



## 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

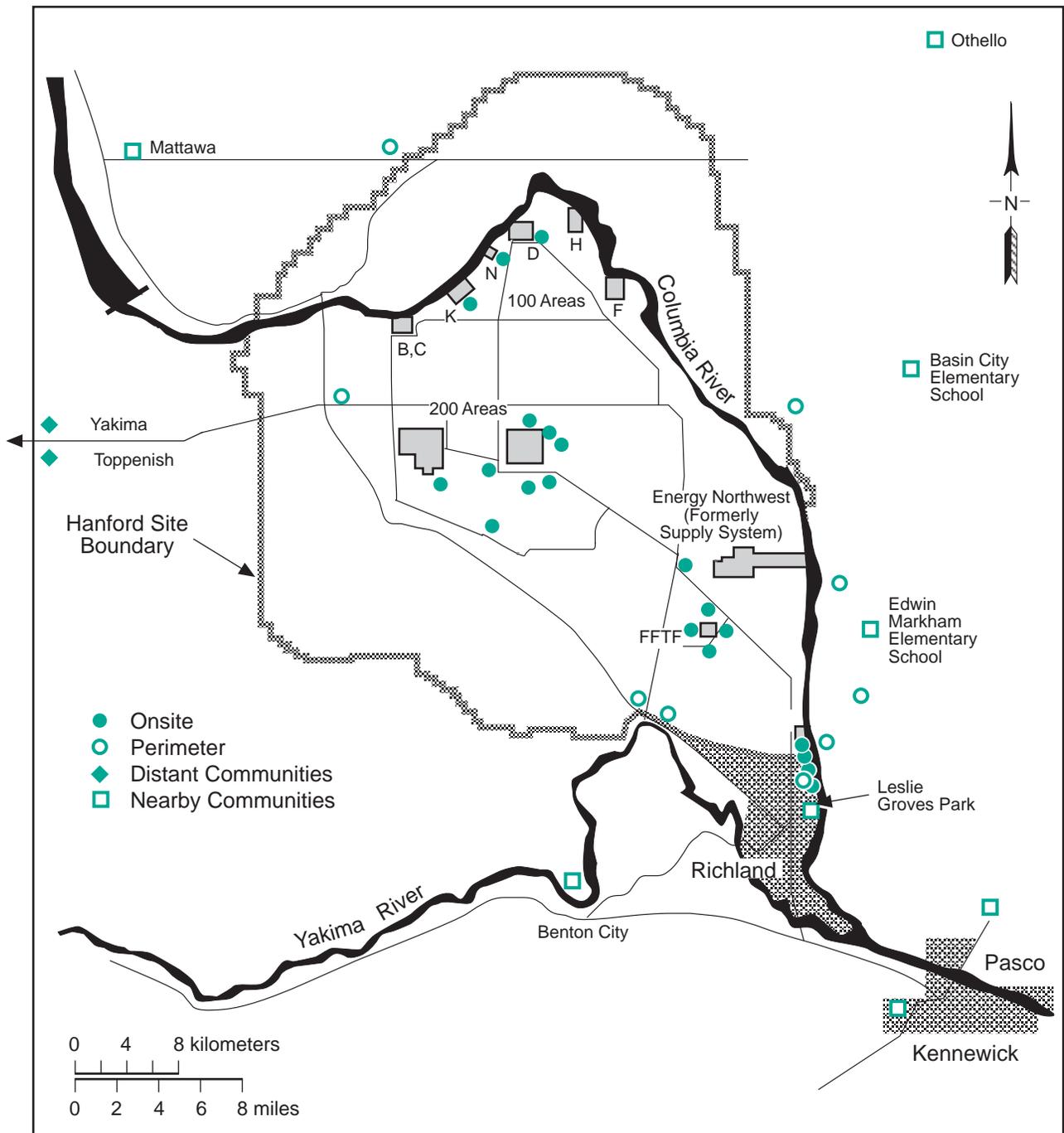
section discusses sample collection techniques and analytes tested for at each location and summarizes the analytical results of the air surveillance program. A complete listing of all analytical results summarized in this section is reported separately (PNNL-12088, APP. 1). A detailed description of 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 radionuclide samples were collected 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, Kennewick, Mattawa, Othello, Pasco, and Richland 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-11803). The air sampling locations and the analytes tested for at each location are given in Table 4.1.1. 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 72 h. 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-wk period was too small to be readily measured. The sensitivity and accuracy of sample results were increased by combining biweekly samples for nearby locations (or, in some cases, a single location) into



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Figure 4.1.1. Air Sampling Locations, 1998 (see Table 4.1.1 for location names)



**Table 4.1.1. Air Sampling Locations, Sample Composite Groups, and Analyses, 1998**

<b>Map<sup>(a)</sup></b>	<b>Location</b>	<b>Sampling Location</b>	<b>Analytes<sup>(b)</sup></b>	<b>Composite Group</b>	<b>Analytes<sup>(c)</sup></b>
<b>Onsite</b>					
1		100-K Area	Alpha, beta, <sup>3</sup> H	100 Areas	Gamma, Sr, Pu
2		100-N, 1325 Crib	Alpha, beta, <sup>3</sup> 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, <sup>3</sup> H, <sup>129</sup> 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, <sup>3</sup> 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, <sup>3</sup> H		
14		300 Trench	Alpha, beta, <sup>3</sup> H	300 NE	Gamma, Sr, Pu, U
15		300 NE			
16		400-East	Alpha, beta, <sup>3</sup> 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
<b>Perimeter</b>					
21		Ringold Met. Tower	Alpha, beta, <sup>3</sup> H, <sup>129</sup> 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, <sup>3</sup> H	Dogwood Met. Tower	Gamma, Sr, Pu, U
24		Byers Landing	Alpha, beta, <sup>3</sup> H, <sup>129</sup> I	Byers Landing	Gamma, Sr, Pu, U
25		Battelle Complex	Beta	Battelle Complex	Gamma - Annual
26		Horn Rapids			
27		Substation Prosser Barricade	Alpha, beta <sup>3</sup> H	Prosser Barricade	Gamma, Sr, Pu, U
28		Yakima Barricade	Alpha, beta	Yakima Barricade	Gamma, Sr, Pu
29		Wahluke Slope	Alpha, beta, <sup>3</sup> H	Wahluke Slope	Gamma, Sr, Pu



**Table 4.1.1. (contd)**

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

(a) See Figure 4.1.1.

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

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

(d) A community-operated environmental surveillance station.

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.

Samples were collected for iodine-129 at four 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 cartridges containing silica gel, which were exchanged every 4 wk. 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.

**Table 4.1.2. Airborne Radionuclide Activities in the Hanford Environs, 1998 Compared to Previous Years**

Radionuclide	Location Group <sup>(a)</sup>	1998				1995-1997				Derived Concentration Guide <sup>(e)</sup>
		No. of Samples	No. of Detections <sup>(b)</sup>	Maximum <sup>(c)</sup>	Average <sup>(d)</sup>	No. of Samples	No. of Detections <sup>(b)</sup>	Maximum <sup>(c)</sup>	Average <sup>(d)</sup>	
				pCi/m <sup>3</sup>	pCi/m <sup>3</sup>			pCi/m <sup>3</sup>	pCi/m <sup>3</sup>	
Tritium	300 Area	54	49	25 ± 3.0	4.1 ± 1.2	141	32	5 ± 2	0.81 ± 0.18	100,000
	Onsite	65	40	7.9 ± 1.9	1.7 ± 0.37	187	47	24 ± 20	1.1 ± 0.34	
	Perimeter	66	36	6.1 ± 2.1	1.4 ± 0.28	184	21	12 ± 22	0.92 ± 0.28	
	Nearby communities	39	21	14 ± 2.0	1.7 ± 0.68	116	13	16 ± 15	1.2 ± 0.48	
	Distant communities	26	10	5.1 ± 2.1	1.2 ± 0.41	91	6	5.2 ± 5	0.57 ± 0.19	
		1998				1993-1997				
Gross beta	Onsite	531	531	0.035 ± 0.0052	0.015 ± 0.00051	2,457	2,455	0.070 ± 0.0070	0.018 ± 0.00044	No standard
	Perimeter	204	204	0.037 ± 0.0055	0.015 ± 0.00086	995	992	0.098 ± 0.010	0.018 ± 0.00071	
	Nearby communities	210	210	0.052 ± 0.0080	0.014 ± 0.00089	874	874	0.079 ± 0.0082	0.018 ± 0.00070	
	Distant communities	58	58	0.034 ± 0.0050	0.013 ± 0.0017	281	281	0.095 ± 0.0099	0.016 ± 0.0013	
					aCi/m <sup>3</sup>	aCi/m <sup>3</sup>			aCi/m <sup>3</sup>	
Gross alpha	Onsite	484	353	3,100 ± 1,000	680 ± 36	2,253	1,748	5,500 ± 1,300	500 ± 15	No standard
	Perimeter	181	140	2,000 ± 710	700 ± 53	922	757	2,200 ± 600	530 ± 21	
	Nearby communities	112	83	1,900 ± 730	660 ± 65	515	428	1,800 ± 530	540 ± 25	
	Distant communities	58	32	1,400 ± 830	530 ± 88	279 <sup>(f)</sup>	210	4,800 ± 920	470 ± 60	
Strontium-90	Onsite	10	6	290 ± 58	61 ± 56	51	13	300 ± 96	24 ± 18	9,000,000
	Perimeter	7	5	390 ± 79	89 ± 100	35	3	35 ± 11	-3.4 ± 6.5	
	Nearby communities	4	3	69 ± 32	47 ± 31	20	2	16 ± 16	-3.2 ± 6.2	
	Distant communities	2	1	78 ± 27	53 ± 49	11	0	68 ± 120	2.6 ± 15	
Iodine-129	Onsite	4	4	22 ± 1.1	23 ± 1.7	20	20	52 ± 4.5	36 ± 4.9	70,000,000
	Perimeter	8	8	1.5 ± 0.12	0.65 ± 0.41	40	40	2.3 ± 0.28	1.1 ± 0.17	
	Distant communities	4	4	0.088 ± 0.0056	0.065 ± 0.022	20	20	0.10 ± 0.010	0.053 ± 0.010	
Plutonium-238	Onsite	10	1	2.9 ± 0.94	0.25 ± 0.52	52	1	0.68 ± 2.2	-0.14 ± 0.11	30,000
	Perimeter	7	0	0.18 ± 0.3	-0.034 ± 0.092	36	0	3.1 ± 4.1	-0.021 ± 0.24	
	Nearby communities	4	0	0.097 ± 0.37	-0.04 ± 0.11	24	1	0.76 ± 3.3	-0.0060 ± 0.15	
	Distant communities	2	0	0.14 ± 0.44	0.0010 ± 0.28	13	0	0.86 ± 3.5	0.09 ± 0.20	



Table 4.1.2. (contd)

Radionuclide	Location Group <sup>(a)</sup>	1998				1993-1997				Derived Concentration Guide <sup>(e)</sup>
		No. of Samples	No. of Detections <sup>(b)</sup>	Maximum <sup>(c)</sup>	Average <sup>(d)</sup>	No. of Samples	No. of Detections <sup>(b)</sup>	Maximum <sup>(c)</sup>	Average <sup>(d)</sup>	
				aCi/m <sup>3</sup>	aCi/m <sup>3</sup>			aCi/m <sup>3</sup>	aCi/m <sup>3</sup>	
Plutonium-239,240	Onsite	10	5	2.0 ± 1.3	0.69 ± 0.44	51	22	12.4 ± 2.5	1.4 ± 0.64	20,000
	Perimeter	7	2	0.74 ± 0.52	0.28 ± 0.24	35	11	1.8 ± 1.7	0.45 ± 0.17	
	Nearby communities	4	0	0.44 ± 0.5	0.18 ± 0.19	20	7	1.8 ± 1.7	0.39 ± 0.31	
	Distant communities	2	0	0.51 ± 0.57	0.30 ± 0.42	11	1	1.2 ± 1.2	0.17 ± 0.30	
Uranium-234	Onsite	9	9	52 ± 13	28 ± 11	42	41	140 ± 210	25 ± 6.8	90,000
	Perimeter	4	4	35 ± 6.3	26 ± 13	20	20	54 ± 18	28 ± 5.5	
	Nearby communities	3	3	31 ± 6.4	27 ± 5.8	15	15	37 ± 13	24 ± 3.8	
	Distant communities	2	2	19 ± 4.9	19 ± 1.1	11	11	31 ± 10	20 ± 4.4	
Uranium-235	Onsite	9	5	6.3 ± 5.7	1.8 ± 1.3	42	10	51 ± 130	2 ± 2.4	100,000
	Perimeter	4	3	2.4 ± 1.6	1.4 ± 1.1	20	8	4.3 ± 4.8	1.4 ± 0.51	
	Nearby communities	3	0	0.98 ± 1.3	0.77 ± 0.36	15	6	4.3 ± 4.8	1.3 ± 0.6	
	Distant communities	2	0	0.37 ± 0.98	0.13 ± 0.48	11	0	3.3 ± 4.0	0.68 ± 0.7	
Uranium-238	Onsite	9	9	50 ± 8.4	25 ± 10	42	41	58 ± 14	19 ± 3.6	100,000
	Perimeter	4	4	41 ± 6.9	27 ± 14	20	20	43 ± 8.6	26 ± 4.3	
	Nearby communities	3	3	32 ± 6.5	28 ± 4.8	15	15	36 ± 13	24 ± 4.0	
	Distant communities	2	2	20 ± 4.9	20 ± 0.30	11	10	30 ± 7.5	17 ± 3.8	
Cobalt-60	Onsite	43	0	700 ± 470	84 ± 82	197	27	880 ± 490	66 ± 37	80,000,000
	Perimeter	29	0	1,000 ± 530	-56 ± 176	143	11	740 ± 870	41 ± 45	
	Nearby communities	20	0	630 ± 720	4.1 ± 170	89	5	800 ± 560	7.0 ± 57	
	Distant communities	9	0	640 ± 460	219 ± 140	44	5	680 ± 440	148 ± 81	
Cesium-137	Onsite	43	0	710 ± 530	-55 ± 80	197	17	570 ± 420	30 ± 39	400,000,000
	Perimeter	29	0	600 ± 550	53 ± 111	143	9	660 ± 620	2.0 ± 40	
	Nearby communities	20	0	860 ± 580	8.9 ± 145	89	5	710 ± 330	45 ± 44	
	Distant communities	9	0	190 ± 530	-6.2 ± 98	44	1	390 ± 290	26 ± 66	

(a) Location groups are identified in Table 4.1.1 and located on Figure 1.1.1.

(b) Detection is defined as the result reported greater than the 2-sigma total propagated analytical uncertainty except for gamma-emitting radioisotopes (e.g., cobalt-60, cesium-137). Detect is greater than minimum detectable activity.

(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/m<sup>3</sup> at Sunnyside and 8,000 ± 1,000 aCi/m<sup>3</sup> at Yakima [Skoog and West 1980]).





Some air samples were collected at nine community-operated environmental surveillance stations (see Section 7.4, “Community-Operated Environmental Surveillance Program”). 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 radionuclides. A gamma-emitting radionuclide is detectable if the radionuclide library of the software determines an isotope activity 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 gross alpha radioactivity at the site perimeter was slightly elevated compared to the levels measured at distant stations (see Table 4.1.2) and was similar to values reported for 1993 through 1997 (Figure 4.1.2). The highest onsite gross alpha radioactivity was at the S of 200E sampling location (7 on Figure 4.1.1).

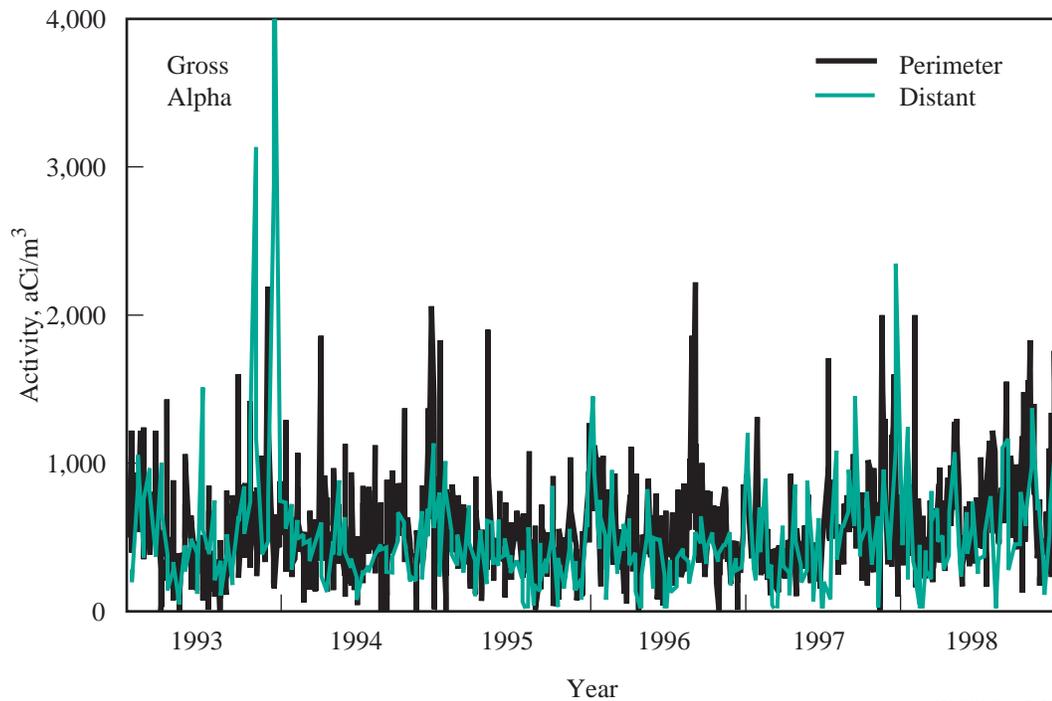
Tritium activities measured in 1998 (excluding 300 Area samples) were similar to values reported for 1995 through 1997 (see Table 4.1.2) and did not show the highly elevated activities and widely variable results reported for 1991 through 1994 (Section 4.1 in PNL-11139). For 1998, approximately 60% of the samples analyzed for tritium had results reported above the detection limit (the methodology is capable of detecting activities of no less than 1 pCi/m<sup>3</sup>). Sample results above the detection limit were consistently determined for the 300 Area samples. Tritium releases in the 300 Area are

associated with research and development activities (see Section 3.1, “Facility Effluent Monitoring”). These activities are expected to continue for the next 2 yr; therefore, higher tritium activities are expected for the 300 Area samples. Table 4.1.2 shows the slightly elevated 300 Area average tritium activity with respect to other onsite average tritium activities.

The annual average tritium activity measured at the site perimeter ( $1.4 \pm 0.28$  pCi/m<sup>3</sup>) was slightly higher than the annual average value at the distant locations ( $1.2 \pm 0.41$  pCi/m<sup>3</sup>); however, the difference was not statistically significant (log transformed, two-tailed t-test, 5% significance level). The annual average tritium measured at the site perimeter in 1998 was <0.002% of the 100,000-pCi/m<sup>3</sup> DOE derived concentration guide (DOE Order 5400.5).

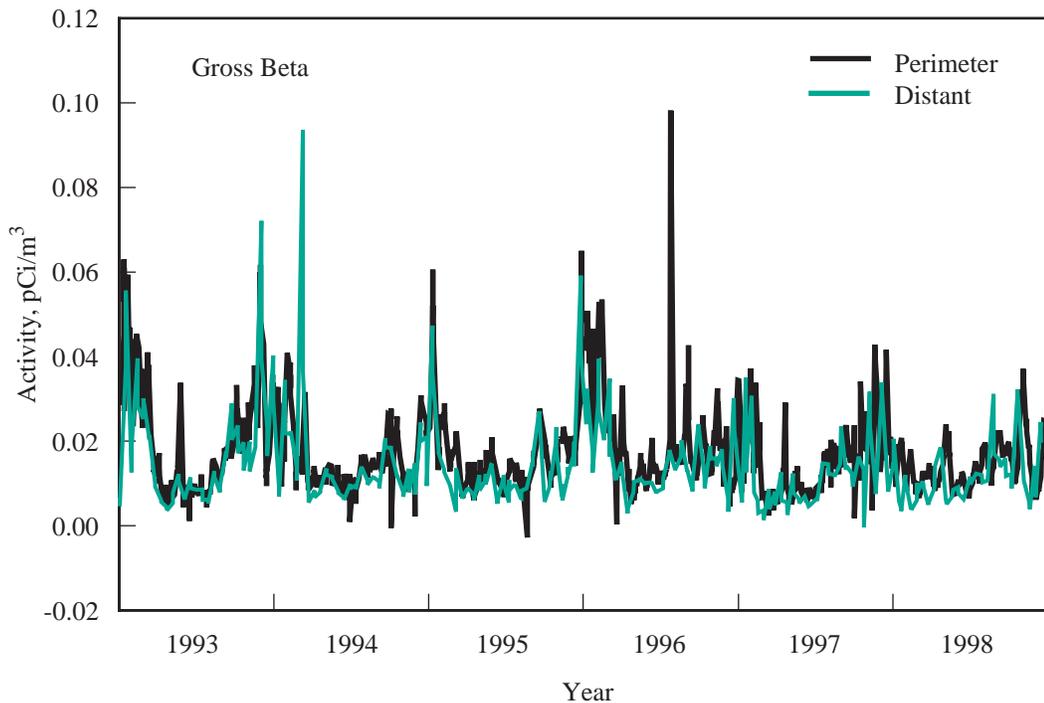
Gross beta levels in air for 1998 (Figure 4.1.3) peaked during the winter, repeating a pattern of natural annual radioactivity fluctuations (Eisenbud 1987). The average gross beta activity was slightly higher at the site perimeter than the annual average value at the distant location; however, the difference 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.

For samples analyzed for strontium-90 in 1998, 15 of the 23 samples were above the detection limit (see Table 4.1.2). This number of samples (65%) above the detection limit is abnormally high compared to the previous 5 yr (15%) (Figure 4.1.4). These apparently anomalous results are probably due to an error or sample contamination during the



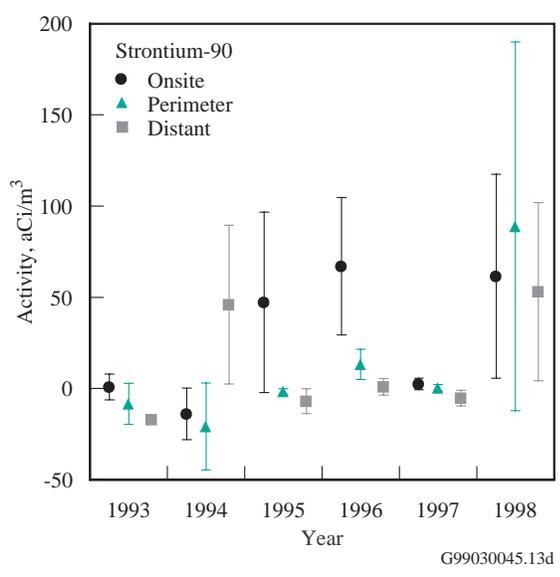
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**Figure 4.1.2.** Gross Alpha in Airborne Particulate Samples, 1993 Through 1998



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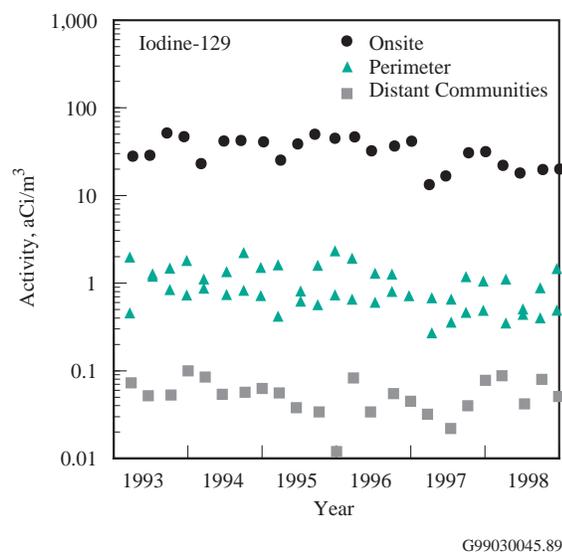
**Figure 4.1.3.** Gross Beta in Airborne Particulate Samples, 1993 Through 1998



**Figure 4.1.4.** Annual Average Strontium-90 Activities ( $\pm 2$  standard error of the mean) in Air, 1993 Through 1998

analytical process. No significant Hanford Site effluent source was reported for strontium-90 in 1998 (see Table 3.1.1 in Section 3.1, “Facility Effluent Monitoring”). The perimeter average appears to be elevated with respect to both the onsite average and the distant activities; however, the difference was not statistically significant (log transformed, two-tailed t-test, 5% significance level). The highest level ( $390 \pm 79$  aCi/m<sup>3</sup>) was determined for the Ringold Met. Tower composite sample (location 21 on Figure 4.1.1), which is 0.004% of the 9,000,000-aCi/m<sup>3</sup> derived concentration guide.

Iodine-129 analyses were performed on samples collected downwind of the Plutonium-Uranium Extraction Plant, at two downwind perimeter locations, and at a distant location (Yakima) in 1998 (see Figure 4.1.1). Onsite levels in 1998 were elevated compared to those measured at the site perimeter, and perimeter levels were higher than those measured at Yakima, the distant location (Figure 4.1.5 and see Table 4.1.2). Iodine-129 activity differences between these locations were statistically significant

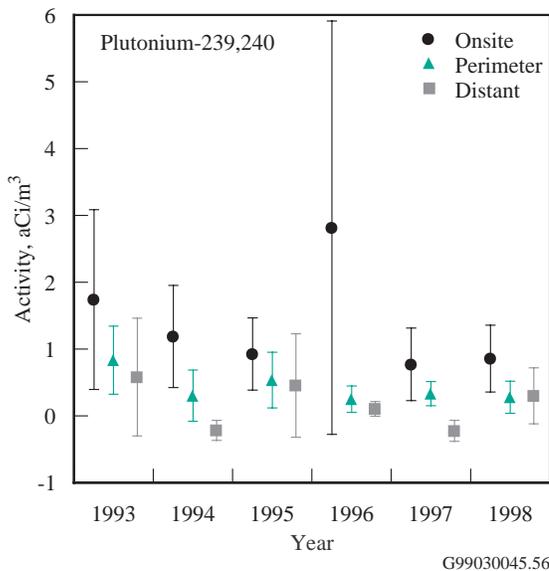


**Figure 4.1.5.** Iodine-129 Activities in Air, 1993 Through 1998

(log transformed, two-tailed t-test, 5% significance level) and indicated a Hanford source. Onsite and perimeter air activities have remained at their respective levels from 1993 through 1998 (see Figure 4.1.5). Onsite air activities of iodine-129 were influenced by minor emissions (0.00031 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 activity at the downwind perimeter in 1998 ( $0.65 \pm 0.41$  aCi/m<sup>3</sup>) was <0.000001% of the 70,000,000-aCi/m<sup>3</sup> derived concentration guide.

Plutonium-238 was detected in only 1 of the 23 air samples for 1998 (nominal detection limit of 0.4 aCi/m<sup>3</sup>). The highest activity ( $2.9 \pm 0.94$  aCi/m<sup>3</sup>) was determined for the 300 Area composite sample (locations 12 and 13 on Figure 4.1.1), which is 0.01% of the 30,000-aCi/m<sup>3</sup> derived concentration guide.

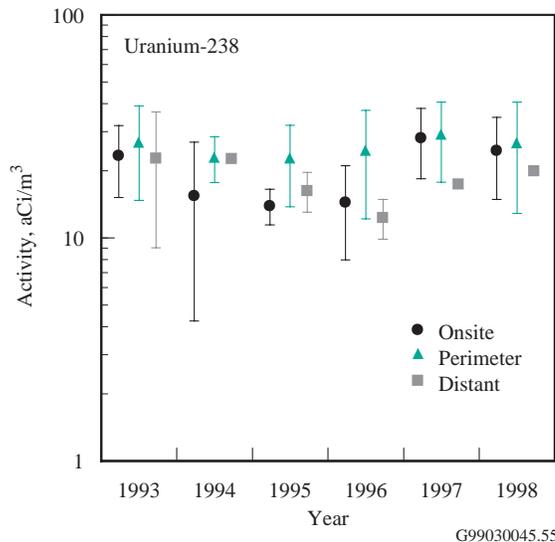
The average plutonium-239,240 activities detected in onsite and offsite air samples are given in Table 4.1.2 and Figure 4.1.6. The annual average air activity of plutonium-239,240 at the site perimeter was  $0.28 \pm 0.24$  aCi/m<sup>3</sup>, which is <0.002% of the



**Figure 4.1.6.** Annual Average Plutonium-239,240 Activities ( $\pm 2$  standard error of the mean) in Air, 1993 Through 1998

20,000-aCi/m<sup>3</sup> derived concentration guide. The annual average air activity was slightly lower for the site perimeter locations than the distant locations ( $0.30 \pm 0.42$  aCi/m<sup>3</sup>). The maximum Hanford Site plutonium-239,240 air activity ( $2.0 \pm 1.3$  aCi/m<sup>3</sup>) was observed for the 200-West Area composite sample (location 11 on Figure 4.1.1). This represents <0.02% of the 20,000-aCi/m<sup>3</sup> derived concentration guide.

Average isotopic uranium activities (uranium-234, -235, and -238) in airborne particulate matter in 1998 were similar on the site, at the site perimeter, and at distant communities (see Table 4.1.2 and Figure 4.1.7). The 1998 annual average uranium-238 activity for the site perimeter was  $27 \pm 14$  aCi/m<sup>3</sup>, which is 0.03% of the 100,000-aCi/m<sup>3</sup> derived concentration guide.



**Figure 4.1.7.** Annual Average Uranium-238 Activities ( $\pm 2$  standard error of the mean) in Air, 1993 Through 1998

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 101 samples analyzed by gamma spectroscopy, none of the samples had activities above the minimum detectable activity for the sample for that isotope. The cobalt-60 and cesium-137 results for 1998 samples are included in Table 4.1.2. Even the maximum estimated individual measurements for these radionuclides ( $1,000 \pm 530$  and  $860 \pm 580$  aCi/m<sup>3</sup>, respectively) were <0.002% of their derived concentration guides.