

## 8.9 Soil Monitoring



The following sections summarize soil monitoring efforts conducted on and around the Hanford Site in 2004. Radiological monitoring of soil is conducted onsite near facilities and operations, onsite away from facilities and operations (site-wide), and offsite at perimeter and distant locations and in nearby communities. Contaminant concentration data are used to determine the effectiveness of effluent monitoring and controls within facilities, to assess the adequacy of containment at waste disposal sites, to detect and monitor unusual conditions, and to provide information on long-term radionuclide contamination trends in soil at undisturbed locations. Soil samples have been collected on and around the Hanford Site for more than 40 years. Consequently, a large database documents onsite and offsite levels of manmade radionuclides in Hanford Site soil. These data provide a baseline against which unplanned releases can be compared. For further information about these monitoring efforts, the programs that support them, and their purposes see Section 8.0 and DOE/RL-91-50.

### 8.9.1 Soil Monitoring Near Hanford Site Facilities and Operations

R. M. Mitchell

Soil samples are collected near facilities and operations to evaluate long-term trends in the environmental

accumulation of radioactive materials and to detect potential migration and deposition of facility emissions. Contamination in soils can occur as the result of resuspension of contaminants in air and movement from radiologically contaminated surface areas, uptake of contaminants into plants whose roots contact below-ground waste, or translocation of buried waste by intruding animals.

#### 8.9.1.1 Soil Sampling Near Hanford Site Facilities and Operations

Soil samples were collected on or adjacent to waste disposal sites and from locations downwind and near or within the boundaries of operating facilities and remedial action sites. The number and locations of soil samples collected during 2004 are summarized in Table 8.9.1. Only radionuclide concentrations above analytical detection limits are discussed in this section. A comprehensive presentation of the analytical data from these samples can be found in PNNL-15222, APP. 2.

Each 1-kilogram (2.2-pound) soil sample represented a composite of five plugs of soil, each 2.5 centimeters (1 inch) deep and 10 centimeters (4 inches) in diameter. Soil samples were sieved in the field to remove rocks and plant debris and dried in the laboratory prior to analysis to remove residual moisture.

Hanford Site samples were analyzed for radionuclides expected to occur in the areas sampled (i.e., gamma-emitting radionuclides [Appendix F, Table F.1],

**Table 8.9.1. Number and Locations of Soil Samples Collected Near Hanford Site Facilities and Operations, 2004**

Sample Type	Number of Sampling Locations	Operational Area								
		100-B/C	100-D/DR	100-K	100-F	100-H	100-N	ERDF <sup>(a)</sup>	200/600	300/400
Soil	83	2	0	1	2	0	7	1	56	14

(a) Environmental Restoration Disposal Facility in the 200-West Area.



strontium-90, uranium isotopes, and/or plutonium isotopes). The analytical results from Hanford Site samples were compared to concentrations of radionuclides measured in samples collected offsite at various sampling locations in Grant, Yakima, Walla Walla, Adams, Benton, and Franklin Counties. These comparisons were used to determine the level of measured radioactivity in samples resulting from site operations and remedial actions and resulting from natural sources and worldwide fallout.

Soil sampling results also were compared to the accessible soil concentrations (WHC-SD-EN-TI-070) developed specifically for use at the Hanford Site (see PNNL-15222, APP. 2 for a complete listing of concentrations). These concentration values for radionuclides were established to assure that effective dose equivalents to the public do not exceed the established limits for any reasonable scenario, such as direct exposure, inadvertent ingestion, inhalation, and ingestion of foods, including animal products. The accessible soil concentration values are based on a radiation dose estimate scenario in which an individual would have to spend 100 hours per year in direct contact with the contaminated soil. The conservatism inherent in pathway modeling assures that the required degrees of protection are in place (WHC-SD-EN-TI-070). These concentrations apply specifically to the Hanford Site with respect to onsite waste disposal operations and cleanup, decontamination, and decommissioning activities.

Some degree of variability is always associated with the collection and analysis of environmental samples. Therefore, variations in sample concentrations from year to year are expected. In general, radionuclide concentrations in soil samples collected from or adjacent to waste disposal facilities in 2004 were higher than the concentrations in samples collected farther away and were significantly higher than concentrations measured offsite. The data also show, as expected, that concentrations of certain radionuclides in 2004 were higher within different operational areas when compared to concentrations measured in distant communities. Generally, the predominant radionuclides detected were activation and fission products in the 100-N Area, fission products in the 200 and 600 Areas, and uranium in the 300 and 400 Areas.

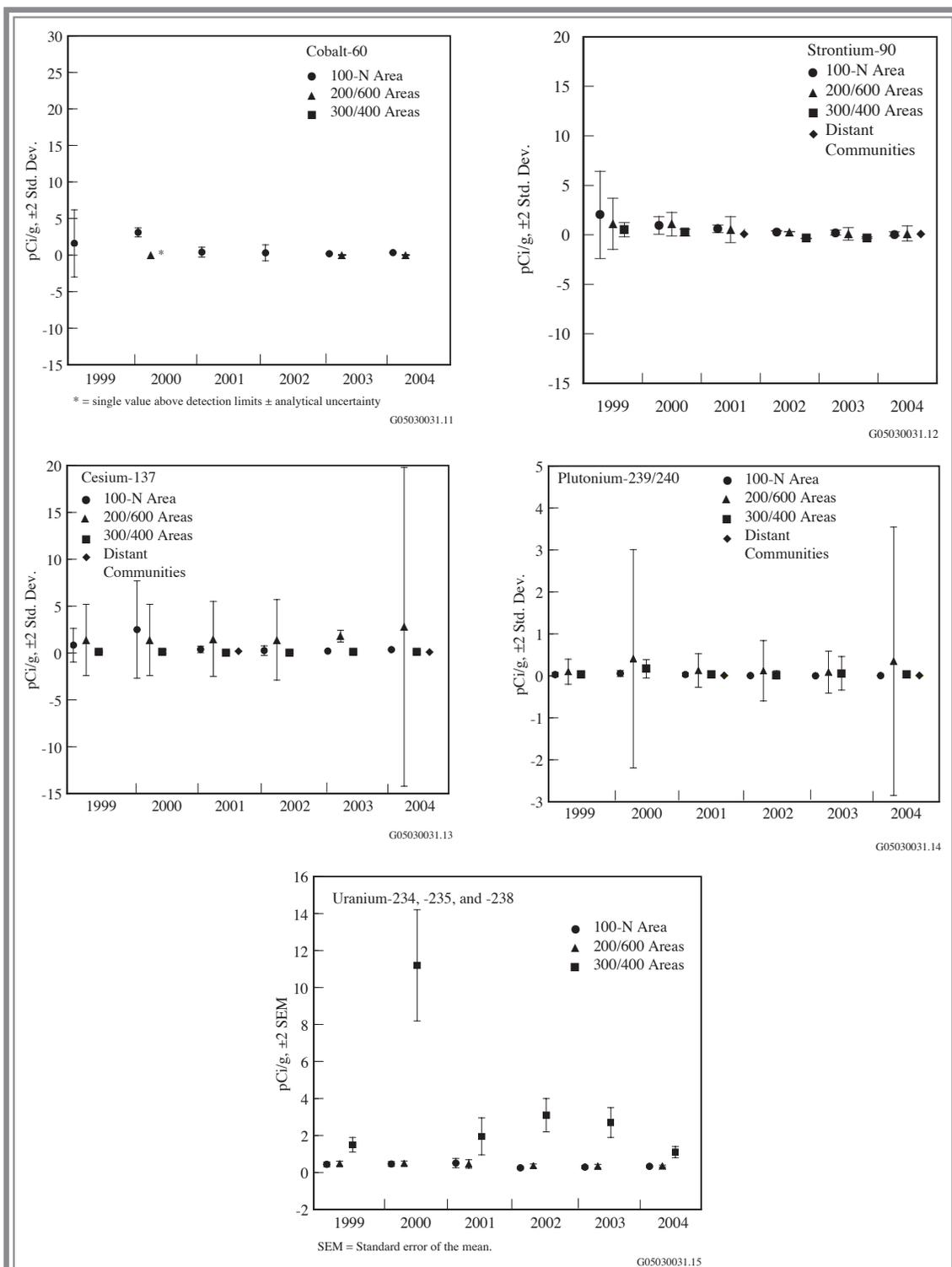
### 8.9.1.2 Analytical Results for Soil Samples Collected Near Hanford Site Facilities and Operations

Cobalt-60, strontium-90, cesium-137, plutonium-239/240, and uranium were detected consistently in 2004 samples. Concentrations of these radionuclides were elevated near and within facility boundaries when compared to historical concentrations measured offsite at distant communities. Figure 8.9.1 shows the average concentrations of selected radionuclides in soil samples collected during 2004 and the preceding 5 years. Some individual levels demonstrate a high degree of variability, though overall trends are stable.

Three surface soil samples were collected near the 116-N-3 liquid waste disposal facility (1325-N) in the 100-N Area in 2004. Their analytical results were comparable to results observed in past years. Average radionuclide concentrations detected in the surface soil samples collected in the 100-N Area from 1999 through 2004 are presented in Table 8.9.2. The 2004 results and the average for distant communities and accessible soil concentration limits are compared in Table 8.9.3.

Soil samples were collected from 56 sampling locations in the 200 and 600 Areas during 2004. Analytical results from the 2004 samples demonstrated comparable average radionuclide concentration levels to those seen in 2003, with the exceptions of strontium-90 and plutonium-239/240, which were higher (Table 8.9.4). Consistent with historical results, the sampling location at the outlet end of the retired B Pond facility (east of the 200-East Area) had the highest concentrations of cesium-137, plutonium-238, and plutonium-239/240 of any soil sampling location near a facility or operation. The 2004 maximum, average, and distant community average concentrations and accessible soil concentration limits for commonly measured radionuclides are compared in Table 8.9.5. Complete listings of radionuclide concentrations and sampling location maps are provided in PNNL-15222, APP. 2.

Soil samples were collected from 13 sampling locations in the 300 Area and one location in the 400 Area in 2004.



**Figure 8.9.1. Average Concentrations of Selected Radionuclides in Soil Samples Collected on the Hanford Site Near Facilities and Operations Compared to Those Collected in Distant Communities (Section 8.9.2), 1999 through 2004. Radionuclide concentrations below analytical detection limits are not shown. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.**



**Table 8.9.2. Average Radionuclide Concentrations (pCi/g<sup>[a]</sup> dry wt.)<sup>[b]</sup> in Surface Soil Samples Collected on the Hanford Site in the 100-N Area, 1999 through 2004**

Year	<sup>60</sup> Co	<sup>90</sup> Sr	<sup>137</sup> Cs	<sup>234</sup> U	<sup>238</sup> U	<sup>239/240</sup> Pu
1999	1.6 ± 4.6	1.9 ± 4.4	0.84 ± 1.8	0.22 ± 0.04	0.20 ± 0.03	0.026 ± 0.05
2000	3.1 ± 0.6	0.84 ± 0.9	2.1 ± 5.2	0.22 ± 0.09	0.22 ± 0.03	0.050 ± 0.074
2001	0.27 ± 0.68	0.20 ± 0.42	0.32 ± 0.44	0.24 ± 0.09	0.25 ± 0.07	0.022 ± 0.04
2002 <sup>(c)</sup>	0.3 ± 1.1	0.15 ± 0.47	0.26 ± 0.51	0.13 ± 0.05	0.11 ± 0.04	0.006 ± 0.006
2003 <sup>(c)</sup>	0.18 ± 0.02	-0.08 ± 0.24	0.21 ± 0.04	0.14 ± 0.05	0.15 ± 0.05	0.002 ± 0.006
2004	0.19 ± 0.25	-0.21 ± 0.69	0.28 ± 0.12	0.15 ± 0.06	0.15 ± 0.03	0.004 ± 0.005

- (a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.  
 (b) ±2 times the standard deviation.  
 (c) Represents one sample site only; ± total analytical uncertainty.

**Table 8.9.3. Average Radionuclide Concentrations (pCi/g<sup>[a]</sup> dry wt.) in Surface Soil Samples Collected on the Hanford Site in the 100-N Area in 2004, Compared to Distant Communities and Accessible Soil Concentration Limits**

	<sup>60</sup> Co	<sup>90</sup> Sr	<sup>137</sup> Cs	<sup>234</sup> U	<sup>238</sup> U	<sup>239/240</sup> Pu
Result <sup>(b)</sup>	0.19 ± 0.25	-0.21 ± 0.69	0.28 ± 0.12	0.15 ± 0.06	0.15 ± 0.03	0.004 ± 0.005
Distant community <sup>(b,c)</sup>	NM	0.029 ± 0.054	0.10 ± 0.16	NM	0.13 ± 0.088	0.0033 ± 0.0060
Accessible soil concentration limits (WHC-SD-EN-TI-070) <sup>(d)</sup>	7.1	2,800	30	630	370	190

- (a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.  
 (b) ±2 times the standard deviation.  
 (c) See Section 8.9.2.  
 (d) Hanford soil that is not behind security fences.  
 NM = Not measured.

**Table 8.9.4. Average Radionuclide Concentrations (pCi/g<sup>[a]</sup> dry wt.)<sup>[b]</sup> in Surface Soil Samples Collected Near Hanford Site Facilities and Operations in the 200 and 600 Areas, 1999 through 2004**

Year	<sup>60</sup> Co	<sup>90</sup> Sr	<sup>137</sup> Cs	<sup>234</sup> U	<sup>238</sup> U	<sup>239/240</sup> Pu
1999	ND	0.51 ± 1.9	1.3 ± 3.8	0.23 ± 0.13	0.22 ± 0.13	0.08 ± 0.27
2000	0.006 ± 0.006	0.99 ± 1.3	1.4 ± 3.8	0.23 ± 0.22	0.23 ± 0.22	0.29 ± 2.3
2001	ND	0.31 ± 1.1	1.5 ± 4.0	0.22 ± 0.11	0.22 ± 0.11	0.10 ± 0.37
2002	ND	0.27 ± 0.66	1.4 ± 4.3	0.17 ± 0.10	0.17 ± 0.11	0.12 ± 0.72
2003	0.002 ± 0.013 <sup>(c)</sup>	0.084 ± 0.63	1.8 ± 0.63	0.16 ± 0.10	0.17 ± 0.10	0.09 ± 0.50
2004	0.001 ± 0.011	0.13 ± 0.78	2.8 ± 17.0	0.17 ± 0.19	0.17 ± 0.15	0.35 ± 3.2

- (a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.  
 (b) ±2 times the standard deviation.  
 (c) Single value above detection limit.  
 ND = Not detected.

**Table 8.9.5. Radionuclide Concentrations (pCi/g<sup>(a)</sup> dry wt.) in Surface Soil Samples Collected Near Hanford Site Facilities and Operations in the 200 and 600 Areas in 2004, Compared to Distant Communities and Accessible Soil Concentration Limits**

	<sup>60</sup> Co	<sup>90</sup> Sr	<sup>137</sup> Cs	<sup>234</sup> U	<sup>238</sup> U	<sup>239/240</sup> Pu
Maximum <sup>(b)</sup>	0.02 ± 0.019	1.2 ± 0.36	61.0 ± 9.7	0.84 ± 0.23	0.68 ± 0.19	1.2 ± 0.4
Average <sup>(c)</sup>	0.001 ± 0.011	0.13 ± 0.78	2.8 ± 17.0	0.17 ± 0.19	0.17 ± 0.15	0.35 ± 3.2
Distant community <sup>(c,d)</sup>	NM	0.029 ± 0.054	0.10 ± 0.16	NM	0.13 ± 0.088	0.0033 ± 0.0060
Accessible soil concentration limits (WHC-SD-EN-TI-070) <sup>(e)</sup>	7.1	2,800	30	630	370	190

(a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.

(b) ± total analytical uncertainty.

(c) ±2 times the standard deviation.

(d) See Section 8.9.2.

(e) Hanford soil that is not behind security fences.

NM = Not measured.

Average values reported for strontium-90 and uranium isotopes were somewhat less than the concentrations reported in 2003. Uranium concentrations were, as expected, higher in the 300 Area samples than at other site locations because uranium was processed during past fuel fabrication operations in the 300 Area. Analytical results for 2004 and the preceding 5 years are summarized in Table 8.9.6. The 2004 maximum and average concentrations, distant community average concentrations, and accessible soil concentration limits are compared in Table 8.9.7. Complete listings of radionuclide concentrations and sampling location maps are provided in PNNL-15222, APP. 2.

For non-routine soil sampling in support of the environmental restoration contractor projects in 2004, three soil samples were collected at the remedial action project in the 100-B/C Area, four at the 100-NR-1 remedial action project in the 100-N Area, and one at the 100-KR-1 remedial action project in the 100-K Area. A single sample was collected from the Environmental Restoration Disposal Facility in the 200-West Area to determine the effectiveness of contamination controls. Analytical results from each of these locations were comparable to

those observed at other near-facility sampling locations at Hanford. Table 8.9.8 provides a summary of selected analytical results for samples from these sites. All of the 2004 data are provided in PNNL-15222, APP. 2.

### 8.9.1.3 Investigations of Radioactive Contamination in Soil Near Hanford Site Facilities and Operations

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Investigative sampling is conducted in and near operational areas to monitor the presence or movement of radioactive materials around areas of known or suspected contamination or to verify radiological conditions at

**Table 8.9.6. Average Radionuclide Concentrations (pCi/g<sup>(a)</sup> dry wt.)<sup>(b)</sup> in Surface Soil Samples Collected Near Hanford Site Facilities and Operations in the 300 and 400 Areas, 1999 through 2004**

Year	<sup>60</sup> Co	<sup>90</sup> Sr	<sup>137</sup> Cs	<sup>234</sup> U	<sup>238</sup> U	<sup>239/240</sup> Pu
1999	ND	0.85 ± 0.70	0.09 ± 0.10	0.70 ± 1.8	0.66 ± 1.8	0.03 ± 0.05
2000	ND	0.56 ± 0.40	0.09 ± 0.23	5.4 ± 24	5.4 ± 2.4	0.07 ± 0.21
2001	ND	ND	0.04 ± 0.08	0.94 ± 3.0	0.95 ± 3.1	0.03 ± 0.10
2002	ND	0.03 ± 0.03	0.07 ± 0.13	1.5 ± 6.4	1.5 ± 6.4	0.02 ± 0.10
2003	ND	0.06 ± 0.07	0.08 ± 0.14	1.3 ± 5.1	1.3 ± 5.2	0.08 ± 0.40
2004	ND	ND	0.09 ± 0.14	1.0 ± 2.9	1.0 ± 3.0	0.03 ± 0.07

(a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.

(b) ±2 times the standard deviation.

ND = Not detected.



**Table 8.9.7. Radionuclide Concentrations (pCi/g<sup>[a]</sup> dry wt.) in Surface Soil Samples Collected Near Hanford Site Facilities and Operations in the 300 and 400 Areas in 2004, Compared to Distant Communities and Accessible Soil Concentration Limits**

	<sup>60</sup> Co	<sup>90</sup> Sr	<sup>137</sup> Cs	<sup>234</sup> U	<sup>238</sup> U	<sup>239/240</sup> Pu
Maximum <sup>(b)</sup>	ND	ND	0.023 ± 0.04	4.7 ± 1.2	4.6 ± 1.2	0.12 ± 0.43
Average <sup>(c)</sup>	ND	ND	0.09 ± 0.14	1.0 ± 2.9	1.0 ± 3.0	0.03 ± 0.07
Distant community <sup>(c,d)</sup>	NM	0.029 ± 0.054	0.10 ± 0.16	NM	0.13 ± 0.088	0.0033 ± 0.0060
Accessible soil concentration limits (WHC-SD-EN-TI-070) <sup>(e)</sup>	7.1	2,800	30	630	370	190

- (a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.  
 (b) ± total analytical uncertainty.  
 (c) ±2 times the standard deviation.  
 (d) See Section 8.9.2.  
 (e) Hanford soil that is not behind security fences.  
 ND = Not detected.  
 NM = Not measured.

**Table 8.9.8. Radionuclide Concentrations (pCi/g<sup>[a]</sup> dry wt.)<sup>(b)</sup> in Soil Samples Collected on the Hanford Site for Environmental Restoration Contractor Projects, 2004**

Site	Sample Location <sup>(c)</sup>	<sup>60</sup> Co	<sup>90</sup> Sr	<sup>137</sup> Cs	<sup>234</sup> U	<sup>238</sup> U	<sup>239/240</sup> Pu
ERDF	D146	ND	ND	ND	0.24 ± 0.079	0.15 ± 0.057	ND
100-B/C	D153	ND	ND	0.27 ± 0.05	0.14 ± 0.049	0.10 ± 0.038	ND
100-F	D154	ND	ND	0.029 ± 0.01	0.14 ± 0.048	0.21 ± 0.063	ND
100-F	D155	ND	ND	0.25 ± 0.044	0.09 ± 0.036	0.09 ± 0.035	ND
100-N	D156	0.03 ± 0.009	0.54 ± 0.230	0.06 ± 0.017	0.14 ± 0.050	0.15 ± 0.053	ND
100-N	D157	3.7 ± 0.34	ND	2.1 ± 0.34	0.14 ± 0.050	0.16 ± 0.054	0.05 ± 0.022
100-N	D158	0.17 ± 0.02	ND	0.24 ± 0.043	0.11 ± 0.038	0.11 ± 0.04	ND
100-N	D159	0.17 ± 0.022	ND	0.35 ± 0.059	0.18 ± 0.056	0.16 ± 0.051	0.07 ± 0.031
100-KR-1	D163	0.02 ± 0.008	ND	0.31 ± 0.058	0.13 ± 0.051	0.14 ± 0.052	1.1 ± 0.30
100-B/C	D165	ND	ND	0.13 ± 0.023	0.09 ± 0.042	0.12 ± 0.050	ND
Distant communities <sup>(d,e)</sup>		NM	0.029 ± 0.054	0.10 ± 0.16	NM	0.13 ± 0.088	0.0033 ± 0.0060
Accessible soil concentration <sup>(f)</sup>		7.1	2,800	30	630	370	190

- (a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.  
 (b) ± total analytical uncertainty.  
 (c) Sampling location code. See PNNL-15222, APP. 2.  
 (d) ±2 times the standard error of the mean.  
 (e) See Section 8.9.2.  
 (f) Hanford soil that is not behind security fences.  
 ERDF = Environmental Restoration Disposal Facility.  
 ND = Not detected.  
 NM = Not measured.

specific project sites. All investigative samples are field surveyed for alpha and beta/gamma radiation and some samples are analyzed at a laboratory to identify specific radionuclides. Most samples are disposed of without being analyzed. Generally, the predominant radionuclides in investigative samples from the 100 and 200 Areas are strontium-90, cesium-137, and plutonium-239/240.

Uranium-234, uranium-235, and uranium-238 are usually found in 300 Area samples.

During 2004, there were 19 instances of radiological contamination in investigative soil samples. Of the 19, 13 were identified as speck contamination. One of the investigative soil samples was submitted for radioisotopic

analysis. Of the 19 locations, 16 were cleaned up, and the contaminated soil was disposed of onsite in burial grounds. At the remaining locations, the contamination levels did not exceed the radiological control limits for the sites and the soil was left in place. The number of investigative soil contamination incidents, range of radiation dose levels, and radionuclide concentrations in 2004 were generally within historical values (WHC-MR-0418). Contaminated soil found outside of a radiological control area was cleaned up and posted as surface contamination if the dose rate exceeded the established radiological control limit for the location.

The number and general locations of soil contamination incidents investigated during 2004 are summarized in Table 8.9.9. The number of contamination incidents investigated in 2004 and during the previous 10 years are provided in Table 8.9.10.

**Table 8.9.9. Number and Location of Soil Contamination Incidents Investigated Near Hanford Site Facilities and Operations, 2004**

<u>Location</u>	<u>Number of Incidents</u>
200-East Area tank farms	7
200-West Area tank farms	5
200-East Area burial grounds	0
200-West Area burial grounds	0
200-East Area cribs, ponds, and ditches	3
200-West Area cribs, ponds, and ditches	0
200-East Area fence lines	0
200-West Area fence lines	0
200-East Area roads and railroads	1
200-West Area road and railroads	0
200-East Area unplanned release sites	1
200-West Area unplanned release sites	0
200-East Area underground pipelines	1
200-West Area underground pipelines	0
Cross-site transfer line	0
200-East Area miscellaneous	0
200-West Area miscellaneous	1
200-North Area	0
100 Areas	0
300 Area	0
400 Area	0
600 Area	0
former 1100 Area	0
<b>Total</b>	<b>19</b>

**Table 8.9.10. Annual Number of Soil Contamination Incidents Investigated Near Hanford Site Facilities and Operations, 1994 through 2004**

<u>Year</u>	<u>Number of Incidents</u>	<u>Year</u>	<u>Number of Incidents</u>
1994	94	2000	25
1995	73	2001	20
1996	37	2002	22
1997	51	2003	30
1998	41	2004	19
1999	42		

## 8.9.2 Soil Monitoring at Site-Wide and Offsite Locations

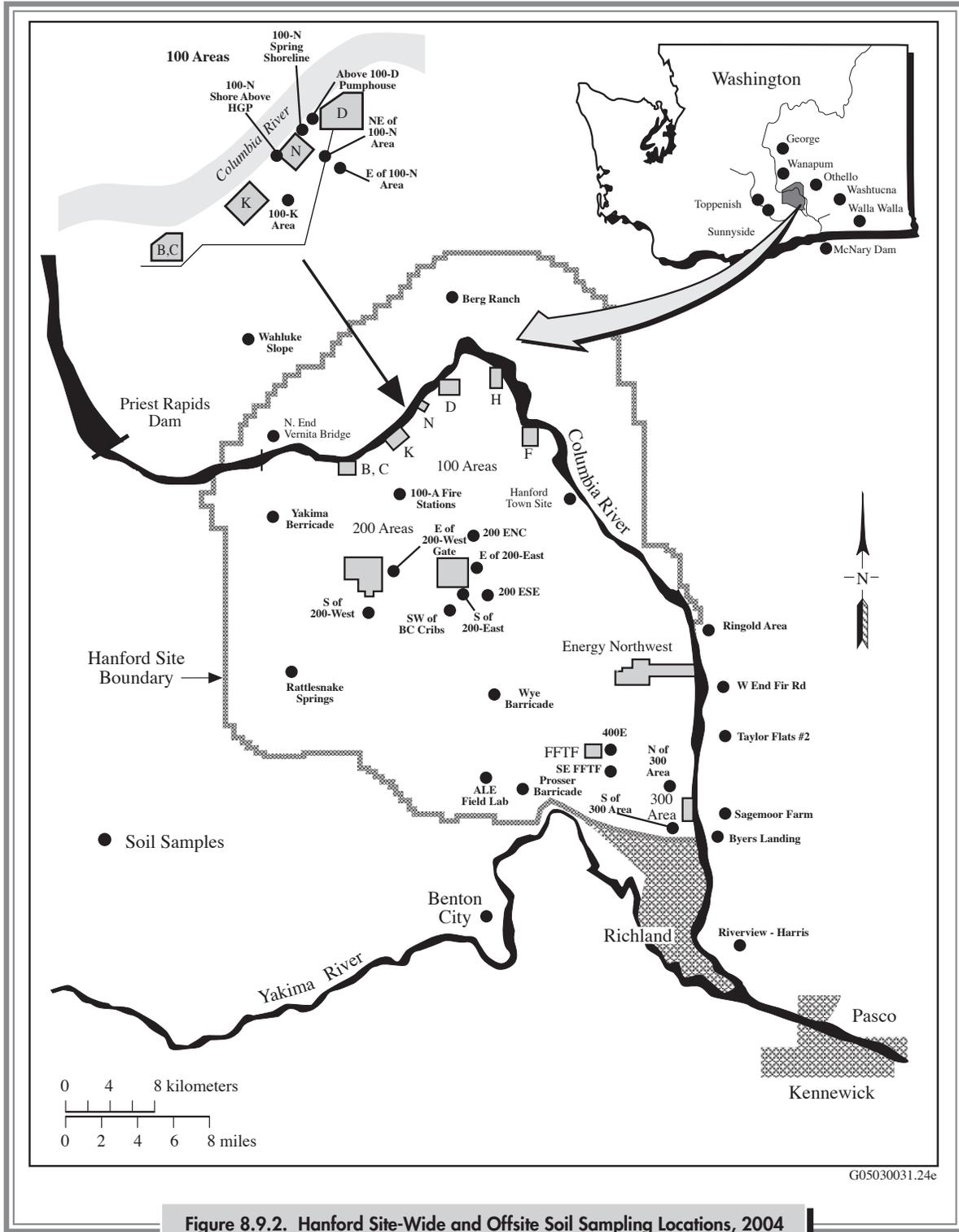
B. G. Fritz

Soil monitoring provides information on long-term contamination trends and baseline environmental radionuclide activities at undisturbed locations both on and off the Hanford Site (DOE/RL-91-50). Soil samples have been collected on and around the Hanford Site for more than 50 years. Consequently, a large database exists that documents onsite and offsite levels of manmade radionuclides in soil at specific locations. This database contains baseline data against which analysis results from unplanned contaminant releases from the Hanford Site can be compared. Routine radiological monitoring of soil at site-wide (onsite away from facilities and operations) and offsite locations was last conducted in 2001 (Section 4.6 in PNNL-13910).

### Soil Sampling at Site-Wide and Offsite Locations

In 2004, soil samples were collected at the locations shown in Figure 8.9.2. Samples were organized into four distinct groups: (1) site-wide (onsite), (2) perimeter, (3) the Fitzner/Eberhardt Arid Lands Ecology Reserve Unit of the Hanford Reach National Monument, and (4) distant. Site-wide samples were collected at undisturbed locations around areas of industrial development on the site. Perimeter samples were collected on the edge of





**Figure 8.9.2. Hanford Site-Wide and Offsite Soil Sampling Locations, 2004**

the Hanford Site and at locations in Franklin County. Two samples were collected on the Fitzner/Eberhardt Arid Lands Ecology Reserve Unit on the northeast side of Rattlesnake Mountain. Distant samples were collected at George, McNary Dam, Sunnyside, Toppenish, Walla Walla, Wanapum, and Washtucna, Washington.

Each soil sample consisted of five plugs, each 2.54 centimeters (1 inch) deep and 10.2 centimeters (4 inches) in diameter, collected within 10 meters (33 feet) of one another, and combined to form one bulk sample. Samples were collected from undisturbed areas in order to monitor materials deposited on the soil surface. Samples were dried and sieved at the laboratory prior to analysis to remove residual moisture, rocks, and plant debris.

All samples were analyzed for gamma-emitting radionuclides (Appendix F, Table F.1), strontium-90, uranium-234, uranium-235, uranium-238, plutonium-238, and plutonium-239/240. Selected samples were analyzed for americium-241 (Table 8.9.11). The 2004 analytical results were compared to results from 1993 through 2001 (Table 8.9.12).

In 2004, observed mean radionuclide activities in soil samples for all isotopes in all groups were similar to their respective averages from 1993 to 2001 (Table 8.9.12). Also, the maximum detectable concentrations for each radionuclide in each group were similar to the maximum concentrations observed between 1993 and 2001. This indicates that there has been no appreciable increase in radionuclide

concentrations in soil in the last several years. The site-wide average soil concentrations in 2004 were higher than at site perimeter or distant locations for the radionuclides measured (Table 8.9.12). This was consistent with historical data and reflected the higher site-wide soil concentrations associated with years of nuclear materials production. The sampling location east of the 200-West Area gate had the highest observed activities of any sampling location. This was consistent with historical results.

Plutonium-239/240 and cesium-137 are detected in most soil samples collected on and around the Hanford Site. The site-wide average concentration of each isotope is higher by a statistically significant amount than the average concentrations at perimeter and distant locations (two-tailed t-test, 95% confidence interval). Although there is no discernible trend in the data collected since 1993 (Figure 8.9.3), the difference is likely a result of historical Hanford operations.

In the past, soil samples from the Fitzner/Eberhardt Arid Lands Ecology Reserve Unit were included in the perimeter grouping. After the transfer of management of this reserve to the U.S. Fish and Wildlife Service in 1997, results from the Rattlesnake Springs and Arid Lands Ecology Field Laboratory stations (Figure 8.9.2) were reported separately. A separate study in 2004 involved the collection of 50 soil samples at locations across the Fitzner/Eberhardt Arid Lands Ecology Reserve Unit. This study is summarized in Section 7.0.1 of this report.

**Table 8.9.11. Sampling Information for Hanford Site-Wide and Offsite Soil Samples Collected and Analyzed, 2004**

<b>Location</b>	<b>No. of Samples</b>	<b>Frequency</b>	<b>Analytes<sup>(a)</sup></b>
Onsite <sup>(b)</sup>	20	Annual to once every 5 years	Gamma, <sup>90</sup> Sr, U <sub>iso</sub> <sup>(c)</sup> , Pu, <sup>(d)</sup> <sup>241</sup> Am
ALE <sup>(e)</sup>	2 <sup>(f)</sup>	Annual to once every 5 years	Gamma, <sup>90</sup> Sr, U <sub>iso</sub> , Pu, <sup>241</sup> Am
Perimeter	13	Annual to once every 5 years	Gamma, <sup>90</sup> Sr, U <sub>iso</sub> , Pu, <sup>241</sup> Am
Distant	7	Annual to once every 5 years	Gamma, <sup>90</sup> Sr, U <sub>iso</sub> , Pu, <sup>241</sup> Am

(a) Not all analytes are analyzed for at each location.

(b) Onsite denotes sample locations designated as "onsite." Some perimeter samples are collected inside the Hanford Site boundary.

(c) Isotopic uranium (<sup>234</sup>U, <sup>235</sup>U, <sup>238</sup>U).

(d) Plutonium-238 and plutonium-239/240.

(e) Fitzner/Eberhardt Arid Lands Ecology Reserve Unit.

(f) Two samples collected, but only one analyzed. One sample was destroyed during sample preparation at the analytical laboratory.



**Table 8.9.12. Concentrations of Selected Radionuclides (pCi/g dry wt.)<sup>(a)</sup> in Hanford Site Soil Samples Collected Site-Wide and Offsite, 2004 Compared to Previous Years**

Location	Radionuclide	2004			1993, 1994, 1998, and 2001		
		No. of Samples	No. Detected <sup>(b)</sup>	Mean <sup>(c)</sup> Maximum <sup>(d)</sup>	No. of Samples	No. Detected <sup>(b)</sup>	Mean <sup>(c)</sup> Maximum <sup>(d)</sup>
Site-Wide (Onsite)	<sup>241</sup> Am	3	1	-0.022 ± 0.15 0.065 ± 0.020	13	10	0.030 ± 0.13 0.24 ± 0.14
	<sup>239/240</sup> Pu	20	16	0.031 ± 0.46 0.52 ± 0.070	68	67	0.032 ± 0.17 0.53 ± 0.058
	<sup>238</sup> Pu	20	3	0.00052 ± 0.0056 0.0059 ± 0.0035	68	51	0.00066 ± 0.0027 0.0081 ± 0.0013
	<sup>137</sup> Cs	20	18	0.21 ± 0.98 0.99 ± 0.12	68	66	0.94 ± 4.7 12 ± 1.3
	<sup>90</sup> Sr	20	8	0.056 ± 0.32 0.31 ± 0.037	68	66	0.18 ± 0.76 3.1 ± 0.70
	<sup>238</sup> U <sup>(e)</sup>	20	15	0.14 ± 0.26 0.31 ± 0.11	68	68	0.42 ± 0.63 1.5 ± 0.29
ALE <sup>(f)</sup>	<sup>239/240</sup> Pu	1	1	0.0015 ± 0.00072 0.00021 ± 0.00026	4	4	0.0091 ± 0.0071 0.014 ± 0.0026
	<sup>238</sup> Pu	1	0		4	4	0.00029 ± 0.00025 0.00045 ± 0.00033
	<sup>137</sup> Cs	1	1	0.14 ± 0.023 -0.012 ± 0.048	4	4	0.26 ± 0.063 0.29 ± 0.039
	<sup>90</sup> Sr	1	0		4	4	0.083 ± 0.031 0.11 ± 0.022
	<sup>238</sup> U <sup>(e)</sup>	1	1	0.12 ± 0.099 0.12 ± 0.099	4	4	0.44 ± 0.84 1.0 ± 0.50
Perimeter	<sup>241</sup> Am	1	0		4	2	0.0016 ± 0.0032 0.0030 ± 0.0015
	<sup>239/240</sup> Pu	13	7	0.0035 ± 0.0076 0.011 ± 0.0048	30	30	0.0075 ± 0.011 0.030 ± 0.0044
	<sup>238</sup> Pu	13	2	0.00018 ± 0.0022 0.0019 ± 0.0022	30	21	0.00028 ± 0.00057 0.00083 ± 0.00050
	<sup>137</sup> Cs	13	12	0.14 ± 0.22 0.40 ± 0.053	30	29	0.26 ± 0.33 0.62 ± 0.073
	<sup>90</sup> Sr	13	3	0.020 ± 0.062 0.061 ± 0.032	30	27	0.062 ± 0.071 0.15 ± 0.027
	<sup>238</sup> U <sup>(e)</sup>	13	11	0.21 ± 0.42 0.81 ± 0.18	30	28	0.42 ± 0.65 1.1 ± 0.51
Distant	<sup>241</sup> Am	1			3	3	0.0051 ± 0.0027 0.0066 ± 0.0024
	<sup>239/240</sup> Pu	7	3	0.0033 ± 0.0060 0.0084 ± 0.0051	9	9	0.0071 ± 0.012 0.017 ± 0.0021
	<sup>238</sup> Pu	7	1	0.00069 ± 0.0022 0.0029 ± 0.0024	9	6	0.00028 ± 0.00042 0.00059 ± 0.00025
	<sup>137</sup> Cs	7	6	0.10 ± 0.16 0.21 ± 0.036	9	9	0.29 ± 0.49 0.74 ± 0.083
	<sup>90</sup> Sr	7	2	0.029 ± 0.054 0.074 ± 0.054	9	6	0.086 ± 0.15 0.24 ± 0.055
	<sup>238</sup> U <sup>(e)</sup>	7	5	0.13 ± 0.088 0.22 ± 0.01	9	8	0.34 ± 0.60 0.81 ± 1.14

(a) 1 pCi = 0.037 Bq.

(b) Detection is defined as a value reported above the minimum detectable activity or above the total analytical uncertainty.

(c) Reported mean values ± 2 standard deviations.

(d) Reported maximum values ± the total analytical uncertainty.

(e) Samples from 1993 and 1994 analyzed by chemical analysis; samples since 1994 analyzed by alpha spectrometry.

(f) Fitzner/Eberhardt Arid Lands Ecology Reserve Unit. In 2004, two samples were collected from this unit, but only one sample was analyzed as a result of sample loss during preparation for analysis.

