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# **Five-Year ALARA Review of Dosimetry Results, 1 January 2008 through 31 December 2012**

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# **Five-Year ALARA Review of Dosimetry Results**

## **1 January 2008 through 31 December 2012**

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### **Abstract**

A review of personnel dosimetry (external and internal) and environmental monitoring results from 1 January 2008 through 31 December 2012 performed at Sandia National Laboratories, New Mexico was conducted to demonstrate that radiation protection methods used are compliant with regulatory limits and conform with the ALARA philosophy. ALARA is the philosophical approach to radiation protection by managing and controlling radiation exposures (individual and collective) to the work force and to the general public to levels that are As Low As is Reasonably Achievable taking social, technical, economic, practical, and public policy considerations into account. ALARA is not a dose limit but a process which has the objective of attaining doses as far below applicable dose limits As Low As is Reasonably Achievable.



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## CONTENTS

1. Introduction.....	8
1.1. Methods and Materials.....	8
2. Results and Discussion .....	10
3. Conclusion .....	16
4. References.....	18
Distribution .....	20

## FIGURES

Figure 1. Five-year trend of average individual Total Effective Dose (TED) measurements (i.e., $\geq 0.010$ rem) and collective TED. Average individual TED measurements are in blue and collective TED in green. Trend lines with corresponding equations for the line and correlation coefficients are shown in blue and green for individual TED measurements and collective TED measurements, respectively. ....	11
Figure 2. Histogram of Individual Total Effective Dose Measurements at SNL/NM for the monitoring period starting 1 January 2008 and ending 31 December 2012.....	12
Figure 3. Average Annual Environmental TLD measurement for the monitoring period starting 1 January 1991 and ending 31 December 2012. Error bars represent the 1-sigma sample standard deviation of measurements collected. The red dotted line represents the 0.100 rem public dose limit and the green dotted line represents the expected annual exposure from background and medical exposures (NCRP 160). ....	15

## TABLES

Table 1 Summary Descriptive Statistics for SNL Personnel Dosimetry Reported Results for Calendar Years 2008 through 2012 .....	10
Table 2 – Distribution of Personnel Participating in the Dosimetry Program at Sandia National Laboratories as well as Collective Dose as a Function of Division during the 2012 Calendar Year .....	13
Table 3 – Descriptive Statistics of Annual Environmental TLD Measurements Obtained on and around Sandia National Laboratories, New Mexico from 1 January 2008 through 31 December 2012.....	14

## **NOMENCLATURE**

ACL	Administrative Control Level
ALARA	As Low As is Reasonably Achievable
DOE	Department of Energy
DOELAP	DOE Laboratory Accreditation Program
RPDP	Radiation Protection Dosimetry Project
SNL	Sandia National Laboratories
SNL/NM	Sandia National Laboratories, New Mexico
TED	Total Effective Dose
TLD	Thermoluminescent Dosimeter

# 1. INTRODUCTION

ALARA is a philosophical approach to radiation protection by managing and controlling radiation exposures (individual and collective) to the work force and to the general public to levels that are As Low As is Reasonably Achievable taking social, technical, economic, practical, and public policy considerations into account. ALARA is not a dose limit but a process which has the objective of attaining doses as far below applicable dose limits As Low As is Reasonably Achievable [10 CFR 835.2].

This report documents a review of personnel dosimetry (external and internal) and environmental monitoring results for the five-year period starting 1 January 2008 through 31 December 2012 performed at Sandia National Laboratories, New Mexico (SNL/NM) by the Radiation Protection Safety Committee, ALARA Subcommittee. Results demonstrate that radiation protection methods used at SNL are compliant with regulatory limits and the ALARA philosophy.

## 1.1. Methods and Materials

The dosimetry program at SNL/NM is administered by the Radiation Protection Dosimetry Project (RPDP, Department 04121) using procedures maintained by RPDP. The dosimetry program is accredited by the DOE Laboratory Accreditation Program (DOELAP). Dose measurements reported for the period starting 1 January 2008 and ending 31 December 2012 were reviewed and data were reduced using MS Excel<sup>1</sup> spreadsheets to generate summary descriptive statistics (i.e., mean or arithmetic average, median, standard deviation, minimum and maximum Total Effective Dose (TED) measured). Individual measurements were compared to applicable regulatory limits and SNL-specific Administrative Control Levels (ACLs). Also, data were plotted with respect to time to identify potential adverse trends.

Environmental Programs (Department 04143) conducts environmental monitoring at SNL/NM. Environmental radiation exposures are measured using Thermoluminescent Dosimeters (TLDs) placed at locations on and around property controlled by SNL/NM and readily accessible to individuals with access to SNL/NM. TLDs were placed for approximately 90-days (i.e., a calendar quarter) and measured radiation exposure for the entire time that the TLD is deployed (i.e., 8,760 hours per year). Data reduction was performed using MS Excel spreadsheets to generate summary descriptive statistics (i.e., mean or arithmetic average, median, standard deviation, minimum effective dose and maximum effective dose measured) for the period between 1 January 2008 and 31 December 2012. Monitoring data were plotted over time using a MS Excel spreadsheet for the period 1 January 1991 through 31 December 2012 to provide historical perspective. Data were reviewed to ensure that radiation doses measured at generally accessible locations on SNL-controlled property in and surrounding areas were not in excess of public limits.

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<sup>1</sup> Microsoft® Excel® 2010 (version 14.0.6112.5000), Part of Microsoft Office Professional Plus 2010, copyright 2010



## 2. RESULTS AND DISCUSSION

During the 2012 calendar year, 2,313 individuals participated in the SNL/NM radiation dosimetry monitoring program. The majority of the TED measurements were reported as “zero” corresponding to less than or equal to the detection capability of the dosimeter used (i.e., 0.010 rem) with 102 individuals with annual reportable TED measurements. Most (99.7%) of the annual TED measurements were less than 0.100 rem. A small fraction of annual TED measurements (6 individuals or 0.3% of those monitored) were in excess of 0.100 rem and all were less than 0.500 rem. Five of these individuals were involved with Auxiliary Hot Cell activities at Tech Area 5 and one individual provided radiation protection support to activities at Tech Area 4. No one exceeded his or her applicable Administrative Control Level. Summary descriptive statistics for the same measurements are shown for the period between 1 January 2008 and 31 December 2012 in **Table 1**. To provide perspective, collective TED measurements (in person-rem) for the same period of time are included.

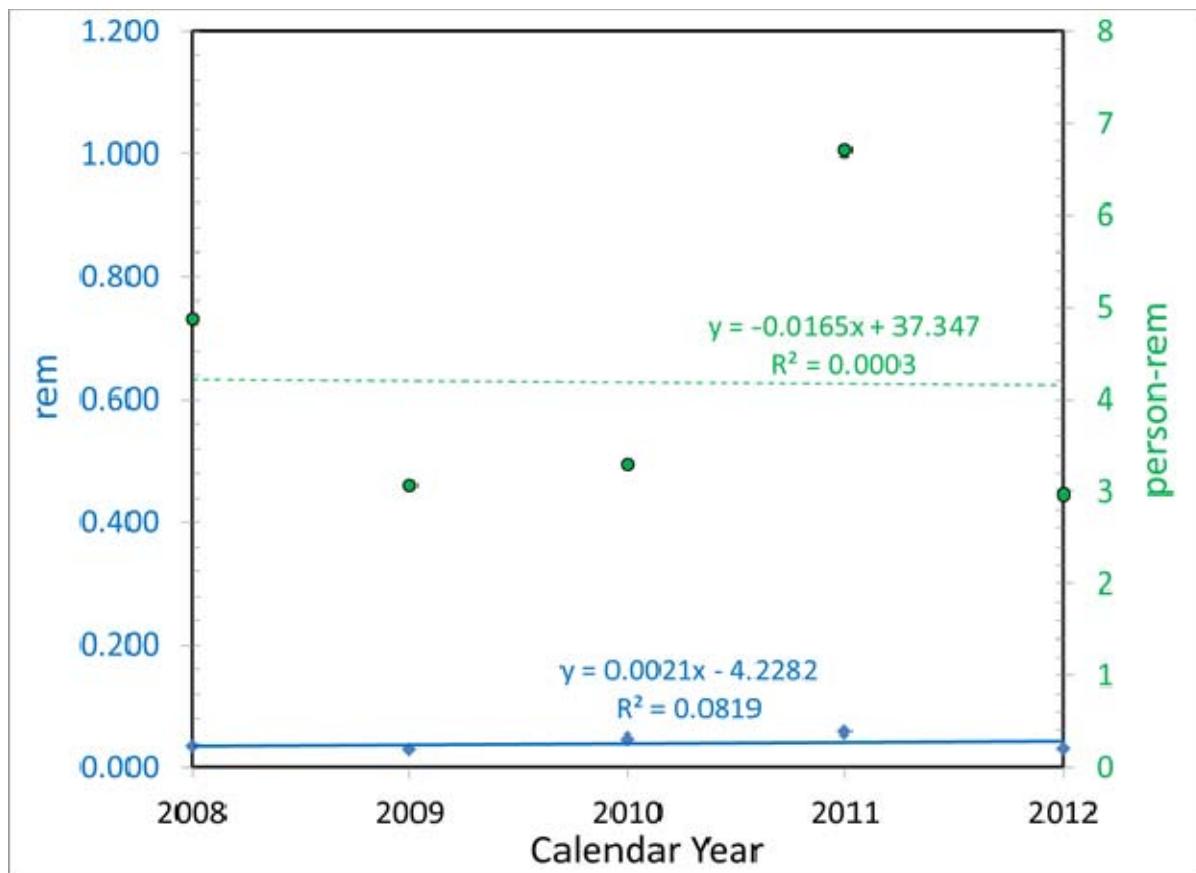
**Table 1 Summary Descriptive Statistics for SNL Personnel Dosimetry Reported Results for Calendar Years 2008 through 2012**

	2008	2009	2010	2011	2012
<b>Average (in rem):</b>	0.035	0.030	0.047	0.058	0.032
<b>Median (in rem):</b>	0.014	0.014	0.020	0.023	0.016
<b>Standard Deviation (in rem):</b>	0.055	0.053	0.076	0.081	0.035
<b>Maximum (in rem):</b>	0.395	0.454	0.477	0.377	0.194
<b># of Individuals with Measureable Dose <sup>a</sup>:</b>	139 (5.5%) <sup>b</sup>	101 (4.4%) <sup>b</sup>	70 (2.8%) <sup>b</sup>	116 (4.6%) <sup>b</sup>	102 (4.4%) <sup>b</sup>
<b># of Individuals Participating in Program:</b>	2,536	2,292	2,463	2,536	2,313
<b>Collective Total Effective Dose (in person-rem):</b>	4.876	3.058	3.299	6.705	2.970

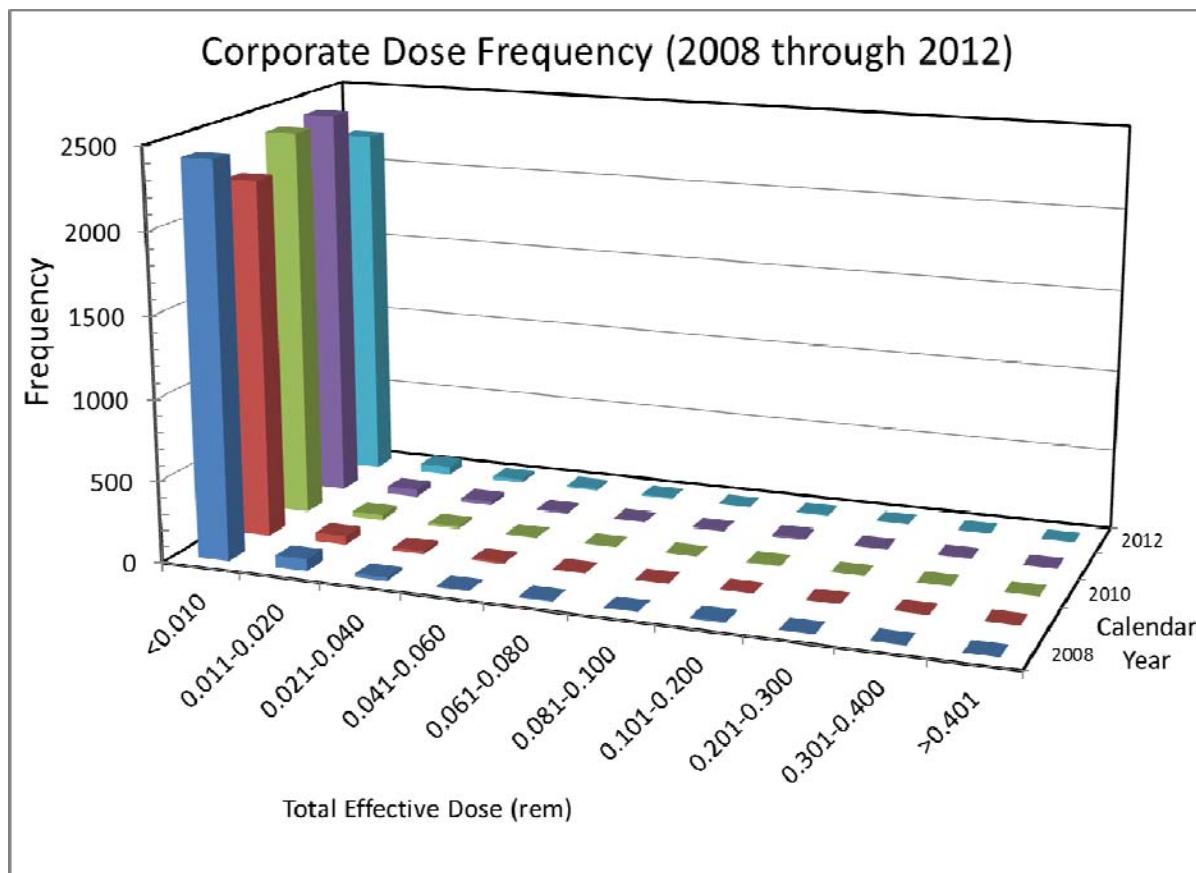
<sup>a</sup> TED in excess of 0.010 rem

<sup>b</sup> Percentage of individuals participating in the program with measureable dose

These data are plotted as a function of time with a trend line generated using MS Excel (**Figure 1**). The plot suggests (a weak) increase in the average individual TED and a decrease in the collective dose. However, the correlation coefficients ( $R^2 = 0.0819$  for individual TED measurements and  $R^2 = 0.0003$  for collective TED measurements) indicate that the trend is inconclusive. A histogram showing the distribution of reported doses (TED) during the monitoring period is shown in **Figure 2**.



**Figure 1. Five-year trend of average individual Total Effective Dose (TED) measurements (i.e.,  $\geq 0.010$  rem) and collective TED. Average individual TED measurements are in blue and collective TED in green. Trend lines with corresponding equations for the line and correlation coefficients are shown in blue and green for individual TED measurements and collective TED measurements, respectively.**



**Figure 2. Histogram of Individual Total Effective Dose Measurements at SNL/NM for the monitoring period starting 1 January 2008 and ending 31 December 2012.**

One aspect of ALARA is to minimize dose to the individual as well as minimizing overall dose received by Members of the Workforce (i.e., collective dose). As such, a distribution of the number of individuals participating in the SNL dosimetry program as well as the collective TED measurements are shown as a function of SNL Division in **Table 2**. As shown, nearly two-thirds (66.1%) of the individuals monitored during the 2012 calendar year were with Divisions 1000, 4000, and 8000. It may be worthy to note that over three-quarters (77.6%) of the collective dose was received by Division 1000 and 4000. Also, Division 9000 and 10000 accounted for about six-percent of the individuals monitored but received no measurable dose during the 2012 calendar year.

**Table 2 – Distribution of Personnel Participating in the Dosimetry Program at Sandia National Laboratories as well as Collective Dose as a Function of Division during the 2012 Calendar Year**

	Participants	Collective TED (person-rem)
<b>Division 0000</b>	57 (2.5%) <sup>a</sup>	0.033 (0.8%) <sup>b</sup>
<b>Division 1000</b>	621 (26.8%) <sup>a</sup>	1.698 (42.6%) <sup>b</sup>
<b>Division 2000</b>	322 (13.9%) <sup>a</sup>	0.252 (6.3%) <sup>b</sup>
<b>Division 3000</b>	22 (1.0%) <sup>a</sup>	0.076 (1.9%) <sup>b</sup>
<b>Division 4000</b>	714 (30.9%) <sup>a</sup>	1.396 (35.0%) <sup>b</sup>
<b>Division 5000</b>	155 (6.7%) <sup>a</sup>	0.053 (1.3%) <sup>b</sup>
<b>Division 6000</b>	94 (4.1%) <sup>a</sup>	0.215 (5.4%) <sup>b</sup>
<b>Division 8000</b>	194 (8.4%) <sup>a</sup>	0.266 (6.7%) <sup>b</sup>
<b>Division 9000</b>	12 (0.5%) <sup>a</sup>	0.000 (0.0%) <sup>b</sup>
<b>Division 10000</b>	122 (5.3%) <sup>a</sup>	0.000 (0.0%) <sup>b</sup>

<sup>a</sup> Percent of number of individuals participating in the dosimetry program at SNL.  
<sup>b</sup> Percent of corporate collective dose

The public dose limit (0.100 rem per year) is in excess to dose received from natural background and/or medical exposures. An expected natural background from cosmic and terrestrial radiation sources for Albuquerque, New Mexico is 0.089 rem·year<sup>-1</sup> (Mauro and Briggs, 2005). Using this published background value, the gross environmental dosimetry measurement at publicly accessible locations should not exceed 0.189 rem to demonstrate compliance with 10CFR835.208 (i.e., Public Limit = 0.089 + 0.100 = 0.189 rem).

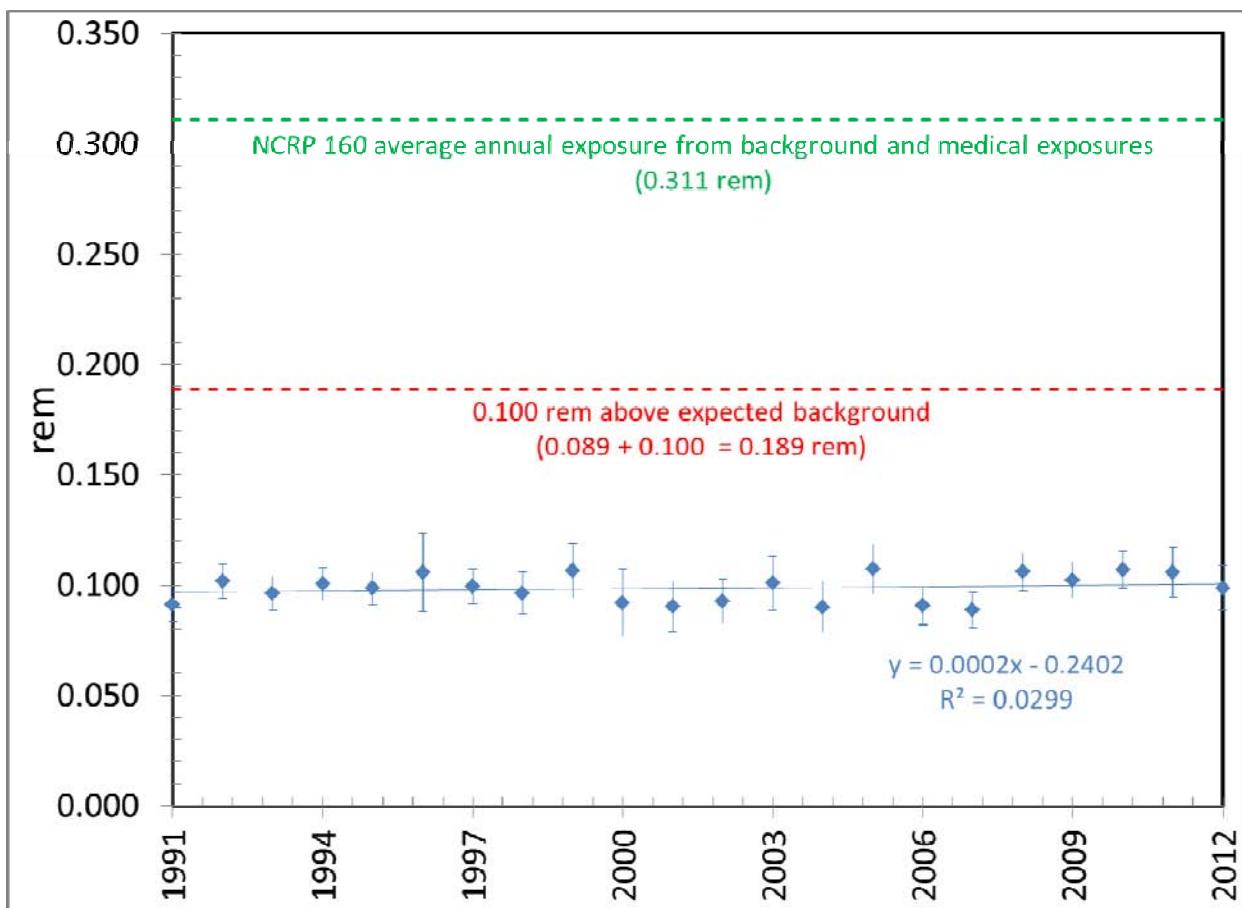
For perspective, the National Council on Radiation Protection and Measurements (NCRP) published an average dose of 0.311 rem per year from natural and medical sources of ionizing radiation (including radon) to the population of the United States in NCRP Report 160 (NCRP 2009). Environmental TLD measurements at SNL New Mexico are well below that value.

Descriptive summary statistics of environmental TLD measurements collected during the monitoring period 1 January 2008 through 31 December 2012 are shown in **Table 2**. During this monitoring period, no environmental TLD measurements exceeded the public dose limit.

**Table 3 – Descriptive Statistics of Annual Environmental TLD Measurements Obtained on and around Sandia National Laboratories, New Mexico from 1 January 2008 through 31 December 2012**

	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>
<b>Average (in rem)</b>	0.106	0.102	0.107	0.106	0.099
<b>Median (in rem)</b>	0.105	0.101	0.108	0.104	0.100
<b>Standard Deviation (in rem)</b>	0.009	0.008	0.008	0.011	0.010
<b>Minimum (in rem)</b>	0.091	0.084	0.082	0.087	0.071
<b>Maximum (in rem)</b>	0.129	0.123	0.125	0.146	0.118
<b># of Locations Monitored</b>	38	38	38	38	38

To provide a historical perspective, average annual environmental dosimetry results from 1 January 1991 through 31 December 2012 were plotted to help identify qualitative trends in radiation exposures at environmental monitoring locations (**Figure 3**). A trend line was generated using MS Excel with the equation for the trend line and correlation coefficient ( $R^2 = 0.0299$ ). Although the equation for the trend line has a positive slope indicating an increase in measured dose, the weak correlation coefficient suggests that this trend is inconclusive.



**Figure 3. Average Annual Environmental TLD measurement for the monitoring period starting 1 January 1991 and ending 31 December 2012. Error bars represent the 1-sigma sample standard deviation of measurements collected. The red dotted line represents the 0.100 rem public dose limit and the green dotted line represents the expected annual exposure from background and medical exposures (NCRP 160).**

### 3. CONCLUSION

The philosophy of dose minimization known as “ALARA” uses justification, optimization, and dose limitation as the means to keep exposures to ionizing radiation As Low As is Reasonably Achievable. In accordance with DOE policy (DOE P 441.1, 1996), SNL/NM has maintained radiation exposures to workers below regulatory limits with deliberate efforts to keep exposures and releases ALARA. Based upon this evaluation it appears that SNL/NM maintains a level of dose control for radiological operations commensurate with the radiological risks involved and in the spirit of the ALARA philosophy. That is, radiation protection methods used at SNL/NM are compliant with regulatory limits and conform with the ALARA philosophy

There is no clear indication that average measured occupational TED measurements or collective TED measurements have changed over the five-year period evaluated. However, it may be worthy to note that the majority (77.6%) of collective TED received by SNL personnel was received by Divisions 1000 and 4000. This is consistent with historical evaluations and attributable to the radiological operations conducted by Division 1000 which were supported by Division 4000 personnel (i.e., Organizations 04128 (Radiation Protection) and 04144 (Waste Management & Pollution Prevention)).

Dose to a member of the public exposed to radiation and/or radioactive material did not exceed the applicable dose limit in the monitoring period from 1 January 2008 to 31 December 2012. Environmental monitoring data demonstrate that environmental exposures are protective of public health. Since 1 January 1991, one annual environmental TLD dose measurement (0.221 rem) obtained at the northwestern corner of the Radioactive and Mixed Waste Management Facility (RMWMF) in 1997 exceeded 0.189 rem. This was a facility monitor that did not monitor dose to the general public. However, this is a SNL-controlled location with a low rate of occupancy. A potentially impacted individual would be a member of the SNL workforce who is not a radiological worker. Assuming an occupancy factor of 1/8 (12.5 percent occupancy), and the impacted member of the workforce spends 2,000 hours per year at the uncontrolled location, the corresponding dose would have been 0.006 rem, well below the annual dose limit to a member of the public.

$$\left(1/8\right) \left(\frac{2,000 \text{ h}}{8,760 \text{ h}}\right) (0.221 \text{ rem}) = 0.006 \text{ rem}$$



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