Appendix C

Supplemental Air Information

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Abbreviations

BCG	Biota Concentration Guide
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FRL	final remediation level
IEMP	*Integrated Environmental Monitoring Plan*
LM	DOE Office of Legacy Management
OSL	optically stimulated luminescence
OU5 ROD	*Operable Unit 5 Record of Decision*

Measurement Abbreviations

cfs	cubic feet per second
mrem	millirem
pCi/L	picocuries per liter
rad	radiation absorbed dose
rem	roentgen equivalent man
yr	year

Appendix C presents additional dosimeter data and analysis in support of Section 5 of this *Fernald Preserve 2012 Site Environmental Report*. This appendix consists of two attachments:

- Attachment C.1 provides information on the direct radiation monitoring program, including an assessment of 2012 results with respect to historical data.
- Attachment C.2 provides the results of supplemental dose assessments that are part of the standards and requirements contained in DOE Order 5400.5. The methods and data sources used for the population and biota dose assessments are explained. In addition, an evaluation of trends observed in the dose assessments over the past 10 years is also provided.

References

DOE (U.S. Department of Energy), 2002. *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, Final Technical Standard, Project No. ENVR-0011, Washington, D.C.

DOE (U.S. Department of Energy), 2006a. Approval for removing Phase 1 – TLD, Radon and Particulate Monitors (AMS-04, AMS-05, AMS-07, AMS-23, AMS-25 and AMS-28), received at weekly conference call on 11 April 2006.

DOE (U.S. Department of Energy), 2006b. Phase II Site Boundary Air Monitor Reductions approval letter, received from EPA on November 29, 2006.

DOE (U.S. Department of Energy), 2010. *Comprehensive Legacy Management and Institutional Controls Plan*, LMS/FER/S03496, Revision 4, prepared by S.M. Stoller Corporation for DOE, Fernald Area Office, Cincinnati, Ohio, April.

DOE (U.S. Department of Energy), 2012. *Comprehensive Legacy Management and Institutional Controls Plan*, LMS/FER/S03496, Revision 5, prepared by S.M. Stoller Corporation for DOE, Fernald Area Office, Cincinnati, Ohio, December.

DOE Order 5400.5. U.S. Department of Energy. *Radiation Protection of the Public and the Environment,* Change 2, Washington, D.C., January 1993.

Ohio EPA (Ohio Environmental Protection Agency), 2003. *NPDES Permit Fact Sheet*, Public Notice# 03-04-019, April 7, 2003.

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Attachment C.1.0: Direct Radiation

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The Fernald Preserve maintains 11 optically stimulated luminescence (OSL) dosimeters, which are used to collect direct radiation measurements as part of the Integrated Environmental Monitoring Plan (IEMP) Dose Assessment Program, which is Attachment D of the *Comprehensive Legacy Management and Institutional Controls Plan* (DOE 2012). The OSL dosimeters are at one background, five boundary, and four trail locations, as well as a single location at the Visitors Center (Figure C.1−1). Three OSL dosimeters are deployed at each location to track and evaluate direct radiation, and each OSL dosimeter is collected and measured quarterly (approximately every 91 days). The three measurements are averaged to obtain a quarterly result for each location. Quarterly results are plotted on Figure 29 in Section 5. The OSL dosimeter data for each location are presented on the U.S. Department of Energy Office of Legacy Management's (LM) website under the Fernald Preserve (http://www.lm.doe.gov/fernald/Sites.aspx)

Table C.1−1 provides a summary of the annual dose for 2012 and 2011. Annual dose is calculated by summing the quarterly results at each location. Quantification of the direct radiation dose delivered to an individual at the Fernald Preserve boundary (Section 5) indicates there is no significant dose associated with direct radiation. These results are in agreement with Figure C.1−2, which shows that the 95 percent confidence interval of the mean values for the onsite dosimeters and background dosimeter overlap. Two exceptions are the lower 95 percent confidence intervals for OSL-2 and OSL-35 are slightly above the upper 95 percent confidence interval for OSL-27. Note that OSL-54 is inside the Visitors Center, and direct radiation is lowest there due to the shielding effects of the building. Given the remediation of the Fernald Preserve to soil final remediation levels (FRLs), and statistically similar boundary and background values in 2012, it is reasonable to expect future readings to be at or near background levels.

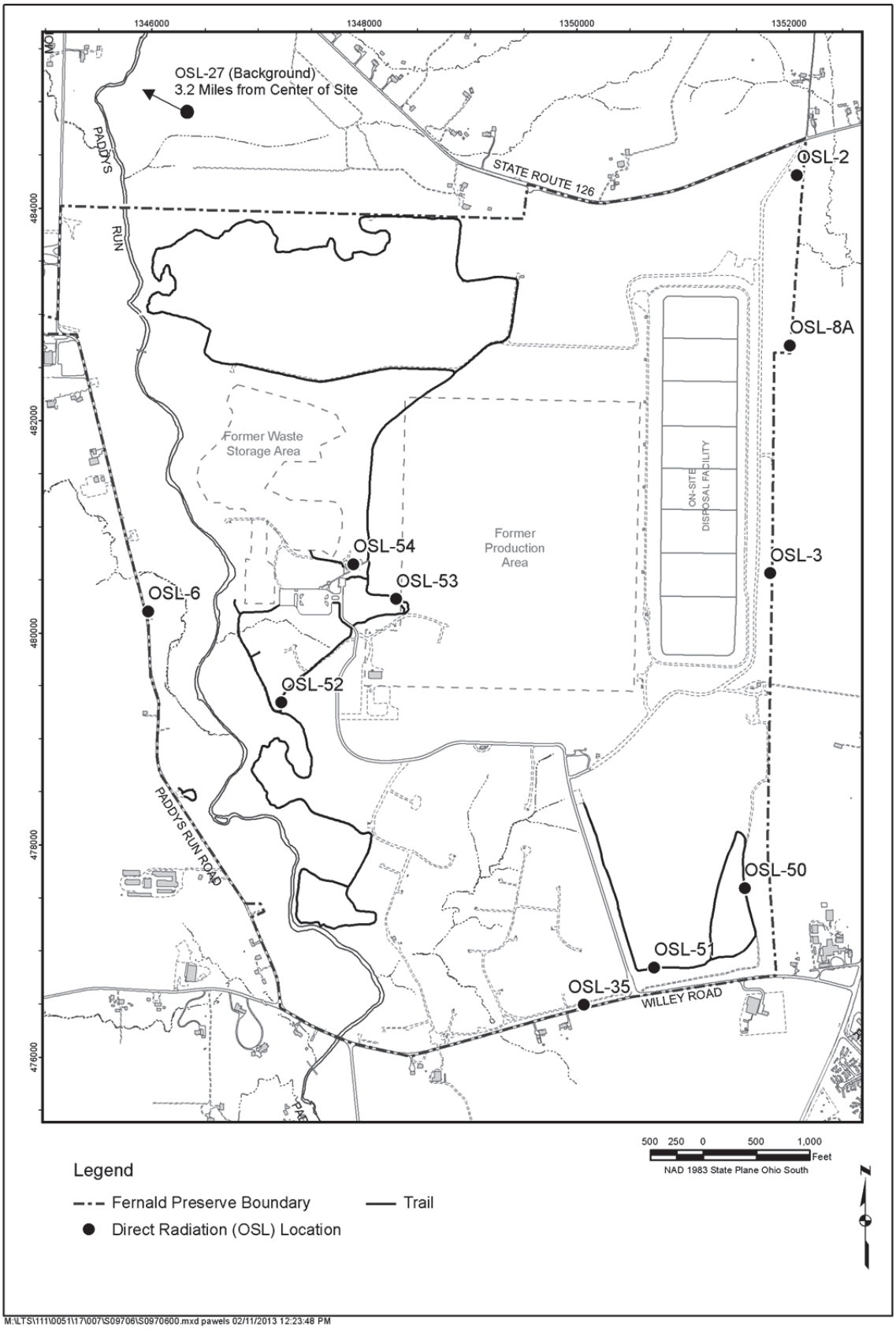

Figure C.1–1. Direct Radiation (OSL) Monitoring Locations

Table C.1–1. Dose Based on Direct Radiation (OSL) Measurements

	Direct Radiation (mrem)[a]	
Location	2012	2011
Boundary		
2	32	33
3	26	25
6	15	16
8A	29	33
35	31	28
50	26	25
51	27	30
52	24	23
53	20	21
54	5.3	6.0
Minimum	**5.3**	**6.0**
Maximum	**32**	**33**
Background		
27	21	21

[a]Annual dose is derived by summing the average quarterly result for each location.

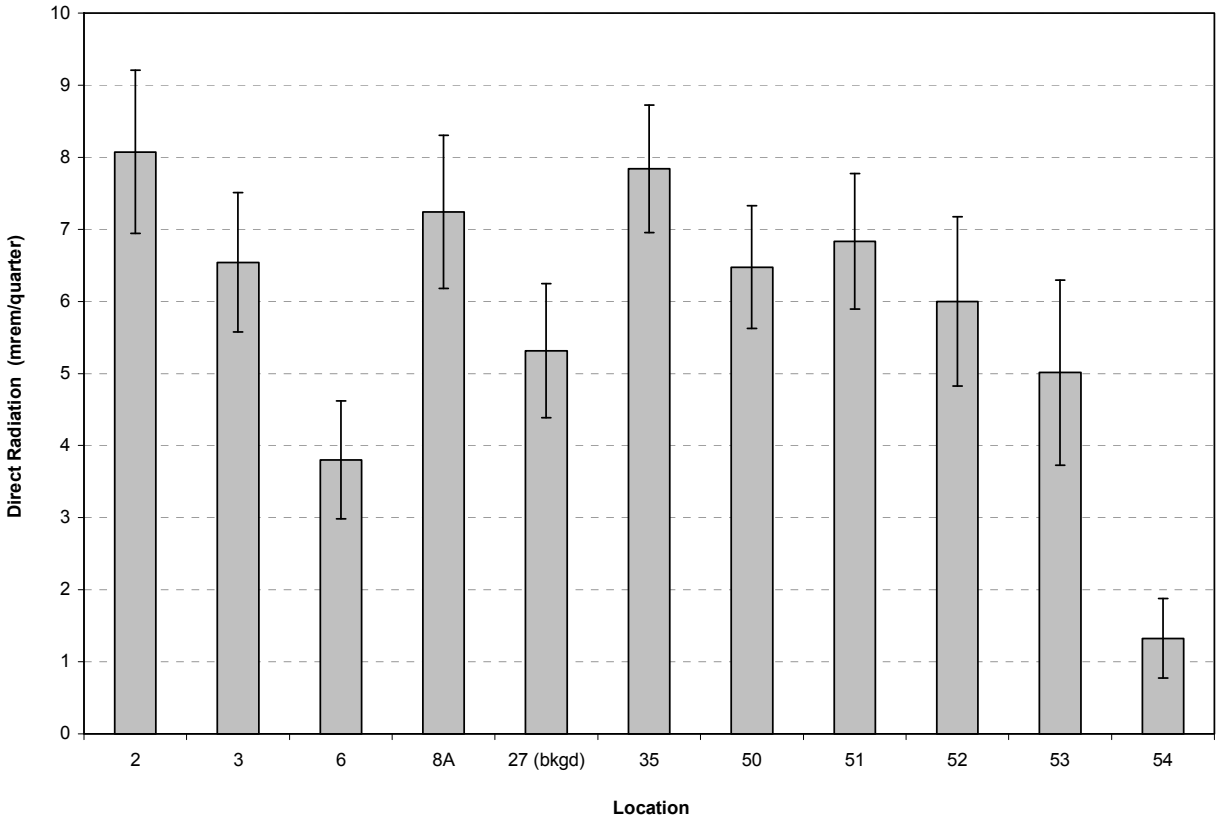

Figure C.1–2. 2012 Mean and 95 Percent Confidence Interval for Quarterly Dosimeter Measurements

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Attachment C.2.0: Supplemental Dose Assessments

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This attachment contains a detailed discussion of the supplemental dose assessments performed for calendar year 2012, and compares the 2012 results to those from 2001 through 2011. The supplemental dose assessment comprises the population and biota dose assessments, which provide required information for compliance with DOE Order 5400.5.

The 2012 population dose assessment provides an aggregate measure of the impact of direct radiation from sources at the Fernald Preserve to the population in the area. However, with the completion of soil remediation, removal of the silo and waste pit material, and capping of the final OSDF cells in 2006, the only remaining source for direct radiation is the soil. As the soil has been certified to contain contaminant levels below the OU5 FRLs, there is no significant remaining source to deliver a dose to the public in excess of the dose that corresponds to an incremental lifetime cancer risk of 1 in 10,000, which is acceptable for EPA superfund sites. The population dose assessment presented below supports this conclusion.

The groundwater remediation program continues to discharge large volumes of water to the Great Miami River, and the biota dose assessment provides information on the Fernald Preserve's compliance with dose limits to aquatic organisms in the Great Miami River. Groundwater is not considered as part of the population dose because contaminated groundwater is not consumed by the public.

C.2.1 Population Dose Assessment

Computation of a population dose is a requirement of DOE Order 5400.5, which defines population dose as the collective effective dose equivalent. Collective effective dose is the dose spread across the population within a 50-mile radius of the site. For 2012, the effective dose equivalent was 0.043 person-rem/yr from the direct radiation component (Table C.2–1). Monitoring of the air inhalation pathway was discontinued at the beginning of 2010 and there was no estimated biota dose to the population from consumption of produce, as the produce monitoring program was completed in 2003.

Table C.2–1. Estimated Population Doses (person-rem)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010[c]	2011	2012
Air Inhalation	3.35	3.47	3.84	3.87	1.20	0.485	0.010	0.039	0.014	NA	NA	NA
Direct radiation	0.159	0.23	0.155	0.47	0.35	0.030	0.015	0.019	0.028	0.019	0.048	0.043
Biota[a,b]	NA	NA	0.002	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total	**3.51**	**3.70**	**4.00**	**4.34**	**1.55**	**0.515**	**0.025**	**0.058**	**0.042**	**0.019**	**0.048**	**0.043**

[a]NA = not applicable.
[b]Produce for biota dose was sampled every three years, and program was completed in 2003.
[c]Particulate monitoring for the air inhalation pathway was discontinued in 2010.

The direct radiation dose component was estimated by using the population distribution within 50 miles of the site, as distributed between 16 equally spaced compass sectors (N, NNE, NE, ENE, etc.). In 2012, monitoring was performed at the 5 boundary locations approved by EPA (DOE 2006a and 2006b), resulting in direct radiation dose data that are not uniformly distributed between the 16 sectors. Therefore, an estimate of the direct radiation at the unmonitored 11 compass sectors is used to evaluate the direct radiation dose.

The 95 percent confidence interval of the mean for quarterly measurements at the onsite and background locations overlap (Attachment C.1). This implies that direct radiation at the site

boundary is not significantly different from background; therefore, the background value was applied to the 11 compass sectors that had no collected data. A dose was estimated for each population sector based on the direct radiation level that exceeded background at the site boundary, and the distance between the location of the population and the site boundary. The following conservative assumptions were used in the calculations:

- Population lives 8,760 hours per year in area (DOE Order 5400.5).
- The number of people per household is estimated by total population per sector per mile divided by number of households per sector per mile.
- The net direct radiation levels are calculated from onsite OSL dosimeter results minus the background result, with no correction for analytical uncertainty.

The collective effective population dose in 2012 was slightly lower than 2011 (Table C.2–1). The air inhalation pathway is no longer evaluated at the Fernald Preserve, per DOE and EPA agreement (DOE 2010). As discussed in Attachment C.1, the direct radiation dose has been at or near background for the past several years.

The collective population dose attributed to direct radiation at the Fernald Preserve (Table C.2–1) is very low relative to background dose values from the sun and food products. The background radiation dose from the sun and naturally occurring radionuclides in food products and the earth is estimated to be 300,000 person-rem for the population within 50 miles of the Fernald Preserve. A review of the 2012 estimated dose in Table C.2–1 shows dose attributable to the Fernald Preserve is over 6 million times less than background dose, which implies it is an insignificant dose in terms of compliance with DOE Order 5400.5.

C.2.2 Biota Dose Assessment

DOE Order 5400.5 requires that populations of aquatic biota be protected at a dose limit of 1 rad/day. DOE has issued a technical standard entitled *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002) and supporting software (RAD-BCG) for use in the evaluation and reporting of biota dose limits. A biota dose assessment divides the radionuclide concentrations in surface water and/or sediment samples by pre-established biota concentration guides (BCGs) for specific radionuclides and sums the fractions for each radionuclide. If the resulting sum of fractions is less than 1.0, compliance with the biota dose limit is assured. BCGs have been established for radionuclides that are relatively common constituents in past radionuclide releases to the environment from DOE facilities. For the isotopes at the Fernald Preserve, the radium isotopes have the lowest BCG values, hence they account for most of the weight in the sum of fractions presented here.

For 2000 through 2005, the Fernald site determined compliance with the biota dose limit to aquatic biota using RAD-BCG and the diluted (i.e., mixed) concentration for each applicable radionuclide discharged to the Great Miami River at the Parshall Flume. Although the Parshall Flume was the only discharge point evaluated through 2005, two discharge points (Paddys Run and the Parshall Flume) are delivering mass to the Great Miami River. Beginning in 2006, both discharge points were evaluated to calculate the dose to aquatic biota in the Great Miami River.

In 2003, Ohio EPA published a fact sheet that provided the harmonic mean flow of 0.19 cubic feet per second (cfs) for Paddys Run (Ohio EPA 2003), allowing this discharge point to be

evaluated in addition to the Parshall Flume. Therefore, the biota assessments for 2003 through 2012 were performed using the mass delivered from both discharge points to determine the annual average mixing concentration in the Great Miami River. These assessments only evaluate the contaminant contribution from the Fernald Preserve, and contaminant concentrations in the Great Miami River may be higher due to other sources that discharge similar pollutants.

The maximum measured concentration for total uranium was used for the Parshall Flume (PF 4001) and Paddys Run (SWP-03). Radium isotopes were available only for Paddys Run, and one-half of the detection limit was used in the calculation because radium-226 and radium-228 were reported at detection limit values. These values were multiplied by the annual volume of water discharged to the Great Miami River at the Parshall Flume and Paddys Run to obtain an estimate of the maximum activity of each radionuclide delivered to the river at each discharge point (e.g., pCi/L × L = total pCi). For each radionuclide, the activity discharged at the Parshall Flume was added to the activity discharged at Paddys Run to obtain the annual total activity delivered to the river. The annual total activity delivered to the river was divided by the annual total volume of mixed water (Parshall Flume + Paddys Run + Great Miami River) to obtain the annual radionuclide activities used in RAD-BCG for the biota dose assessment (as noted above, this activity represents discharge from a single source, the Fernald Preserve).

Table C.2–2 contains a summary of the output from RAD-BCG for 2001 through 2012. Results for 2012 show that the sum-of-fractions result (0.002) is well below the compliance threshold value of 1.0.

Table C.2–2. Estimated Sum-of-Fractions[a] for Biota Dose

	2001[b]	2002[b]	2003	2004	2005	2006[b]	2007[b]	2008[b]	2009[b]	2010[b]	2011[b]	2012[b]
A	0.038	0.023	0.035	0.059	0.017	NA	NA	NA	NA	NA	NA	NA
B	NA	NA	0.035	0.059	0.005	0.062	0.009	0.010	0.005	0.007	0.006	0.002

Note: A = 2001 through 2005 calculated using one discharge point (Parshall Flume)
B = 2003 through 2012 calculated using two discharge points (Paddys Run and Parshall Flume)

[a]Sum-of-the-fractions calculated with the RAD-BCG code.
[b]NA = not applicable.

Recalculated results for 2003 and 2004, for two discharge points, are identical to the initial results calculated for one discharge point. This indicates that the mass delivered from Paddys Run is insignificant relative to the mass delivered at the Parshall Flume. When the contaminant concentration is similar at the two discharge points, the contaminant mass delivered to the Great Miami River from Paddys Run will be much less than the mass delivered to the river at the Parshall Flume because of the large difference in discharge volume. Based on the harmonic mean flow for Paddys Run (0.19 cfs; Ohio EPA 2003), the annual volume of water discharged in 2012 to the Great Miami River is 1.70×10^8 L, compared to 9.62×10^9 L for the Parshall Flume.

The 2005 sum-of-fractions result for Scenario A (one discharge point) is greater than that for Scenario B (two discharge points). This anomaly is due to an incorrect calculation of the mass of radium discharged to the Great Miami River for Scenario A. In 2005, the maximum radium concentration recorded for water discharged to Paddys Run was multiplied by the annual volume discharged at the Parshall Flume. As the maximum radium concentration at Paddys Run was much higher than radium values recorded at the Parshall Flume, changing the radium concentration to maximum observed at the Parshall Flume (lower than the maximum value for Paddys Run) lowers the mass of radium delivered to the Great Miami River and decreases the sum-of-fractions result for Scenario B to the proper value.