface drainage lines and conduits, handling subsurface soil, and removing debris clogging the subsurface lines, primarily by "snaking" the lines.

In September 1995, a radiological survey of the subsurface drains in the affected areas of Buildings 4 and 10 was performed to determine the concentrations, distribution, and inventory of uranium present in the drainage system as a result of historical nuclear materials processing (Weston 1996). SC&A reviewed the NIOSH model of subsurface areas below Building 10 that specifically focuses on the subsurface drain lines. Although the white paper references use of soil samples, the 44 samples used in the modeling are volumetric samples taken from inside the pipes. This material is better characterized as sludge or sediment. Soil samples would be inappropriate to use in this instance because the integrity of the pipes was compromised, and thus removal of the pipes, or snaking of pipes, would result in the material inside of the pipes becoming exposed and potentially airborne.

SC&A reviewed the NIOSH modeling file and found that NIOSH accurately calculated the geometric mean of the pipe samples to be 147.12 picocuries per gram (pCi/g) and a geometric standard deviation of 7.68. However, SC&A does not believe this value is appropriate to use for the modeling of subsurface material intakes.

The pipe samples were taken in 1995. The drainage pipe system under Building 10 does not represent a closed system; i.e., the materials in the pipes at the time of sampling is not entirely representative of the materials that were there at the end of operations. A major theme that emerged throughout the interviews was that the pipes under the building would frequently back up and require attention to unclog them. Some instances required the pipes to be snaked, which would result in some materials being removed from the pipe. In other instances, the pipes would need to be physically replaced. These actions reduced the quantity of materials in the remaining pipes and, thus, source term that was available to be sampled in the 1990s. The pipes that would require these actions were likely the pipes with the most material in them and are potentially the most contaminated areas. The geometric mean of the pipe sampling results does not reasonably bound potential exposures to subsurface workers.

Total uranium concentrations in the subsurface pipes in Building 10 ranged from 9.75 pCi/g to 53,224.7 pCi/g. The highest value was taken from "location 1" which consisted of two pipes and was the basis for the remediation recommendation by Weston:

> *During pilot investigations, high readings from the pipe feed line were noted and the pipe was excavated and removed to the main lines. The 4-inch CI and 4-inch VC pipes were opened; a small rod (5 inches long and 1/2-inch in diameter) was removed. Significant sediment buildup was identified. The sediment blocked at least 90 percent of the CI pipe and 50 percent of the VC pipe. This sediment was sampled and shipped for isotopic uranium analysis. It should be noted that these findings were the basis for the WESTON recommendation to perform drain line characterization prior to full-scale remediation activities.* [Weston 1996, p. 10]

The location 1 pipe sample represents the hottest sample from any remediation work done on site and is more than 4 times higher than the next highest sample anywhere on site. No other fuel pieces were found on site during remediation. The second highest pipe reading represents the upper 95th percentile of total uranium in the pipes, 5,878.1 pCi/g. This sample was taken from "location 6," which was down gradient from "location 1."

SC&A notes that selection of a percentile from the sampling to use in modeling is a site profile issue rather than an SEC issue.

Recommendation 1: NIOSH should consider a more bounding concentration of uranium in soil for the purpose of reconstructing internal exposures to M&C workers involved in subsurface activities beneath Building 10.

Part of this section of the white paper refers to air sampling data collected by Weston during cleanup activities in the 1990s, which reveals that the inhalation doses to these workers were about 20 mrem/quarter committed effective dose equivalent. We presume that this value establishes a benchmark that might have applicability to exposure experienced by M&C workers involved in subsurface activities earlier in the residual period. SC&A elected not to draw upon the dosimetry data collected in support of cleanup work because all the work was performed under the direction of a formal radiological health and safety program, and, as stated by the petitioners, these data may not be representative of exposures experienced by M&C workers because their work was not performed under a radiological safety program and the workers were not aware that they might have been working in radioactively contaminated areas.

Areas Outside of Building 10

This section of the white paper describes contamination levels and potential exposures in outdoor areas in the vicinity of Building 10, the waste disposal area in the vicinity of Building 12, and other outdoor areas as collected by contractor personnel in 1994 and the early years of the 1990s. SC&A reviewed the same source documents cited in the white paper. On May 1, 2018, SC&A received the Excel data file documenting the NIOSH calculation. In reviewing this file, SC&A identified a potential problem with the calculation and asked for clarification from NIOSH. On May 2, 2018, NIOSH agreed there was an error in the calculation and modified the supporting file. This change affected the outside uranium results in the white paper and caused the geometric mean to change from 53.52 to 50.68 pCi/g on page 5, and the air concentration on page 8 to change from 1.18E-14 to 1.11E-14 microcuries per milliliter (µCi/ml).

Using these values as a starting point, SC&A consulted the source documents used in the calculation. SC&A found that rather the 292 samples cited in the white paper, significantly more data were used in the assessment. Due to the limitations of working with historical data that were not gathered specifically for this analysis, it appears NIOSH had to take various steps to standardize data generated from various sources in order to complete its analysis. SC&A has the following observations concerning the data and their use:

- The values from CPS 1993, page 21, and Sowell 1985 (SRDB 94371) pages 69 and 90, represent single samples rather than average values like the rest of the aggregated data.

The single CPS 1993 value comes from discussion of the maximum value in text. No measurement records could be located to support the value.

- SC&A questions why Table 4 and Table 11 values from Sowell 1985 (SRDB 94371) were not used in the assessment. The samples represent surface soil sampling from the Building 12 burial area and areas outside Building 10, respectively. Other surface samples were used in the analysis from similar locations.
- The values used in the modeling from Site Research Database (SRDB) 165968 (CPS n.d., pp. 7–20) represent diluted averages. NIOSH took the arithmetic average of total uranium (pCi/g) at each depth of the grid location and then took the arithmetic average of each depth in that grid location to come up with an average of the averages. An example of this calculation technique is shown below. These values were then input into the main outdoor model where they are further aggregated by a geometric mean. Although this aggregation technique results in a modestly lower dose, depending on the location it is not mathematically defensible.

Example Calculation Derived from SRDB 165968, PDF page 10

Figure 1. Sample of Subsurface Soil Sample Grid Cell Averages (SRDB 165968, PDF p. 10)

Sub-Surface Soil Sample Grid Cell Averages
Metals Recovery Area Excavation

GRID LOCATION	SAMPLE LOCATION	SAMPLE I.D.	SAMPLE RESULTS (pCi/g Total Uranium) 0'-1'	1'-2'	2'-3'	3'-4'	4'-6'	6'-8'	8'-10'
60Nx210W		B5-126	258	2	2				
		B5-124	30	2	2	17			
		B5-125	163	33	2	63			
		B5-342	273	273	74	74			
		B5-122	307	149	18				
		B5-120	79	96	15				
		AVERAGE	185	93	19	51			

NIOSH method:

$$\frac{\Sigma(Averages)}{number\ of\ averages} = (185 + 93 + 19 + 61)/4 = 358/4 = 87$$

Standard Arithmetic Mean:

$$\frac{\Sigma(sample\ values)}{number\ of\ samples} = (258 + 30 + 163 + 273 + 307 + 79 + 2 + 2 + 33 + 273 + 149 + 96 + 2 + 2 + 2 + 74 + 18 + 15 + 17 + 63 + 74)/21 = 1932/21 = 92$$

The current model that uses averages obtained by various averaging methods in combination with single measurements requires modification. SC&A suggest a more mathematically valid

approach would be to model a distribution of all samples and an additional model where only averages are available, and then compare the model distributions.

With respect to the sources used to support the analysis, SC&A believes there is sufficient documentation to establish a bounding distribution of radiological materials found in the soils in and around the burial ground on site.

Bounding Exposure Model

This section of the white paper presents the methods used to reconstruct internal doses to M&C workers involved in subsurface activities during the residual period using the surrogate data described above. Since SC&A gathered and reviewed the same data and worker interview notes, the only question that remains is whether we believe that doses can be reconstructed in a scientifically sound and claimant favorable manner and, if so, whether NIOSH has performed dose reconstructions that we believe to be appropriate for the exposure scenarios and pathway of concern.

Occupancy

One of the issues addressed in this section of the white paper is occupancy times; i.e., the number of hours each year that a given worker might be involved in subsurface activities both inside and outside Building 10. Based on the interview notes and direct participation in the interviews, NIOSH believes that the collective amount of time workers were performing subsurface activity in Building 10 during a given year was about 1 month. NIOSH also indicates that subsurface workers will also receive assigned residual exposures for the remaining 11 months of each year at the same rate as the other workers that did not perform subsurface work. The petitioner expressed concerns at the August 23, 2018, Advisory Board meeting that this occupancy factor may not capture the full breadth of subsurface work because during the interviews, the 1 month was given as an estimate on the total time the floor in Building 10 was disturbed. According to the petitioner, this quantity does not reflect times the subsurface pipes were snaked to resolve blockages. According to the petitioner, those instances resulted in exposure to subsurface materials without breaching the concrete floor of the building.

SC&A agrees that there is considerable uncertainty in this value. There is ample evidence from the interviews that many different people were involved in subsurface work in any given year and, therefore, it is unlikely that any single individual was involved in all subsurface activities. Hence, we believe that the approach used by NIOSH with respect to the 1 month-per-year assumption may benefit from further Work Group deliberation. Further exploration of occupancy fractions in Building 10 and the outside areas is a site profile rather than SEC issue.

Dust Loading

A large portion of the white paper is dedicated to evaluating the airborne dust loading that subsurface workers might have experienced. The white paper draws from a number of source documents to select a scientifically sound and claimant-favorable dust loading for use in these calculations. The white paper gives a default value of 100 micrograms/m^3 as suggested in

ORAUT-OTIB-0070, Revision 01 (NIOSH 2012), and NUREG/CR-5512, Volume 1 (NRC 1992). However, the white paper explains that this value may not be entirely applicable to M&C activities because the M&C activities were more episodic than the activities addressed in ORAUT-OTIB-0070 and NUREG/CR-5512 and likely involved higher dust loading than the more chronic exposure scenarios.

The white paper also cites dust-loading measurements collected during the Mound Plant Canal Cleanup project (Taulbee 2018), and as depicted in Figure 1 of the white paper. The white paper then evaluates the Mound data against the Advisory Board's surrogate data criteria and concludes that the Mound data satisfy those criteria. On this basis, NIOSH calculated a mean dust loading of 7.18E-5 g/m^3 (71.8 micrograms/m^3) and a 95th percentile value of 2.2E-4 g/m^3 (222 micrograms/m^3). The mean value was less than the of 100 micrograms/m^3 previously determined to be insufficient for this application, so NIOSH selected the 95th percentile value for use in the white paper. On this basis, NIOSH's selection of the default dust loading appears to be justified.

To further evaluate the merits of the dust loading calculated by NIOSH, SC&A compared the 222 micrograms/m^3 value in the white paper to the dust loading values SC&A selected in its review of the SEC petition evaluation report (ER) (SC&A 2018). SC&A selected a dust loading of 200 micrograms/m^3 for its assessment of the internal doses to M&C subsurface workers in Building 10. A detailed discussion of the data and basis for this section is provided in Appendix D of SC&A's review of the SEC petition ER. Hence, there is substantial agreement between the dust loading used in the white paper and those used by SC&A in its review of the SEC petition ER.

Inhalation Rate

The white paper does not refer to inhalation rate. According to the interviews, much of the subsurface work was done by hand, indicating that the breathing rate was likely elevated, compared to the standard breathing rate of 1.2 m^3 per hour used in most dose reconstructions. As a claimant-favorable assumption, SC&A's petition ER review used a breathing rate of 2.5 m^3/h, which is the recommended breathing rate for adult males engaging in moderate activities, including "*heavy indoor cleanup* [and] *performance of major indoor repairs and alterations*" in the U.S. Environmental Protection Agency (EPA) *Exposure Factors Handbook* (1997). Although it is unlikely that any individual respired at this rate during the entirety of their subsurface work, this rate bounds potential intakes.

Recommendation 2: NIOSH should consider adopting an inhalation rate commensurate with elevated breathing rates induced by physical exertion while individuals are involved with subsurface work.

Ingestion

The white paper cites an ingestion rate of 50 mg/workday based on material in Section 6.3.2 of NUREG/CR-5512, Volume 1. SC&A reviewed this section of NUREG/CR-5512 and found that the 50 mg/day value comes from a literature search that identified a 1990 study by Calabrese et

al. that found conservative adult soil ingestions in *residential* scenario are 50 mg/day. NUREG/CR-5512, Volume 1 (NRC 1992, p. 6.14) also states:

> *To estimate the potential radiation doses resulting from secondary ingestion, adult renovation workers are assumed to ingest 10 mg of loose surface contamination per hour of exposure. Workers during routine building occupancy are assumed to ingest surface loose contamination at a lesser rate because of the general reduction of removable surface contamination in the building.*

This value is inconsistent with the value of 50 mg/day NIOSH used in the white paper. The difference appears to be the assumption of working conditions. Therefore, this subject requires further discussion.

External Exposures

The white paper continues to make use of film badge data collected during the Atomic Weapons Employer period as the basis for reconstructing external exposures during the residual period. SC&A notes that the SEC petition ER already intends to use the 1967 dosimetry data at *the 95th percentile* plus accommodations for potential missed dose for production workers. The proposed model in the white paper for subsurface workers assigning one third of the *quarterly GM* of the 1967 results to account for one month of subsurface work will effectively reduce the dose assigned to subsurface workers in comparison to other production workers. This is unacceptable, given the additional exposure risks for subsurface workers. Neither model takes source term depletion into account.

SC&A has remaining concerns (SC&A 2018, Observation 5) about the appropriateness of using operational dosimetry to represent the residual period.

References

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