
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 Hanford air surveillance program. A complete listing of all analytical results summarized in this section is reported separately by Bisping (1997). A detailed description of all radiological sampling and analytical techniques is provided in the DOE (1994a) environmental monitoring plan.

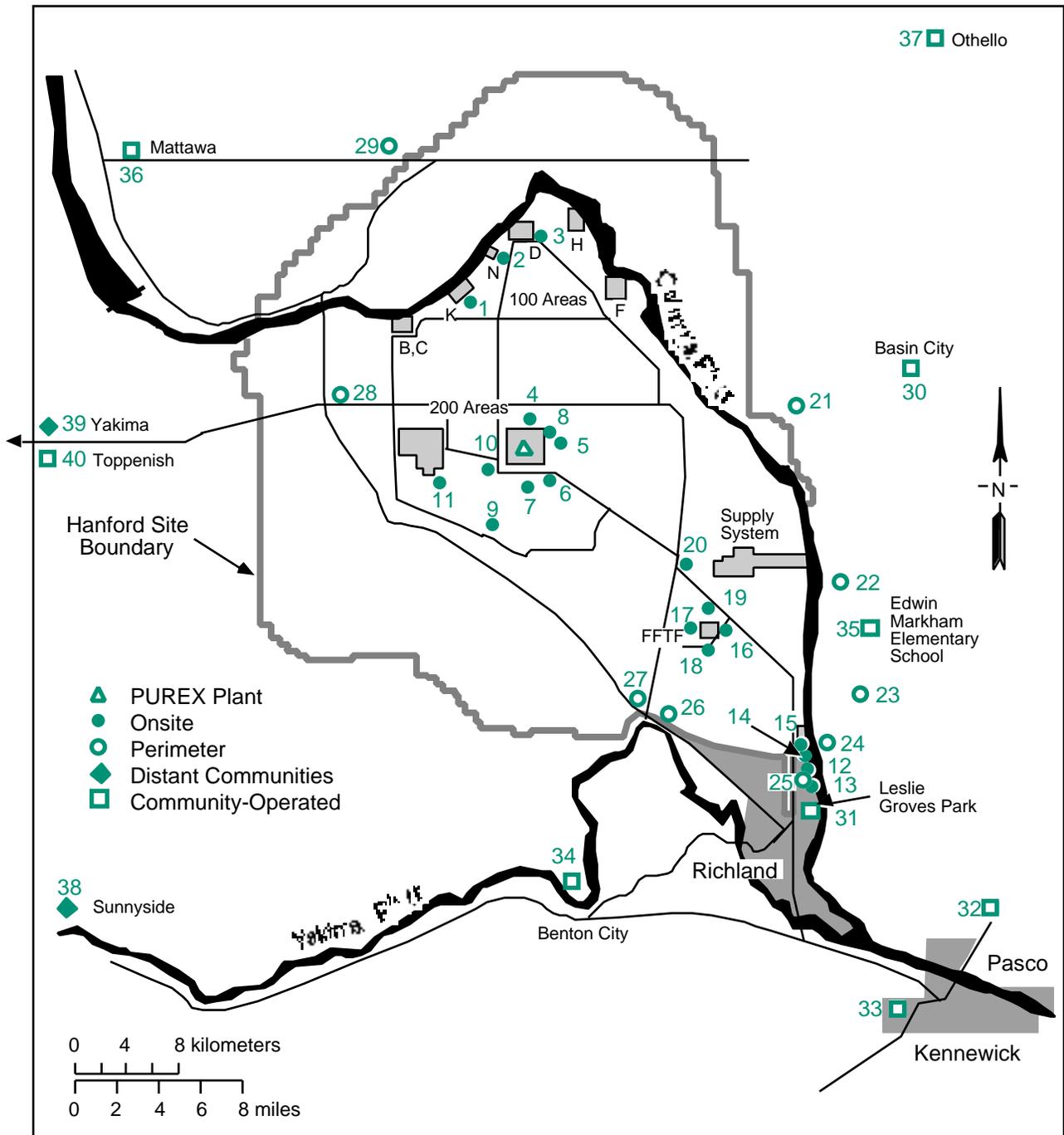
Collection of Air Samples and Analytes Tested for at Each Sample Location

Airborne radionuclides were sampled at 40 continuously operating samplers: 20 on the Hanford Site, 9 near the site perimeter, 8 in nearby communities, and 3 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 6.4, “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 6.1, “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 Sunnyside, 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 (Bisping 1996). 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 filters were collected every 2 weeks and field surveyed with hand-held instruments for total radioactivity to detect any unusual occurrences. Field measurements of radioactivity in samples were used to monitor changes in environmental conditions that could warrant attention before the more detailed and sensitive laboratory analyses were completed. 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 emissions. The filters were then analyzed for total beta radioactivity and most filters were also analyzed for total 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 (16 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.



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Figure 4.1.1. Air Sampling Locations, 1996 (see Table 4.1.1 for location names)

Table 4.1.1. Air Sampling Locations, Sample Composite Groups, and Analyses, 1996

Map ^(a) Location	Sampling Location	Analytes ^(b)	Composite Group	Analytes ^(c)
Onsite				
1	100-K	Beta, alpha, ³ H	100 Areas	Gamma, Sr, Pu
2	100-N, 1325 Crib	Beta, alpha, ³ H		
3	100-D	Beta, alpha		
4	N of 200-East	Beta	North of 200-East	Gamma - Annual
5	S of 200-East	Beta, alpha	South of 200-East East of 200-East 200-East SE	Gamma, Sr, Pu, U
6	E of 200-East	Beta, alpha		
7	200-East SE	Beta, alpha, ³ H, ¹²⁹ I		
8	B Pond	Beta, alpha	B Pond	Gamma, Sr, Pu, U
9	Army Loop Camp	Beta, alpha	200-West, South, and East	Gamma, Sr, Pu, U
10	GTE Building	Beta, alpha, ³ H		
11	200-West SE	Beta, alpha	200-West	Gamma, Sr, Pu, U
12	300 Water intake	Beta	300 Area	Gamma, Sr, Pu, U
13	300-South Gate	Beta, alpha, ³ H		
14	300 Trench	Beta, alpha, ³ H	300 NE	Gamma, Sr, Pu, U
15	300 NE	Beta, alpha, ³ H		
16	400-East	Beta, alpha, ³ H	400 Area	Gamma, Sr, Pu
17	400-West	Beta, alpha		
18	400-South	Beta, alpha		
19	400-North	Beta, alpha		
20	Wye Barricade	Beta, alpha	Wye Barricade	Gamma, Sr, Pu, U
Perimeter				
21	Ringold Met. Tower	Beta, alpha, ³ H, ¹²⁹ I	Ringold Met. Tower	Gamma, Sr, Pu
22	W End of Fir Road	Beta, alpha	W End of Fir Road	Gamma, Sr, Pu, U
23	Dogwood Met. Tower	Beta, alpha, ³ H	Dogwood Met. Tower	Gamma, Sr, Pu, U
24	Byers Landing	Beta, alpha, ³ H, ¹²⁹ I	Byers Landing	Gamma, Sr, Pu, U
25	Battelle Complex	Beta	Battelle Complex	Gamma - Annual
26	Horn Rapids Road	Beta, alpha	Prosser Barricade	Gamma, Sr, Pu, U
27	Prosser Barricade	Beta, alpha, ³ H		
28	Yakima Barricade	Beta, alpha	Yakima Barricade	Gamma, Sr, Pu
29	Wahluke Slope	Beta, alpha, 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)	Beta, alpha, ³ H	Basin City Elem. School	Gamma, Sr, Pu, U
31	Richland ^(d)	Beta, alpha, ³ H	Leslie Groves Park	Gamma, Sr, Pu, U
32	Pasco ^(d)	Beta	} Tri-Cities	Gamma, Sr, Pu
33	Kennewick ^(d)	Beta, alpha		
34	Benton City ^(d)	Beta	Benton City	Gamma - Annual
35	North Franklin County ^(d)	Beta, alpha, 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	Sunnyside ^(e)	Beta, alpha, ³ H	Sunnyside	Gamma, Sr, Pu, U
39	Yakima	Beta, alpha, ³ H, ¹²⁹ I	Yakima	Gamma, Sr, Pu, U
40	Toppenish ^(d)	Beta, alpha, ³ H	Toppenish	Gamma, Sr, Pu, U

(a) See Figure 4.1.1.

(b) Alpha (total) and beta (total) 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]); Sr, Pu, and U analyses are performed on annual composite samples.

(d) A community-operated environmental surveillance station.

(e) Discontinued after March 30, 1996.

Atmospheric water vapor was collected for tritium analysis at 19 locations by continuously passing air through 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 of the environmental surveillance air samples were collected at nine community-operated environmental surveillance stations (see Section 6.4) 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 environmental monitoring programs.

Radiological Results for Air Samples

Radiological air sampling results for onsite, site perimeter, nearby communities, and distant communities for total alpha, total beta, and specific radionuclides are summarized in Table 4.1.2. Some specific radionuclides (cobalt-60, cesium-134, cesium-137, and europium-154) were occasionally (+94% of results were below detection

Table 4.1.2. Airborne Radionuclide Concentrations in the Hanford Environs, 1996 Compared to Values from Previous Years

Radionuclide	Location Group ^(a)	1996				1993-1995				Derived Concentration Guide ^(c)
		No. of Samples	No. of Detects ^(b)	Maximum ^(c)	Average ^(d)	No. of Samples	No. of Detects ^(b)	Maximum ^(c)	Average ^(d)	
Total alpha	Onsite	425	356	2000 ± 580	520 ± 31	1,374	1,130	2300 ± 620	490 ± 17	No Standard
	Perimeter	180	160	2200 ± 600	550 ± 45	564	485	2200 ± 620	520 ± 27	
	Nearby Communities	107	88	1500 ± 490	510 ± 56	311	280	1800 ± 530	530 ± 32	
	Distant Communities	58	45	1200 ± 430	410 ± 63	173 ^(d)	133	4800 ± 920	490 ± 78	
Tritium	Onsite	99	15	2.8 ± 2.4	0.60 ± 0.12	298	2	610 ± 52	6.9 ± 5.6	pCi/m ³
	Perimeter	64	3	5.2 ± 2.4	0.42 ± 0.18	0	0	12 ± 22	1.1 ± 0.29	
	Nearby Communities	39	2	1.4 ± 2.4	0.52 ± 0.14	115	11	120 ± 13	2.6 ± 2.2	
	Distant Communities	31	0	1.3 ± 1.6	0.30 ± 0.17	88	2	5.2 ± 5.0	0.71 ± 0.24	
Total beta	Onsite	477	476	0.070 ± 0.0070	0.020 ± 0.0010	2,556	2,554	0.13 ± 0.012	0.020 ± 0.00051	No Standard
	Perimeter	203	202	0.098 ± 0.010	0.021 ± 0.0019	1,157	1,153	0.15 ± 0.014	0.019 ± 0.00077	
	Nearby Communities	210	210	0.059 ± 0.0060	0.019 ± 0.0014	856	856	0.10 ± 0.0098	0.019 ± 0.00085	
	Distant Communities	58	58	0.041 ± 0.0046	0.017 ± 0.0021	305	305	0.12 ± 0.013	0.018 ± 0.0016	
⁹⁰ Sr	Onsite	9	8	160 ± 34	67 ± 38	82	18	4200 ± 810	110 ± 130	aCi/m ³
	Perimeter	7	3	35 ± 11	13 ± 8.3	42	8	2300 ± 430	210 ± 180	
	Nearby Communities	4	2	16 ± 16	10 ± 4.9	33	8	6300 ± 1200	260 ± 400	
	Distant Communities	2	0	3.2 ± 15	0.92 ± 4.5	21	1	68 ± 120	-5 ± 12	
¹²⁹ I	Onsite	4	4	47 ± 7.1	40 ± 6.2	20	20	74 ± 7.2	43 ± 5.7	70,000,000
	Perimeter	8	8	1.9 ± 0.2	1.2 ± 0.38	40	40	2.5 ± 0.13	1.3 ± 0.19	
	Nearby Communities	4	4	0.083 ± 0.01	0.054 ± 0.021	20	20	0.15 ± 0.013	0.075 ± 0.017	
	Distant Communities	4	4	0.083 ± 0.01	0.054 ± 0.021	20	20	0.15 ± 0.013	0.075 ± 0.017	
²³⁸ Pu	Onsite	9	1	0.39 ± 0.38	0.064 ± 0.11	82	9	2.0 ± 1.2	0.16 ± 0.14	30,000
	Perimeter	7	0	0.33 ± 0.35	0.056 ± 0.11	41	3	3.1 ± 4.1	0.18 ± 0.28	
	Nearby Communities	4	1	0.24 ± 0.24	0.035 ± 0.16	33	1	1.8 ± 1.6	0.12 ± 0.17	
	Distant Communities	2	0	-0.20 ± 0.21	-0.24 ± 0.087	21	2	2.1 ± 1.9	0.32 ± 0.32	

Table 4.1.2. (contd)

Radionuclide	Location Group ^(a)	1996			1991-1995			Derived Concentration Guide ^(e)	
		No. of Samples	No. of Detects ^(b)	Maximum ^(c) aCi/m ³	Average ^(d) aCi/m ³	No. of Samples	No. of Detects ^(b)		Maximum ^(c) aCi/m ³
^{239,240} Pu	Onsite	9	4	12 ± 2.5	2.8 ± 3.1	82	41	13 ± 3.0	1.7 ± 0.47
	Perimeter	7	1	0.82 ± 0.46	0.25 ± 0.20	41	17	2.5 ± 2.0	0.67 ± 0.21
	Nearby Communities	4	1	0.27 ± 0.42	0.19 ± 0.095	33	14	3.3 ± 1.5	0.74 ± 0.31
	Distant Communities	2	0	0.16 ± 0.58	0.11 ± 0.11	21	4	3.9 ± 1.3	0.59 ± 0.46
²³⁵ U	Onsite	7	7	33 ± 7.2	17 ± 7.4	66	63	3500 ± 330	100 ± 110
	Perimeter	4	4	45 ± 8.9	27 ± 15	24	24	54 ± 18	28 ± 4.5
	Nearby Communities	3	3	26 ± 6.6	20 ± 5.7	21	21	44 ± 12	26 ± 3.8
	Distant Communities	2	2	15 ± 4.3	12 ± 6.3	21	21	40 ± 7.8	23 ± 3.6
²³⁵ U	Onsite	7	1	1.2 ± 0.81	0.45 ± 0.35	66	21	370 ± 39	8.8 ± 12
	Perimeter	4	3	2.1 ± 2.1	1 ± 0.72	24	11	4.3 ± 4.6	1.5 ± 0.46
	Nearby Communities	3	2	1.4 ± 1.8	1.1 ± 0.34	21	6	4.3 ± 4.8	1.2 ± 0.63
	Distant Communities	2	0	-0.016 ± 0.76	-0.084 ± 0.14	21	6	11 ± 4	2.0 ± 1.2
²³⁸ U	Onsite	7	7	30 ± 5	15 ± 6.6	66	64	2400 ± 230	72 ± 78
	Perimeter	4	4	40 ± 8.3	25 ± 13	24	24	54 ± 14	26 ± 3.9
	Nearby Communities	3	3	24 ± 6.4	20 ± 4.3	21	21	40 ± 11	26 ± 3.7
	Distant Communities	2	2	14 ± 4.1	12 ± 2.5	21	19	230 ± 30	35 ± 21
⁶⁰ Co	Onsite	39	4	570 ± 250	50 ± 87	190	32	880 ± 490	46 ± 33
	Perimeter	29	2	740 ± 870	3.3 ± 110	124	11	770 ± 1000	15 ± 44
	Nearby Communities	19	1	750 ± 440	9.2 ± 150	84	4	520 ± 270	5.8 ± 44
	Distant Communities	9	1	680 ± 440	220 ± 220	47	7	680 ± 640	59 ± 65
¹³⁷ Cs	Onsite	39	3	570 ± 420	-26 ± 150	190	28	550 ± 440	53 ± 25
	Perimeter	29	1	380 ± 310	-20 ± 81	124	11	650 ± 410	30 ± 38
	Nearby Communities	19	2	710 ± 330	130 ± 98	84	5	390 ± 280	25 ± 33
	Distant Communities	9	1	390 ± 290	110 ± 150	47	2	490 ± 270	17 ± 56

(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) From 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]).

limits) identified in the quarterly or annual composite gamma-ray spectroscopy analyses (see Appendix E) but none of Hanford origin was detected consistently. A detectable value is defined in this section as a value reported above the 2-sigma total propagated analytical uncertainty. 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 total alpha radioactivity at the site perimeter was elevated compared to the concentrations measured at distant stations (see Table 4.1.2), and the difference was statistically significant (log transformed, two-tailed t-test, 5% significance level). However, the concentrations were not beyond the range of measurements from the previous 3 years (Figure 4.1.2).

Tritium concentrations measured in 1996 were similar to values reported for 1993 through 1995 (see Table 4.1.2) and did not show the highly elevated concentrations and widely variable results reported for 1991 and 1992 (Woodruff et al. 1993). The 1991 and 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 1996, only 20 of the 233 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 (0.42 ± 0.18 pCi/m³) was slightly elevated compared to the annual average value at the distant locations (0.30 ± 0.17 pCi/m³); however, the difference was not statistically significant (log transformed, two-tailed t-test, 5% significance level). The annual average tritium concentration at the site perimeter in 1996 was less than 0.0004% of the 100,000-pCi/m³ DOE derived concentration guide (DOE Order 5400.5).

Total beta concentrations in air for 1996 (Figure 4.1.3) peaked during the winter, repeating a pattern of natural annual radioactivity fluctuations (Eisenbud 1987). The average total beta concentrations were slightly higher at the site perimeter compared to 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.

Thirteen of the 22 strontium-90 results for air samples for 1996 were above the detection limit (see Table 4.1.2). Of the detectable concentrations, eight were onsite locations,

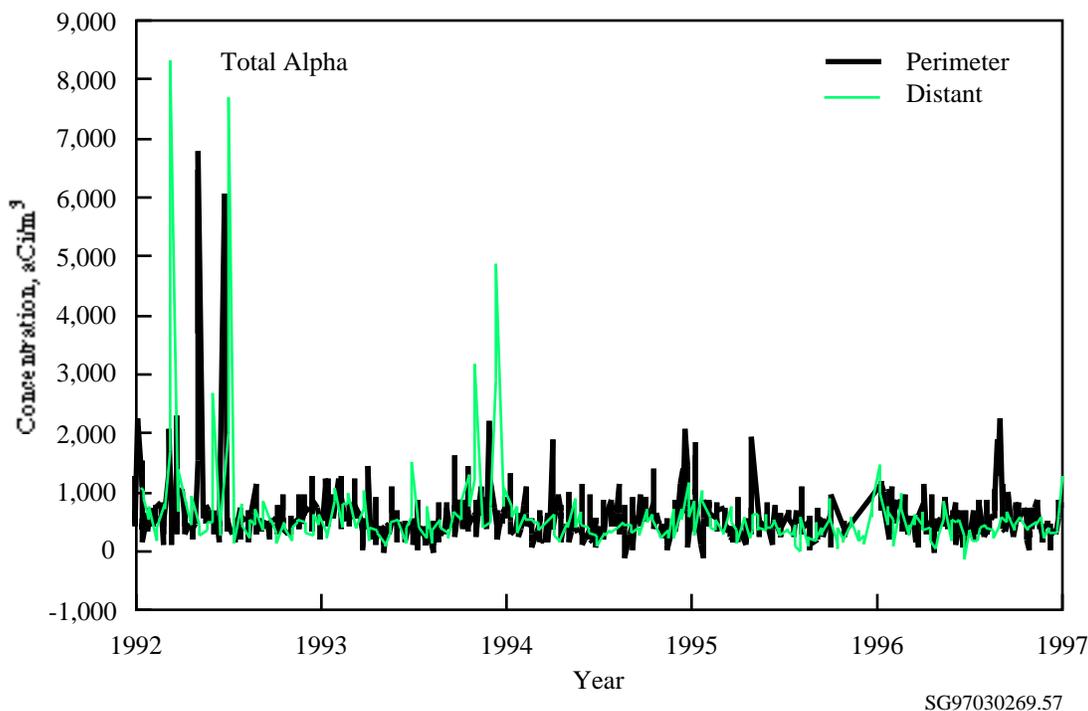


Figure 4.1.2. Total Alpha Radioactivity in Airborne Particulate Samples, 1992 Through 1996

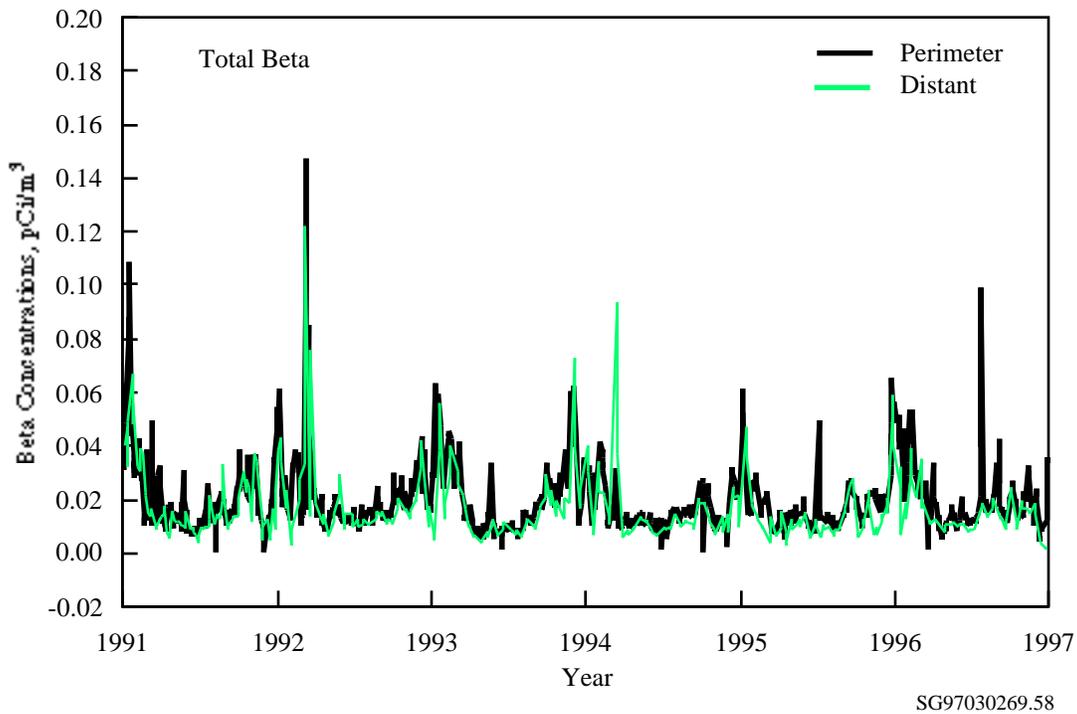


Figure 4.1.3. Total Beta Radioactivity in Airborne Particulate Samples, 1991 Through 1996

three were perimeter locations, and two were nearby community locations. The nominal detection limit of the 22 sample results is 15 aCi/m³. The highest concentration (160 ± 34 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 less than 0.002% of the 9-million-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 1996 (see Figure 4.1.1). Onsite concentrations in 1996 were elevated compared to those measured at the site perimeter, and perimeter concentrations were higher than those measured at Yakima, the distant location (see Figure 4.1.4 and 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 1991 through 1996 (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 1996 (1.2 ± 0.38 aCi/m³) was 0.000003% of the 70-million-aCi/m³ derived concentration guide.

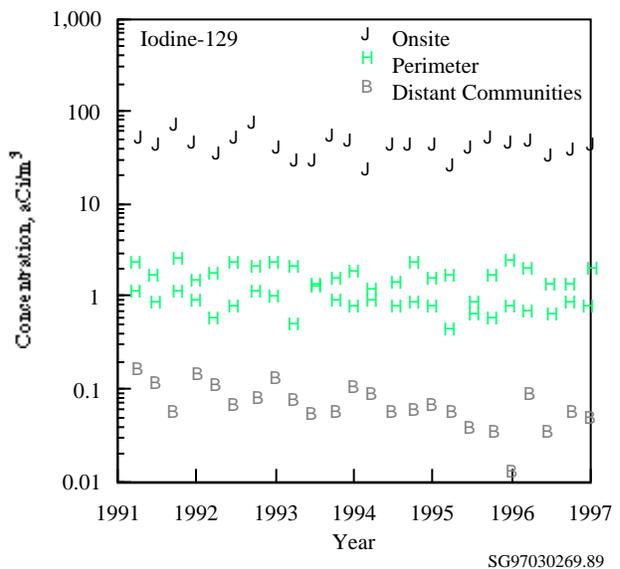


Figure 4.1.4. Concentrations of Iodine-129 in Air, 1991 Through 1996

Plutonium-238 was detected at two locations, one community location and one onsite location, in air samples for 1996 (nominal detection limit of 1 aCi/m³). The onsite location, 200-West Area (location 11 on Figure 4.1.1), was 0.39 ± 0.38 aCi/m³. The community location, Tri-City composite sample (locations 32 and 33 on Figure 4.1.1), was at its detection limit of 0.24 aCi/m³. These plutonium-238 values were well below the nominal detection limit and represents 0.003% 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 0.25 ± 0.20 aCi/m³, which is 0.001% of the 20,000-aCi/m³ derived concentration guide. The annual average air concentration was slightly higher for the site perimeter locations compared to the distant locations (0.11 ± 0.11 aCi/m³); however, this difference was not statistically significant (log transformed, two-tailed t-test, 5% significance level). The maximum Hanford Site plutonium-239,240 air concentration (12 ± 2.5 aCi/m³) was determined for the 200-East Area composite sample (locations 5, 6 and 7 on Figure 4.1.1). This represents 0.06% of the 20,000-aCi/m³ derived concentration guide.

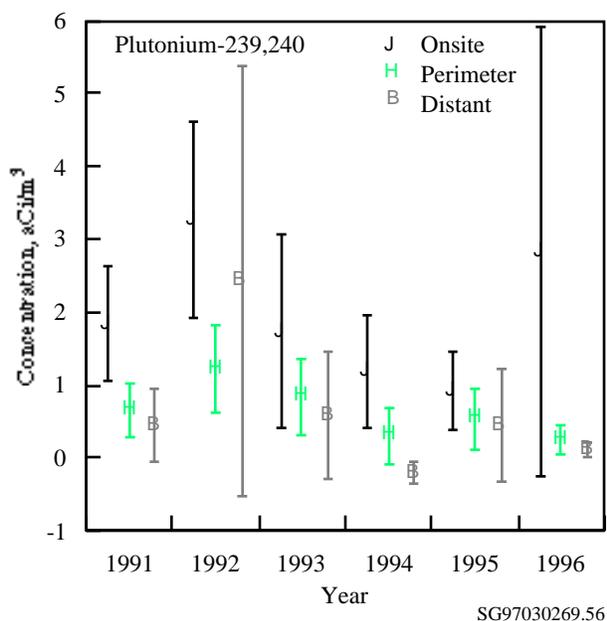


Figure 4.1.5. Annual Average Concentrations (\pm standard error of the mean) of Plutonium-239,240 in Air, 1991 Through 1996

Uranium isotopic concentrations (uranium-234, uranium-235, and uranium-238) in airborne particulate matter in 1996 were similar on the site, at the site perimeter, and at distant communities (see Table 4.1.2 and Figure 4.1.6). The 1996 annual average concentration of uranium-238 for the site perimeter was 25 ± 13 aCi/m³, which was 0.03% of the 100,000-aCi/m³ derived concentration guide.

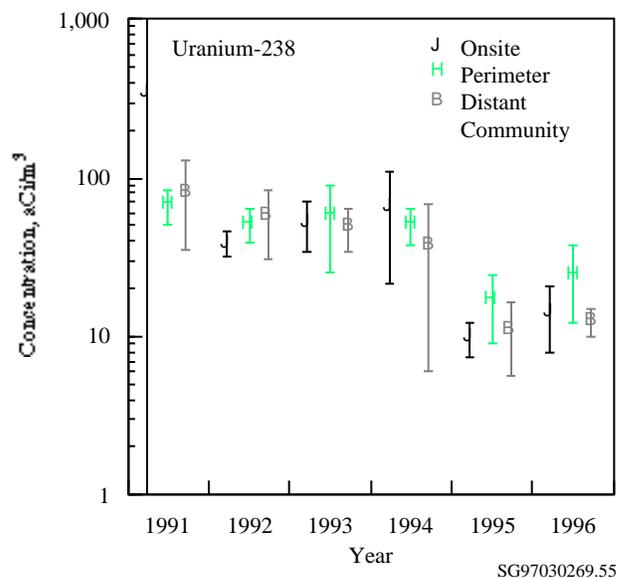


Figure 4.1.6. Annual Average Concentrations (\pm standard error of the mean) of Uranium-238 in Air, 1991 Through 1996

Samples were analyzed quarterly, and at some locations only annually, by gamma-ray 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-ray spectroscopy. Results were generally below detectable concentrations both on and off the Hanford Site. Of the 96 samples analyzed by gamma-ray spectroscopy, only 8 of the cobalt-60 and 7 of the cesium-137 samples had concentrations above the detection limits. The cobalt-60 and cesium-137 results for 1996 samples are included in Table 4.1.2. Even the maximum individual measurements for these radionuclides, 750 ± 440 and 710 ± 330 aCi/m³, and their nominal detection limits of 400 and 370 aCi/m³, respectively, were less than 0.001% of their derived concentration guide.