

4.1 Air Surveillance

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Atmospheric releases of radioactive material from the Hanford Site to the surrounding region are a potential source of human exposure. Radioactive constituents in air are monitored at a number of locations on and around the site. The influence of Hanford emissions on the local environment was evaluated by comparing air concentrations measured at distant locations within the region to concentrations measured at the site perimeter. This section discusses sample collection techniques and analytes tested for at each location and summarizes the analytical results of the air surveillance program. A complete listing of all analytical results summarized in this section is reported separately (PNNL-11796). A detailed description of all radiological sampling and analytical techniques is provided in the environmental monitoring plan (DOE/RL-91-50, Rev. 2).

4.1.1 Collection of Air Samples and Analytes Tested for at Each Sample Location

Airborne radionuclides were sampled at 39 continuously operating samplers: 20 on the Hanford Site, 9 near the site perimeter, 8 in nearby communities, and 2 in distant communities (Figure 4.1.1 and Table 4.1.1). Nine of the stations were community-operated environmental surveillance stations (discussed in Section 7.4, "Community-Operated Environmental Surveillance Program") that were managed and operated by local school teachers. Air samplers on the Hanford Site were located primarily around major operational areas to maximize the ability to detect radiological contaminants resulting from site operations. Perimeter samplers were located around the site, with emphasis on the prevailing downwind directions to the south and east of the site (discussed in Section 7.1, "Climate and Meteorology"). Continuous samplers located in Benton City, Richland, Kennewick, Mattawa, Othello, and Pasco provided data for the nearest population centers. Samplers in the distant communities of Toppenish,

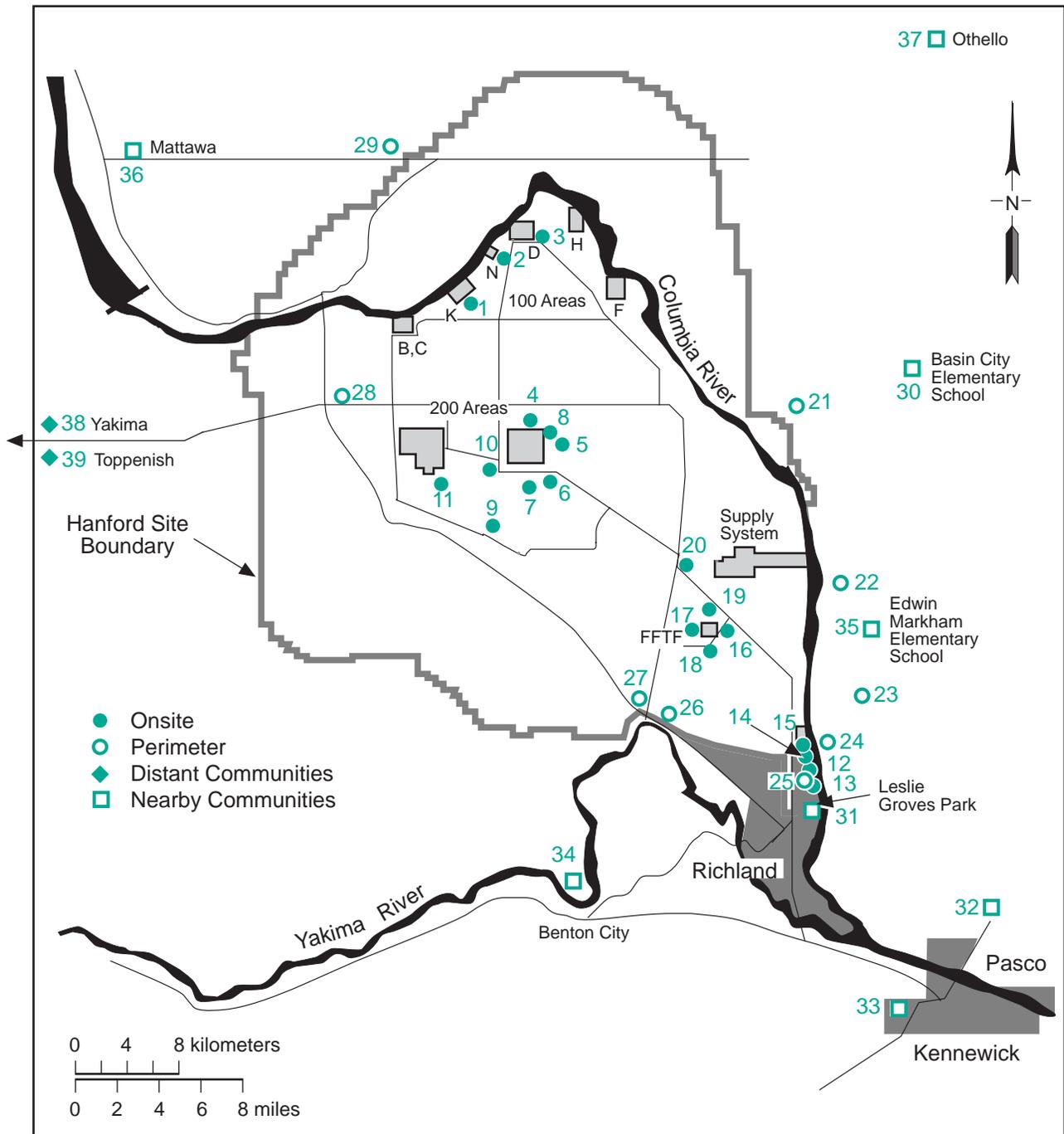
and Yakima provided background data for communities essentially unaffected by site operations.

Samples were collected according to a schedule established before the monitoring year (PNNL-11473). Air sampling locations are listed in Table 4.1.1, along with the analytes tested for at each location. Airborne particles were sampled at each of these locations by continuously drawing air through a high-efficiency glass-fiber filter. The samples were transported to an analytical laboratory and stored for at least 7 days. The storage period was necessary to allow for the decay of short-lived, naturally occurring radionuclides (e.g., radon gas decay products) that would otherwise obscure detection of longer-lived radionuclides potentially present from Hanford Site emissions. The filters were then analyzed for gross beta radioactivity, and most filters were also analyzed for gross alpha radioactivity.

For most radionuclides, the amount of radioactive material collected on the filter during the 2-week period was too small to be readily measured. The sensitivity and accuracy of sample analysis were increased by combining biweekly samples for nearby locations (or, in some cases, a single location) into quarterly or annual composite samples. The quarterly composite samples were analyzed for specific gamma-emitting radionuclides (Appendix E). The quarterly composites were then used to form annual composite samples (Table 4.1.2). Annual composites were analyzed for strontium-90 and plutonium isotopes, with selected annual composites also analyzed for uranium isotopes or gamma-emitting radionuclides.

Iodine-129 (15.7 million-year half-life) was sampled at 4 locations by drawing air through a cartridge containing chemically treated, special, low-background petroleum-charcoal positioned downstream of a particle filter. Samples were collected monthly and combined to form quarterly composite samples for each location.

Atmospheric water vapor was collected for tritium analysis at 19 locations by continuously passing air through



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Table 4.1.1. Air Sampling Locations, Sample Composite Groups, and Analyses, 1997

Map ^(a) Location	Sampling Location	Analytes ^(b)	Composite Group	Analytes ^(c)
Onsite				
1	100-K Area	Alpha, beta, ³ H	100 Areas	Gamma, Sr, Pu
2	100-N, 1325 Crib	Alpha, beta, ³ H		
3	100-D Area	Alpha, beta		
4	N of 200 East	Beta	North of 200-East	Gamma - Annual
5	E of 200E	Alpha, beta	200 E Area	Gamma, Sr, Pu, U
6	200 ESE	Alpha, beta, ³ H, ¹²⁹ I		
7	S of 200E	Alpha, beta		
8	B Pond	Alpha, beta	B Pond	Gamma, Sr, Pu, U
9	Army Loop Camp	Alpha, beta	200 West South East	Gamma, Sr, Pu, U
10	200 Tel. Exchange	Alpha, beta, ³ H		
11	200 West SE	Alpha, beta	200 West	Gamma, Sr, Pu, U
12	300 Water intake	Beta	300 Area	Gamma, Sr, Pu, U
13	300 South Gate	Alpha, beta, ³ H		
14	300 Trench	Alpha, beta, ³ H,	300 NE	Sr, Pu, U
15	300 NE	gamma - Quarterly		
16	400-East	Alpha, beta, ³ H	400 Area	Gamma, Sr, Pu
17	400-West	Alpha, beta		
18	400-South	Alpha, beta		
19	400-North	Alpha, beta		
20	Wye Barricade	Alpha, beta	Wye Barricade	Gamma, Sr, Pu, U
Perimeter				
21	Ringold Met. Tower	Alpha, beta, ³ H, ¹²⁹ I	Ringold Met. Tower	Gamma, Sr, Pu
22	W End of Fir Road	Alpha, beta	W End of Fir Road	Gamma, Sr, Pu, U
23	Dogwood Met. Tower	Alpha, beta, ³ H	Dogwood Met. Tower	Gamma, Sr, Pu, U
24	Byers Landing	Alpha, beta, ³ H, ¹²⁹ I	Byers Landing	Gamma, Sr, Pu, U
25	Battelle Complex	Beta	Battelle Complex	Gamma - Annual
26	Horn Rapids			
27	Substation Prosser Barricade	Alpha, beta ³ H	Prosser Barricade	Gamma, Sr, Pu, U
28	Yakima Barricade	Alpha, beta	Yakima Barricade	Gamma, Sr, Pu
29	Wahluke Slope	Alpha, beta, ³ H	Wahluke Slope	Gamma, Sr, Pu

Table 4.1.1. (contd)

Map ^(a) Location	Sampling Location	Analytes ^(b)	Composite Group	Analytes ^(c)
Nearby Communities				
30	Basin City ^(d)	Alpha, beta, ³ H	Basin City Elem. School	Gamma, Sr, Pu, U
31	Richland ^(d)	Alpha, beta, ³ H	Leslie Groves Park	Gamma, Sr, Pu, U
32	Pasco ^(d)	Beta	Tri-Cities	Gamma, Sr, Pu
33	Kennewick ^(d)	Alpha, beta		
34	Benton City ^(d)	Beta	Benton City	Gamma - Annual
35	North Franklin County ^(d)	Alpha, beta, ³ H	Edwin Markham Elem. School	Gamma, Sr, Pu, U
36	Mattawa ^(d)	Beta	Mattawa	Gamma - Annual
37	Othello ^(d)	Beta	Othello	Gamma - Annual
Distant Communities				
38	Yakima	Alpha, beta, ³ H, ¹²⁹ I	Yakima	Gamma, Sr, Pu, U
39	Toppenish ^(d) (Heritage College)	Alpha, beta, ³ H	Toppenish	Gamma, Sr, Pu, U

(a) See Figure 4.1.1.

(b) Alpha (gross) and beta (gross) samples are collected every 2 weeks, ³H samples are collected every 4 weeks, and ¹²⁹I samples are collected every 4 weeks and combined into a quarterly composite sample for each location.

(c) Gamma scans are performed on quarterly composite samples (or on annual composite samples [gamma - annual]); strontium-90, plutonium-isotopic, and uranium-isotopic analyses are performed on annual composite samples.

(d) A community-operated environmental surveillance station.

cartridges containing silica gel, which were exchanged every 4 weeks. The collection efficiency of the silica gel adsorbent is discussed in Patton et al. (1997). The collected water was distilled from the silica gel and analyzed for its tritium content.

Some air samples were collected at nine community-operated environmental surveillance stations (see Section 7.4, “Community-Operated Environmental Surveillance Program”) located at Basin City Elementary School in Basin City, Edwin Markham Elementary School in north Franklin County, Kiona-Benton High School in Benton City, Leslie Groves Park in Richland, Columbia Basin College in Pasco, Kennewick, Othello, Mattawa, and Heritage College in Toppenish (see Table 4.1.1). These samples were collected by local teachers as part of an ongoing DOE-sponsored program to promote public awareness of Hanford Site environmental monitoring

programs. The samples were submitted to the analytical laboratory and treated the same as all other submitted samples.

4.1.2 Radiological Results for Air Samples

Radiological air sampling results for onsite, site perimeter, nearby communities, and distant communities for gross alpha, gross beta, and specific radionuclides are summarized in Table 4.1.2.

A detectable value is defined in this section as a value reported above the 2-sigma total propagated analytical uncertainty for all analytes of interest except for gamma-emitting radioisotopes. A gamma-emitting radioisotope

Table 4.1.2. Airborne Radionuclide Concentrations in the Hanford Environs, 1997 Compared to Previous Years

Radionuclide	Location Group ^(a)	1997				1993-1996				Derived Concentration Guide ^(e)
		No. of Samples	No. of Detections ^(b)	Maximum ^(c)	Average ^(d)	No. of Samples	No. of Detections ^(b)	Maximum ^(c)	Average ^(d)	
				aCi/m ³	aCi/m ³			aCi/m ³	aCi/m ³	
Gross alpha	Onsite	457	265	5,500 ± 1,260	520 ± 27	1,799	1,486	2,300 ± 620	500 ± 15	No Standard
	Perimeter	180	114	2,000 ± 1,010	550 ± 43	740	641	2,200 ± 620	530 ± 23	
	Nearby communities	104	64	1,460 ± 972	510 ± 56	415	365	1,800 ± 530	530 ± 28	
	Distant communities	50	32	2,340 ± 1,040	410 ± 81	231 ^(f)	178	4,800 ± 920	470 ± 61	
Tritium				pCi/m ³	pCi/m ³			pCi/m ³	pCi/m ³	
	Onsite	107	29	4.9 ± 2.0	0.68 ± 0.16	429	91	610 ± 52	5.0 ± 3.93	100,000
	Perimeter	58	7	3.7 ± 5.8	0.48 ± 0.16	256	23	12 ± 22	0.9 ± 0.23	
	Nearby communities	38	5	2.1 ± 1.6	0.67 ± 0.18	157	16	120 ± 13	2.0 ± 1.61	
Distant communities	26	2	2.9 ± 3.4	0.64 ± 0.27	117	8	5.2 ± 5.0	0.60 ± 0.19		
Gross beta				pCi/m ³	pCi/m ³			pCi/m ³	pCi/m ³	
	Onsite	506	506	0.050 ± 0.007	0.015 ± 0.001	2,464	2,460	0.13 ± 0.012	0.019 ± 0.00047	No Standard
	Perimeter	204	204	0.043 ± 0.006	0.015 ± 0.001	1,035	1,029	0.15 ± 0.014	0.019 ± 0.00077	
	Nearby communities	208	208	0.044 ± 0.005	0.017 ± 0.001	806	806	0.10 ± 0.010	0.019 ± 0.00082	
Distant communities	50	50	0.037 ± 0.004	0.013 ± 0.002	286	286	0.12 ± 0.013	0.018 ± 0.0016		
Strontium-90				aCi/m ³	aCi/m ³			aCi/m ³	aCi/m ³	
	Onsite	9	1	9.6 ± 11	2.15 ± 3.2	50	17	300 ± 96	25 ± 18	9,000,000
	Perimeter	7	0	3.7 ± 9.4	0.350 ± 1.8	34	3	35 ± 11	-3.4 ± 6.6	
	Nearby communities	4	0	7.2 ± 8.5	1.35 ± 4.3	20	2	16 ± 16	-3.4 ± 6.2	
Distant communities	2	0	-3.1 ± 16	-5.28 ± 4.3	11	0	68 ± 120	3.0 ± 15		
Iodine-129	Onsite	4	4	32 ± 2.9	23 ± 13	20	20	74 ± 7.2	41 ± 5.1	70,000,000
	Perimeter	8	8	1.2 ± 0.057	0.65 ± 0.19	41	41	2.3 ± 0.28	1.2 ± 0.18	
	Distant communities	4	4	0.078 ± 0.008	0.043 ± 0.024	21	21	0.14 ± 0.02	0.067 ± 0.014	
Plutonium-238	Onsite	9	0	0.15 ± 0.26	0.017 ± 0.058	50	4	0.90 ± 0.54	-0.12 ± 0.12	30,000
	Perimeter	7	0	0.15 ± 0.28	0.021 ± 0.057	33	0	3.1 ± 4.1	-0.020 ± 0.26	
	Nearby communities	4	0	0.27 ± 0.40	0.13 ± 0.10	20	1	0.76 ± 3.5	-0.019 ± 0.18	
	Distant communities	2	0	0.09 ± 0.64	0.005 ± 0.16	11	0	0.86 ± 3.5	0.10 ± 0.24	

Table 4.1.2. (contd)

Radionuclide	Location Group ^(a)	1997				1992-1996				Derived Concentration Guide ^(e)
		No. of Samples	No. of Detections ^(b)	Maximum ^(c)	Average ^(d)	No. of Samples	No. of Detections ^(b)	Maximum ^(c)	Average ^(d)	
				aCi/m ³	aCi/m ³			aCi/m ³	aCi/m ³	
Plutonium-239,240	Onsite	9	6	2.6 ± 0.82	0.76 ± 0.54	50	24	12 ± 2.5	1.8 ± 0.70	20,000
	Perimeter	7	3	0.73 ± 0.60	0.33 ± 0.18	33	12	2.3 ± 0.92	0.59 ± 0.21	
	Nearby communities	4	2	0.67 ± 0.65	0.38 ± 0.20	20	9	1.8 ± 1.7	0.59 ± 0.36	
	Distant communities	2	0	-0.15 ± 0.43	-0.22 ± 0.16	11	3	3.9 ± 1.3	0.65 ± 0.72	
Uranium-234	Onsite	8	8	59 ± 14	30 ± 11	40	39	142 ± 208	23 ± 6.9	90,000
	Perimeter	4	4	41 ± 8.3	31 ± 11	19	19	54 ± 18	26 ± 5.5	
	Nearby communities	3	3	31 ± 6.8	26 ± 6.0	15	15	37 ± 13	24 ± 4.1	
	Distant communities	2	2	21 ± 5.6	21 ± 0.70	11	11	31 ± 10	20 ± 4.9	
Uranium-235	Onsite	8	3	2.6 ± 2.7	0.95 ± 0.54	40	13	51 ± 129	2.1 ± 2.5	100,000
	Perimeter	4	2	3.4 ± 2.1	1.2 ± 1.5	19	9	4.3 ± 4.8	1.3 ± 0.47	
	Nearby communities	3	3	1.6 ± 1.5	1.3 ± 0.42	15	6	4.3 ± 4.8	1.2 ± 0.6	
	Distant communities	2	0	0.32 ± 1.1	0.15 ± 0.34	11	2	3.3 ± 4.0	0.85 ± 0.7	
Uranium-238	Onsite	8	8	58 ± 14	28 ± 9.9	40	39	44 ± 12	17 ± 3.0	100,000
	Perimeter	4	4	43 ± 8.6	29 ± 12	19	19	42 ± 16	24 ± 4.1	
	Nearby communities	3	3	34 ± 7.2	26 ± 9.2	15	15	36 ± 11	23 ± 4.0	
	Distant communities	2	2	17 ± 5.1	17 ± 0.10	11	10	30 ± 7.5	17 ± 4.5	
Cobalt-60	Onsite	41	0	680 ± 650	74 ± 88	193	31	880 ± 490	55 ± 35	80,000,000
	Perimeter	29	0	500 ± 490	142 ± 92	142	13	740 ± 870	12 ± 42	
	Nearby communities	19	0	800 ± 560	-10 ± 150	92	5	750 ± 440	16 ± 48	
	Distant communities	8	0	640 ± 490	196 ± 190	47	7	680 ± 440	100 ± 75	
Cesium-137	Onsite	41	0	430 ± 290	47 ± 61	193	23	570 ± 420	35 ± 39	400,000,000
	Perimeter	29	0	660 ± 210	-32 ± 110	142	10	650 ± 410	23 ± 35	
	Nearby communities	19	0	500 ± 480	54 ± 120	92	7	710 ± 330	47 ± 37	
	Distant communities	8	0	370 ± 700	-27 ± 230	47	2	390 ± 290	47 ± 53	

(a) Location groups are identified in Table 4.1.1.

(b) Detect is a result reported greater than the 2-sigma total propagated analytical uncertainty.

(c) Maximum single sample result ± total propagated analytical uncertainty at 2-sigma. Negative concentration values are explained in the section "Helpful Information."

(d) Average of all samples ±2 times the standard error of the mean.

(e) DOE derived concentration guide (DOE Order 5400.5; see Appendix C, Table C.5).

(f) Two results from the distant communities were excluded as anomalous values through the use of a Q-test (26,300 ± 3,400 aCi/m³ at Sunnyside and 8,000 ± 1,000 aCi/m³ at Yakima [Skoog and West 1980]).

is detectable if the radionuclide library of the software determines an isotope concentration above the minimum detectable activity of a sample. The nominal detection limit is defined as the average 2-sigma total propagated analytical uncertainty of the population of reported values.

The average concentration of gross alpha radioactivity at the site perimeter was not elevated compared to the concentrations measured at distant stations (see Table 4.1.2) and was similar to values reported for 1993 through 1996 (Figure 4.1.2). The highest onsite gross alpha radioactivity concentration was in the 200 West South East sampling site (location 11 on Figure 4.1.1).

Tritium concentrations measured in 1997 were similar to values reported for 1993 through 1996 (see Table 4.1.2) and did not show the highly elevated concentrations and widely variable results reported for 1992 (Section 4.2 in PNL-8682). The 1992 results are highly suspect and are likely the result of cross-contamination at the analytical laboratory because even the concentrations at distant locations were high and variable. For 1997, only 43 of the 229 samples analyzed for tritium had results reported above the detection limit. The methodology is capable of detecting concentrations of no less than 1 pCi/m³, and the majority of the samples had concentrations of tritium below this detection limit. The annual average tritium concentration measured at the site perimeter (0.48 ± 0.16 pCi/m³) was significantly lower (log transformed, two-tailed t-test, 5% significance level) than the annual average value at the distant locations (0.64 ± 0.27 pCi/m³). The annual average tritium concentration at the site perimeter in 1997 was less than 0.0005% of the 100,000-pCi/m³ DOE derived concentration guide (DOE Order 5400.5).

Gross beta concentrations in air for 1997 (Figure 4.1.3) peaked during the winter, repeating a pattern of natural annual radioactivity fluctuations (Eisenbud 1987). The average gross beta concentration was slightly higher at the site perimeter than the annual average value at the distant location; however the difference was not statistically significant (log transformed, two-tailed t-test, 5% significance level), indicating that the observed levels were predominantly a result of natural sources and worldwide radioactive fallout.

Only one of the 22 strontium-90 results for air samples for 1997 was above the detection limit (see Table 4.1.2). The nominal detection limit of the 22 sample results is 8 aCi/m³. The one detected concentration ($9.3 \pm$

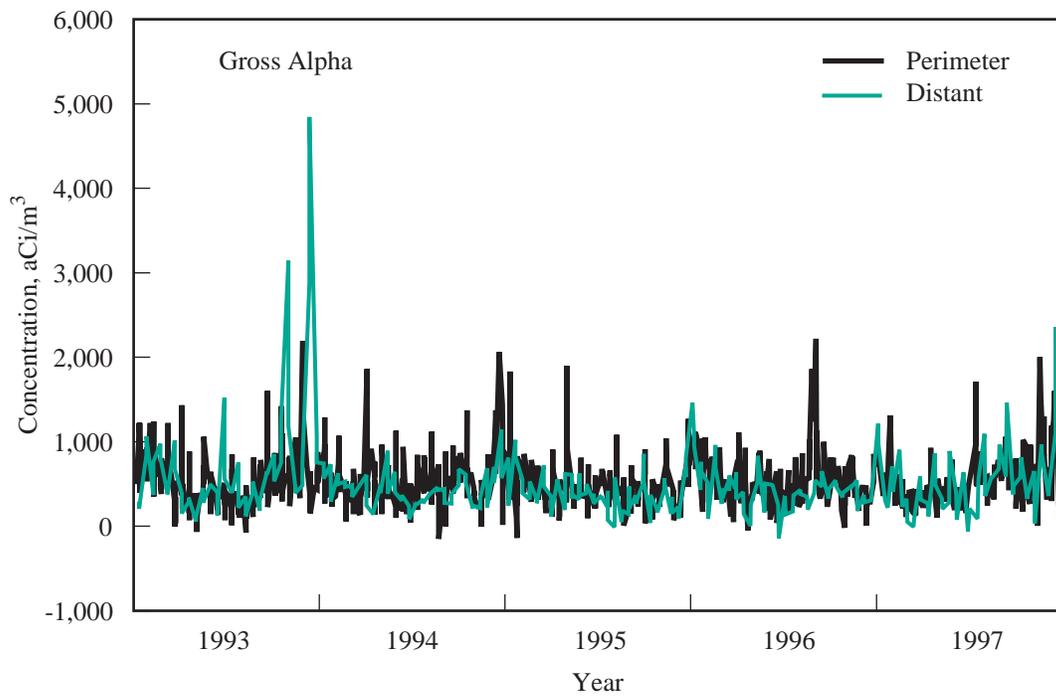
6.3 aCi/m³) was determined for the 200-East Area composite sample (locations 5, 6, and 7 on Figure 4.1.1), and this concentration is 0.0001% of the 9,000,000-aCi/m³ derived concentration guide.

Iodine-129 was sampled downwind of the Plutonium-Uranium Extraction Plant, at two downwind perimeter locations, and at a distant location (Yakima) in 1997 (see Figure 4.1.1). Onsite concentrations in 1997 were elevated compared to those measured at the site perimeter, and perimeter concentrations were higher than those measured at Yakima, the distant location (Figure 4.1.4 and see Table 4.1.2). Iodine-129 concentration differences between these locations were statistically significant (log transformed, two-tailed t-test, 5% significance level) and indicated a Hanford source. Onsite and perimeter air concentrations have remained at their respective levels from 1992 through 1997 (see Figure 4.1.4). Onsite air concentrations of iodine-129 were influenced by minor emissions (0.0039 Ci; see Table 3.1.1) from the Plutonium-Uranium Extraction Plant and possible releases from waste storage tanks and cribs. The annual average iodine-129 concentration at the downwind perimeter in 1997 (0.65 ± 0.19 aCi/m³) was less than 0.000001% of the 70,000,000-aCi/m³ derived concentration guide.

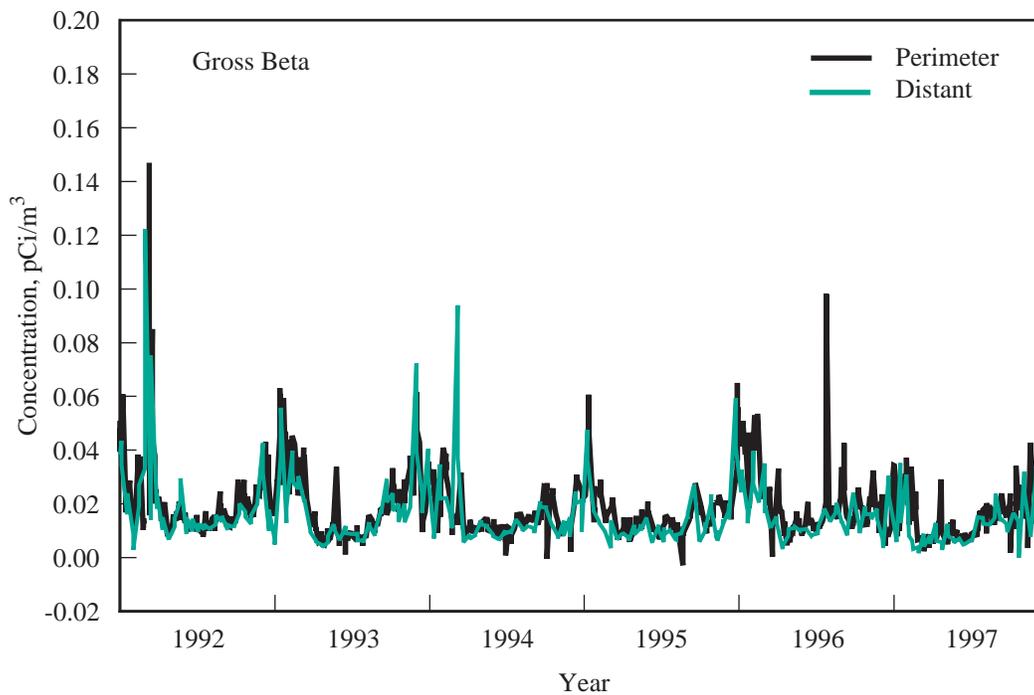
Plutonium-238 was not detected in any of the 22 air samples for 1997 (nominal detection limit of 0.1 aCi/m³). The plutonium-238 nominal detection limit represents 0.0003% of the 30,000-aCi/m³ derived concentration guide.

The average plutonium-239,240 concentrations detected in onsite and offsite air samples are given in Table 4.1.2 and Figure 4.1.5. The annual average air concentration of plutonium-239,240 at the site perimeter was 0.33 ± 0.18 aCi/m³, which is less than 0.002% of the 20,000-aCi/m³ derived concentration guide. The annual average air concentration was higher for the site perimeter locations than the distant locations (0.11 ± 0.11 aCi/m³) and was statistically significant (log transformed, two-tailed t-test, 5% significance level), indicating a Hanford influence. The maximum Hanford Site plutonium-239,240 air concentration (2.6 ± 0.82 aCi/m³) was determined for the 200-West Area composite sample (location 11 on Figure 4.1.1). This represents less than 0.02% of the 20,000-aCi/m³ derived concentration guide.

Average uranium isotopic concentrations (uranium-234, uranium-235, and uranium-238) in airborne particulate matter in 1997 were similar on the site, at the site perimeter, and at distant communities (see Table 4.1.2 and



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Figure 4.1.2. Gross Alpha in Airborne Particulate Samples, 1993 Through 1997

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Figure 4.1.3. Gross Beta in Airborne Particulate Samples, 1992 Through 1997

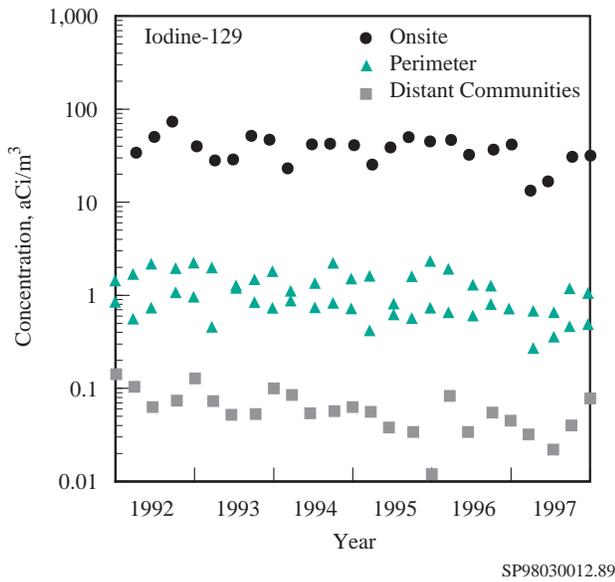


Figure 4.1.4. Iodine-129 Concentrations in Air, 1992 Through 1997

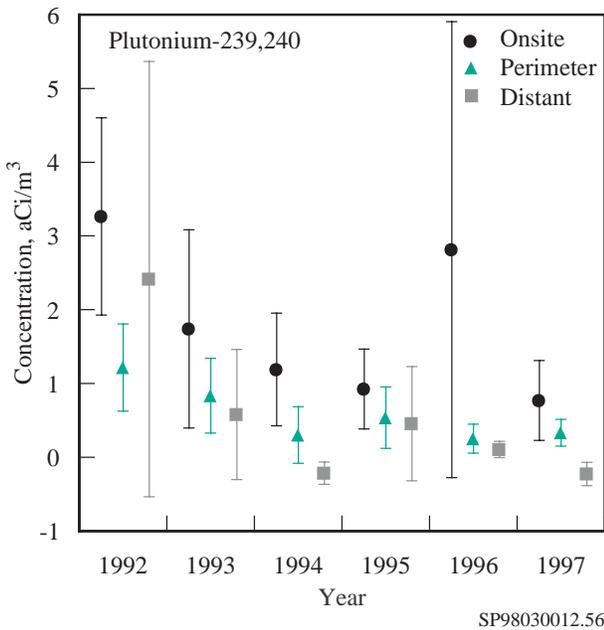


Figure 4.1.5. Annual Average Plutonium-239,240 Concentrations (± 2 standard error of the mean) in Air, 1992 Through 1997

Figure 4.1.6). The 1997 annual average concentration of uranium-238 for the site perimeter was 29 ± 12 aCi/m³, which was 0.03% of the 100,000-aCi/m³ derived concentration guide.

Samples were analyzed quarterly, and at some locations annually, by gamma spectroscopy. Naturally occurring beryllium-7 and potassium-40 were routinely identified. The potential Hanford-origin gamma-emitting radionuclides of cobalt-60 and cesium-137 associated with airborne particulate matter were monitored by gamma spectroscopy. Of the 97 samples analyzed by gamma spectroscopy, none of the samples had concentrations above the minimum detectable activity for the sample for that isotope. The cobalt-60 and cesium-137 results for 1997 samples are included in Table 4.1.2. Even the maximum individual measurements for these radionuclides (800 ± 560 and 660 ± 210 aCi/m³, respectively) were less than 0.001% of their derived concentration guides.

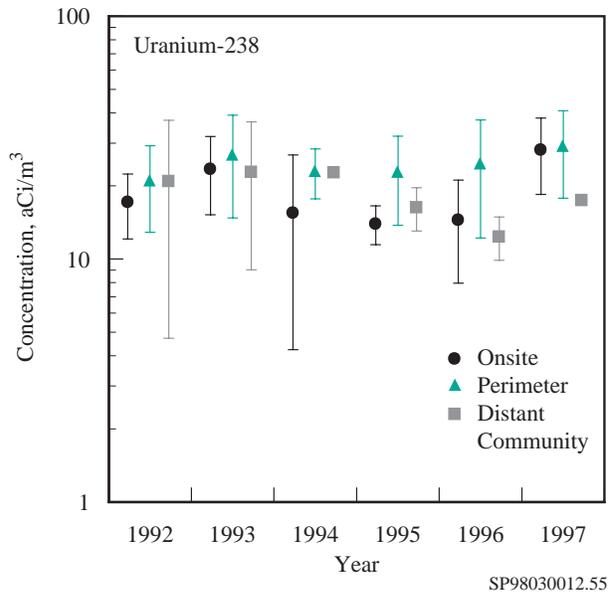


Figure 4.1.6. Annual Average Uranium-238 Concentrations (± 2 standard error of the mean) in Air, 1992 Through 1997