OREGON STATE UNIVERSITY

An Investigation of Resuspension Factors During the Decommissioning, Decontamination, and Demolition of a U.S. Department of Energy Facility

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Talk Outline

- Study Objective
- Resuspension Factor Primer
- Research Question and Hypothesis
- Hanford Building 233-S background
- Methods
  - Resuspension Factor Modeling
- Results
- Conclusions

Study Objective

- Investigate and evaluate resuspension factors during the demolition of Hanford Building 233-S, using historical lapel and grab air sample data coupled temporally and spatially with loose surface contamination data.

Resuspension Factor – estimating airborne radioactivity from removable surface contamination.

- The resuspension factor is the ratio of airborne activity concentration to surface contamination in the residual units of m^{-1}
- Many limitations . . .,
- But easy to use
- Building 233-S RP use a $1\times10^{-5}m^{-1}$ RF to estimate airborne radioactivity during work planning.

$$f_{\text{resusp}}\left(\text{m}^{-1}\right)=\frac{C_{\text{air}}\left(\text{Bq m}^{-3}\right)}{C_{\text{surf}}\left(\text{Bq m}^{-2}\right)}$$

$$C_{air}\,(\text{Bq m}^{-3}) = C_{surface}\,(\text{Bq m}^{-2})\times f_{\text{resusp}}(\text{m}^{-1})$$

Research Question and Hypothesis

- Question. Does the resuspension factor used by the Hanford Building 233-S radiological engineer accurately estimate the airborne radioactivity from loose surface contamination during demolition activities?
  - Null Hypothesis (Ho): The resuspension factor at Building 223 $= 1 \times 10^{-5}\,\mathrm{m}^{-1}$
  - Alternative Hypothesis (Ha): The resuspension factor at Building 223 $\neq 1 \times 10^{-5}\,\mathrm{m}^{-1}$

Hanford Building 233-S

- Overview
  - Operated from 1952 – 1967
  - Further concentrated extracted plutonium after initial separation from fuel.
  - Wide spread, high levels of surface contamination including ^{237}Np, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, and ^{241}Am.
  - Demolition began in 1997.

Work Activities and RP at 233-S

- Work activities at the facility include:
  - mechanical cutting, drilling, maintenance, and occasional jack hammering.
  - Resuspension of surface contamination during demolition activities is a BIG concern.
- Air monitoring
  - All workers don lapel air samplers and a comprehensive CAM and grab air sample program is in place.

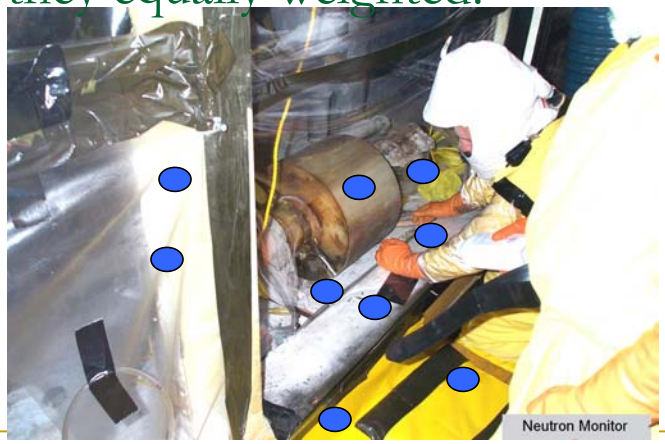
Methods

- Twenty lapel and twenty grab air samples (n=40) were randomly selected from years 1999 – 2001.
- Air samples were temporally and spatially matched surface contamination surveys, with site RP assistance.
- Calculate resuspension factors . . .

Challenges Calculating Resuspension Factors

- The surface contamination values from historical operational survey records can be highly variable.
- One distribution of surface contamination values for a single air sample ranged from 50 to 17,100,000 dpm/100 cm^2. A geometric standard deviation (GSD) of 92. Huge variability.
- Do we give equal weight to survey smears taken in cleaner areas, or should we give more weight to smears with higher activity? Intuitively, we would expect areas with higher activity to contribute more to airborne radioactivity.
- Too much weight given to low activity smears can result in high resuspension factors.

Which smears contribute to resuspension? Which proportion? Are they equally weighted?



A new approach to modeling surface contamination for RF calculations.

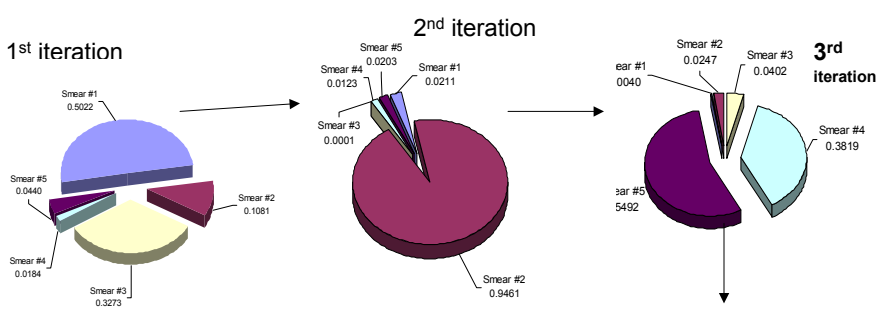
$$f_{\text{resusp}}\left(\text{m}^{-1}\right) = \frac{C_{\text{air}}\left(\text{Bq m}^{-3}\right)}{\sum C_{\text{surf}}\left(\text{Bq m}^{-2}\right) * wt}$$

Instead of an average contamination value for N smears, each ith smear is weighted (*wt)* by a random proportional contribution to airborne RA, then the sum of proportional contributions for N smears is used in the RF calculation. Repeated 10,000 times. Results in a distribution of RFs for each air sample.

- Assume U(i) is the ith random number drawn from [0,1).
- Calculate (1/[1-U(i)])-1 for each of the N variables, then summing them, and normalizing by dividing each by the sum.
- Multiply each ith proportion to ith surface contamination data point for the proportional contribution to airborne radioactivity.

Example.

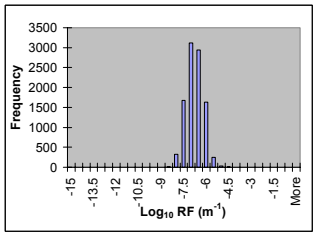
- Generate random proportional contributions of 5 smear data points to airborne radioactivity via a 10,000 iteration Monte Carlo simulation



Do this 9,997 more times . . .

… Results in a Log_{10} Transformed Distribution With Reasonable Symmetry.

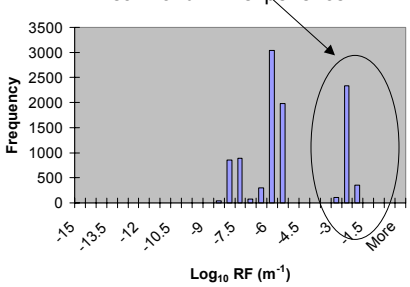
- Mean = -7.01 $\left(9.8\times10^{-8}m^{-1}\right)$
- SD = 0.57
- Median = -7.02



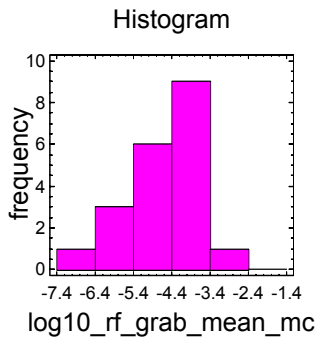
Compared to . . .

- The Log_{10} transformed distribution calculated with discrete equivalent contributions of surface contamination data to airborne radioactivity.
- Mean = -5.49 $\left(3.2\times10^{-6}m^{-1}\right)$
- SD = 1.90
- Median = -6.03

Low activity smears are equally weighted to high activity smears and drive larger RFs ~ counterintuitive to "real world' RP experience.

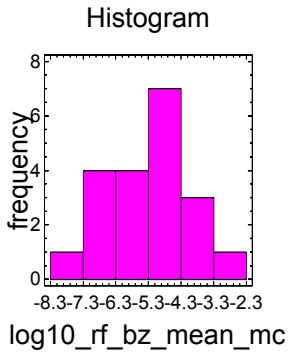


Results – 233-S Grab Air Sample Resuspension Factor



- N = 20
- Mean = $2.3\times10^{-4}\,m^{-1}$
- Standard Error = $1.5\times10^{-4}\,m^{-1}$
- Median = $4.0\times10^{-5}\,m^{-1}$
- Minimum = $8.4\times10^{-8}\,m^{-1}$
- Maximum = $3.1\times10^{-3}\,m^{-1}$
- H_o = $1.0\times10^{-5}\,m^{-1}$
- *p*-value = 0.10
  - Stat test on $\log_{10}$ transformed data
- Fail to reject H_o at 0.05 α

Results – 233-S Breathing Zone Air Sample Resuspension Factor



- N = 20
  - 8 of 20 lapel air samples < *DL* because of low air volume collected.
- Mean = $5.0\times10^{-5}\,m^{-1}$
- Standard Error = $2.6\times10^{-5}\,m^{-1}$
- Median = $6.2\times10^{-6}\,m^{-1}$
- Minimum = $1.0\times10^{-8}\,m^{-1}$
- Maximum = $5.2\times10^{-4}\,m^{-1}$
- H_o = $1.0\times10^{-5}\,m^{-1}$
- *p*-value = 0.24
  - Stat test on $\log_{10}$ transformed data
- Fail to reject H_o at 0.05 α

Conclusions

- The $1\times10^{-5}m^{-1}$ resuspension factor used operationally at 233-S is a reasonable estimate.
- The 8 out of 20 < *DL* breathing zone air samples was undesirable. This was probably due to the low volume of air collected by lapel air samplers and thus they are not recommended as a method to evaluate resuspension factors form historical data.
- Surface contamination data can be wildly variable. The random proportional contribution method presented in this paper can reduce variability and give more weight to the higher activity smears' contribution to airborne radioactivity.

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