4.6 Soil and Vegetation Surveillance

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Soil surveillance provides information on long-term contamination trends and baseline environmental radionuclide concentrations in undisturbed locations (DOE/RL-91-50, Rev. 2). Surveillance of natural vegetation provides information on atmospheric deposition of radioactive materials in uncultivated areas and at onsite locations adjacent to potential sources of man-made radioactivity. Accordingly, concentrations of radionuclides in soil and natural vegetation provide a baseline against which unplanned releases can be compared.

Soil and natural vegetation samples have been collected on and around the Hanford Site for more than 50 years. Consequently, a large database exists that thoroughly documents onsite and offsite concentrations of man-made radionuclides in soil and natural vegetation at specific locations. Because the current site mission is environmental restoration and cleanup and because routine plutonium production operations at the site have ceased, the need for continuous soil and natural vegetation surveillance has diminished. There are several additional reasons for the reduced need for soil and natural vegetation sampling. Man-made radionuclides with short half-lives have decayed to stable isotopes and are no longer present. Moreover, radionuclide releases from the Hanford Site in recent years have been small, and therefore, baseline radionuclide concentrations have not changed appreciably for a number of years. Because only natural or man-made radionuclides with relatively long half-lives presently are found in soil and vegetation, sitewide environmental surveillance sampling of soil and vegetation can be less frequent. Routine surveillance of soil and vegetation was last conducted in 1994 (Section 4.6 in PNNL-10574). While no routine sampling of soil and vegetation was conducted onsite in 1997, special sampling of soil and natural vegetation was conducted in support of site cleanup activities, and a collaborative study was conducted with the Washington State Department of Health along the Columbia River shoreline at the 100-N Area.

Other soil and vegetation sampling by the management and integration contractor was conducted near active facility release points and waste sites on the site. Results are discussed in Section 3.2, "Near-Facility Environmental Monitoring."

4.6.1 300 Area and Franklin County Soil and Vegetation Sampling

In 1997, special soil and vegetation samples were collected in support of cleanup efforts in the 300-FF-1 Operable Unit north of the 300 Area. Samples were collected to the north, east, and west of the cleanup site. Five additional sampling locations were established on the Franklin County side of the Columbia River east and generally downwind of the 300 Area (Figure 4.6.1). Samples of natural vegetation (sagebrush and rabbitbrush) and soil were collected at each location.

Isotopic analyses indicated that uranium concentrations in the 300 Area and Franklin County soil in 1997 were similar. The 1997 samples were analyzed by alpha spectrometry. Samples collected in 1992, 1993, and 1994 were analyzed primarily by low-energy photon analysis. Alpha spectrometry generally will measure lower concentrations of uranium-235 than the low-energy photon method can detect. Also, low-energy photon analysis does not measure uranium-234. Concentrations of uranium reported for the 1992-1994 time period where analyzed predominately by the low-energy photon method.

4.6.1.1 Radionuclide Concentrations in Soil Samples

In 1997, soil samples were analyzed for gamma-emitting radionuclides, strontium-90, uranium-234, uranium-235, and uranium-238. These 1997 results were compared to soil results obtained from the same general areas around the 300 Area and in south Franklin County near the Columbia River between 1992 and 1994. In 1997,

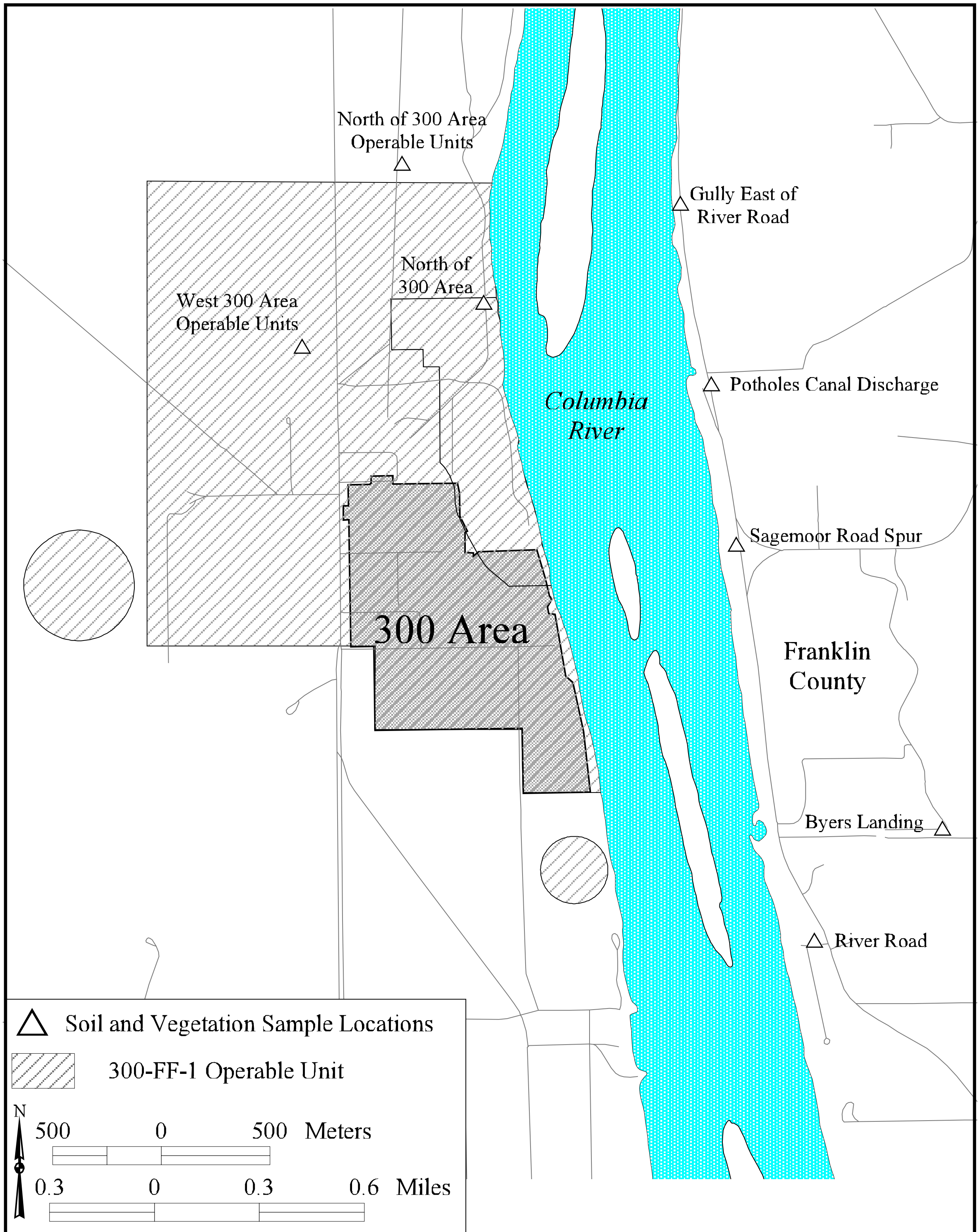

Figure 4.6.1. Soil and Vegetation Sampling Locations Associated with 300-FF-1 Operable Unit Cleanup, 1997

observed concentrations of strontium-90 and cesium-137 in soil were near detection limits, and while there appear to be differences in mean concentrations between Franklin County samples and 300 Area samples, the results from both locations are similar (Table 4.6.1). Similarly, there were no distinct differences between the 1997 results and results for 1992 through 1994. These results do not indicate any offsite dissemination of radionuclides from cleanup activities at the 300-FF-1 Operable Unit.

4.6.1.2 Radionuclide Concentrations in Vegetation Samples

Neither cesium-137 nor other man-made gamma-emitting radionuclides were detected in the special vegetation samples collected in 1997. Strontium-90 concentrations and uranium concentrations were similar in samples collected from north of the 300 Area and Franklin County (Table 4.6.2). There was a slight decrease in strontium-90 concentrations for 1997 results when compared to results of samples collected from earlier years. A mean (±2 standard error of the mean) strontium-90 concentration of 0.14 ± 0.10 pCi/g dry wt. in the 300 Area for the period 1983 through 1993 was reported in PNL-10728.

There were no significant differences in the concentrations of uranium-234, 238 in vegetation between the 300 Area samples and the Franklin County samples in 1997 (see Table 4.6.2). Uranium-235 concentrations were below detection limits at both locations. Comparisons of current data with past data, are difficult because different analytical methods were used from 1983 through 1993. Concentrations of uranium isotopes in vegetation do not indicate any consistent trend over the past 15 years in either the 300 Area or the Franklin County area. The mean uranium-238 concentration for the period 1983 through 1993 in Franklin County was 0.011 ± 0.008 pCi/g. This concentration compares favorably with the 0.013 ± 0.004 pCi/g value observed for the 1997 samples. These vegetation results do not indicate any offsite dissemination of radionuclides from 300-FF-1 Operable Unit cleanup activities.

4.6.2 Tree Sampling on the Hanford Site

During late July and early August 1997, three apricot trees and one quince tree growing on the Hanford Site were

Table 4.6.1. Radionuclides (pCi/g) in Soil Samples Collected from 300 Area and Franklin County

		1997			1992-1994		
Radionuclide	Location	Maximum[a]	Mean[b]	No. Less Than Detection	Maximum[a]	Mean[b]	No. Less Than Detection
Cesium-137	300 Area	0.61 ± 0.07	0.50 ± 0.20	0 of 3	0.56 ± 0.06	0.35 ± 0.70	0 of 5
	Franklin County	0.87 ± 0.04	0.30 ± 0.3	0 of 5	0.85 ± 0.09	0.34 ± 0.02	0 of 10
Strontium-90	300 Area	0.17 ± 0.03	0.140 ± 0.05	0 of 3	0.16 ± 0.04	0.10 ± 0.2	0 of 5
	Franklin County	0.15 ± 0.03	0.062 ± 0.05	0 of 5	0.15 ± 0.03	0.080 ± 0.02	0 of 10
Uranium-234	300 Area	0.34 ± 0.04	0.26 ± 0.09	0 of 3	NA[c]	NA	0
	Franklin County	0.42 ± 0.05	0.24 ± 0.09	0 of 5	0.88 ± 0.11	0.73 ± 0.1	0 of 7
Uranium-235	300 Area	0.019 ± 0.004	0.012 ± 0.008	0 of 3	0.17 ± 0.08	0.045 ± 0.09	3 of 5
	Franklin County	0.019 ± 0.004	0.011 ± 0.004	0 of 5	0.27 ± 0.15	0.013 ± 0.04	10 of 17
Uranium-238	300 Area	0.36 ± 0.04	0.26 ± 0.11	0 of 3	0.85 ± 0.03	0.62 ± 1.2	0 of 5
	Franklin County	0.44 ± 0.05	0.25 ± 0.10	0 of 5	1.1 ± 0.5	0.75 ± 0.09	1 of 17

(a) ± total propagated analytical uncertainty (2-sigma).
(b) ±2 standard error of the mean.
(c) Not available.

Table 4.6.2. Radionuclides (pCi/g) in Vegetation Samples Collected from 300 Area and Franklin County, 1997

Radionuclide	Location	Maximum[a]	Mean[b]	No. Less Than Detection
Strontium-90	300 Area	0.014 ± 0.004	0.010 ± 0.006	0 of 3
	Franklin County	0.037 ± 0.01	0.025 ± 0.01	0 of 5
Uranium-234	300 Area	0.022 ± 0.005	0.011 ± 0.01	0 of 3
	Franklin County	0.021 ± 0.006	0.014 ± 0.006	0 of 5
Uranium-235	300 Area	< Detect[c]	< Detect	3 of 3
	Franklin County	< Detect	< Detect	5 of 5
Uranium-238	300 Area	0.02 ± 0.005	0.009 ± 0.01	0 of 3
	Franklin County	0.019 ± 0.005	0.013 ± 0.004	0 of 5

(a) ± total propagated analytical uncertainty (2-sigma).
(b) ±2 standard error of the mean.
(c) Less than the detection limit.

sampled. Leaves were collected from two apricot trees located in the old orchards northeast of the 100-D Area, a third apricot tree located near the 100-F Area, and a quince tree growing in the Old Hanford Townsite (Figure 4.6.2). Originally, fruit and leaves were to be sampled; however, spring frost destroyed the tree blossoms and apricots were not produced. The quince tree was bearing fruit, and a sample of quince fruit was also collected with the leaves. Leaf samples from all trees were analyzed for gamma emitters, tritium, and strontium-90. Concentrations of tritium were measured with the electrolytic enrichment technique on water distilled from leaves (i.e., the method quantifies tritiated water, the principal form found in vegetation). The electrolytic enrichment method has a detection limit of approximately 10 to 15 pCi/L. The sample of quince fruit was analyzed for gamma emitters and strontium-90. All samples of leaves and fruit were also analyzed by inductively coupled plasma-mass (for trace metals) spectrometry and by cold vapor atomic adsorption spectrometry (for mercury).

4.6.2.1 Radionuclide Concentrations in Fruit Trees

No man-made gamma-emitting radionuclides (see Appendix E) were detected in any of the fruit or leaf samples collected near the 100-D Area, 100-F Area, or Old Hanford Townsite. Strontium-90 was measured in leaf samples from all three locations (Table 4.6.3), but was not detected in quince fruit obtained at the Old Hanford Townsite. From 1983 through 1993, concentrations of strontium-90 in native vegetation collected from the 600 Area ranged from 0.012 to 1.68 pCi/g dry wt. (PNL-10728). Concentrations of strontium-90 in fruit tree leaves were well within this range. The concentration in the 100-F Area apricot leaf sample (0.16 pCi/g) was equal to the reported mean (±2 standard error of the mean) for samples of vegetation shrub collected from the 600 Area (0.16 ± 0.10 pCi/g dry wt.).

Concentrations of tritium in apricot leaves collected adjacent to the 100-D Area indicated accumulation of low levels of tritium (500 to 620 pCi/L; Table 4.6.4). The apricot tree leaves at the 100-D Area were collected from an area within the 2,000-pCi/L plume contour for tritium in the unconfined aquifer, implying some contact with the unconfined aquifer (Section 4.8 in PNNL-11472). The apricot tree in the 100-F Area and the quince tree in the Old Hanford Townsite were just outside the 2,000-pCi/L tritium plume contour (see Figure 4.6.2). Concentrations of tritium in quince fruit should be comparable to levels observed in the distillate of leaves. The tritium concentration in leaves from the 100-F Area apricot

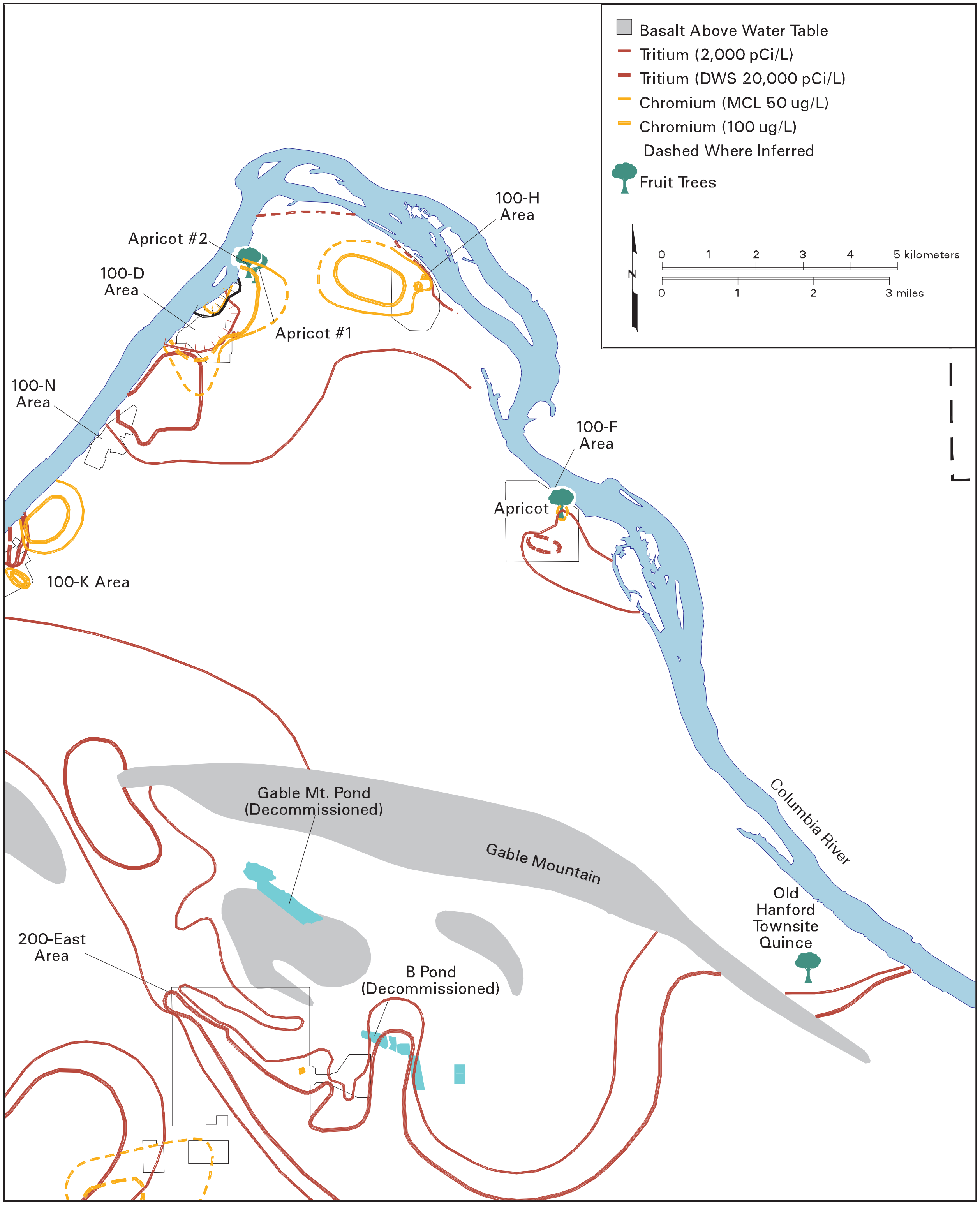

Figure 4.6.2. Fruit Tree Sampling Sites, 1997

Table 4.6.3. Strontium-90 in Fruit Tree Samples from Hanford Site, 1997

Concentration, pCi/g[(a)]	Sample	Location
0.004 ± 0.005	Quince fruit	Old Hanford Townsite
0.094 ± 0.02	Quince leaves	Old Hanford Townsite
0.015 ± 0.005	Apricot leaves	100-D Area
0.011 ± 0.004	Apricot leaves	100-D Area
0.16 ± 0.01	Apricot leaves	100-F Area

(a) ±2 sigma total analytical error.

Table 4.6.4. Tritum in Fruit Tree Samples from Hanford Site, 1997

Concentration, pCi/g[(a)]	Sample	Location
15 ± 7.4	Quince leaves	Old Hanford Townsite
620 ± 57	Apricot leaves	100-D Area
50 ± 47	Apricot leaves	100-D Area
12.1 ± 7.2	Apricot leaves	100-F Area

(a) ±2 sigma total analytical error.

tree and the Old Hanford Townsite quince tree is indicative of background levels and is lower than concentrations observed in Columbia River water.

4.6.2.2 Metals Concentrations in Hanford Trees

Table 4.6.5 presents the concentrations of metals measured in apricot and quince leaves and quince fruit collected in 1997. The last two columns in the table contain the range of background concentrations associated with each metal in vegetation and the levels in vegetation considered toxic (Kabata-Pendias and Pendias 1984). The background concentrations are based on a number of studies. They include concentrations reported for fruits, grains, and vegetables, but there were few data for fruit trees. Because of physiological differences, monocots (e.g., grasses) may accumulate different amounts of metals than dicots (e.g., legumes, forbs, deciduous trees). Consequently, the ranges reported are broad and provide a benchmark of natural background levels.

Antimony, beryllium, selenium, and silver were not detected in apricot leaves, quince leaves, or quince fruit, and the reported values are the analytical detection limits (see Table 4.6.5). Metals that were detected were within background ranges. None of the measured concentrations of metals fell within the range of concentrations that Kabata-Pendias and Pendias (1984) associate with toxic levels.

Chromium was detected in the 100-D Area apricot leaves at levels within the background range, but chromium was not detected in samples from the 100-F Area and in quince samples from the Old Hanford Townsite. The levels measured in 100-D Area apricot leaves were low and close to the detection limit. Both trees sampled from this area were growing in an area bounded by the 100- and 50-mg/L groundwater plume contours in the unconfined aquifer (see Figure 4.6.2). The maximum groundwater concentration of chromium at the 100-D Area was 727 mg/L in well 199-D5-14 (Section 4.8 in PNNL-11472). Cadmium, copper, and zinc concentrations also appeared elevated in the 100-D Area apricot leaves compared to the 100-F Area

Table 4.6.5. Metals (mg/kg dry wt.) in Fruit Trees Sampled from Hanford Site, 1997

	Apricot Leaves			Quince				
	100-D Area (#1)	100-D Area (#2)	100-F Area	Fruit, Old Hanford Townsite	Leaves, Old Hanford Townsite	Detection Limit	Background Range[a]	Excessive or Toxic Range[a]
Antimony[b]	0.015	0.015	0.015	0.015	0.015	0.015	7-50	150
Arsenic	0.25	0.17	0.39	0.15	0.033	0.03	1-1.7	5-20
Beryllium[b]	0.15	0.15	0.15	0.15	0.15	0.15	<1-7	10-50
Cadmium	0.15	0.21	0.097	0.053	0.079	0.02	0.05-0.2	5-30
Chromium	0.29	0.31	0.20	0.20	0.20	0.20	0.1-0.5	5-30
Copper	8.7	8.8	4.3	4.8	3.8	0.02	5-30	20-100
Lead	0.11	0.19	0.15	0.11	0.036	0.036	5-10	30-300
Mercury	0.020	0.021	0.017	0.022	0.002	0.001	--[c]	1-3
Nickel	0.84	1.1	0.79	0.95	0.13	0.020	0.1-5	10-100
Selenium[b]	1.00	1.00	1.00	1.00	1.00	1.00	0.01-2	5-30
Silver[b]	0.045	0.045	0.045	0.045	0.045	0.045	0.5	5-10
Thallium	0.005	0.02	0.005	0.005	0.006	0.005	--	20
Zinc	13	17	9.8	5.9	3.1	0.15	27-150	100-400

(a) Taken from Kabata-Pendias and Pendias (1984). Excessive or toxic range is derived from studies where reported concentrations of metals in vegetation had arisen from elevated environmental exposures.
(b) All measured concentrations were less than the detection limit.
(c) No values reported.

apricot leaves and Old Hanford Townsite quince samples. These few data provide initial insight into the potential for metals contamination in trees; however, additional information would be required to provide a better characterization of the distribution of metals in this area.

4.6.3 Metals Analysis in Reed Canary Grass and Milfoil

Reed canary grass and milfoil (an aquatic plant) were also sampled as part of the collaborative study with the Washington State Department of Health at the 100-N Springs and analyzed for metals by the same methods used for tree leaves. One upstream control sample of each species was collected between Priest Rapids Dam and Vernita Bridge on the Benton County side of the river. Three samples of each species were collected at the 100-N Area. The samples collected provide baseline information about metals concentrations in riparian and aquatic plant species inhabiting the Columbia River and associated shoreline habitat.

4.6.3.1 Analytical Results

Concentrations of arsenic, cadmium, nickel, and zinc in milfoil were higher than concentrations of the same metals in reed canary grass (Table 4.6.6). Concentrations of other metals analyzed in both species were comparable. Concentrations of chromium, copper, lead, and silver in milfoil were markedly higher in the background sample compared to the 100-N Area samples. Concentrations of metals analyzed in reed canary grass did not show this spatial difference. Metals results are within the range of expected concentrations (see Table 4.6.5) and are undergoing further analysis with respect to fish, sediment, and water concentrations to better assess trace metal behavior in the Columbia River ecosystem.

Table 4.6.6. Concentrations of Trace Metals in Reed Canary Grass and Milfoil, 1997

				Concentrations, mg/kg dry wt.						
Organism	Sampling Location	No. of Samples	Data	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead
Reed canary grass	100-N Area	3	Mean	0.034	1.51	0.23	0.42	5.6	11.26	5.497
			Maximum	0.047	3.68	0.40	1.06	15.2	18.13	14.090
			Minimum	0.015	0.29	0.15	0.06	0.5	6.30	0.522
	Vernita Bridge	1	Result	0.015	1.60	0.16	0.41	4.4	12.73	8.896
Milfoil	100-N Area	3	Mean	0.035	5.48	0.36	4.13	11.1	18.04	12.447
			Maximum	0.047	6.10	0.49	4.18	16.1	22.58	17.380
			Minimum	0.022	4.87	0.24	4.08	6.1	13.50	7.514
	Vernita Bridge	1	Result	0.040	8.10	1.07	3.15	29.9	33.61	47.830
		Detection Limit		**0.015**	**0.030**	**0.150**	**0.020**	**0.200**	**0.020**	**0.036**

				Concentrations, mg/kg dry wt.				
Organism	Sampling Location	No. of Samples	Data	Mercury	Nickel	Selenium	Silver	Zinc
Reed canary grass	100-N Area	3	Mean	0.019	4.95	1.00	0.053	104.37
			Maximum	0.033	11.71	1.00	0.069	152.90
			Minimum	0.010	1.04	1.00	0.045	49.00
	Vernita Bridge	1	Result	0.020	4.46	1.00	0.056	78.11
Milfoil	100-N Area	3	Mean	0.028	10.85	1.03	0.07	209.75
			Maximum	0.038	15.23	1.05	0.094	241.50
			Minimum	0.018	6.47	1.00	0.045	178.00
	Vernita Bridge	1	Result	0.073	26.93	1.00	0.182	270.40
		Detection Limit		**0.001**	**0.020**	**1.000**	**0.045**	**0.150**