2019 Highlight

Routine Vegetation Sampling and Radiological Surveys
A total of 52 vegetation samples were collected in calendar year 2019; 44 samples were collected on the Hanford Site and 8 samples were collected from offsite locations. Generally, the concentrations of radionuclides in these samples were consistent with those seen in previous years.

Radiological surveys performed in calendar year 2019 identified 29 instances of radiological contamination in vegetation. All 29 were Russian thistle (*Salsola tragus*) plants or fragments. Of the 29 instances, 2 locations were posted as a contamination area and 27 were cleaned up and disposed of at a licensed facility.

Food and Farm Products
In calendar year 2019, analytical concentrations of potential Hanford-Site produced contaminants and natural occurring radioactive elements were similar to results seen in the previous 5 to 10 years.

Wildlife Surveillance
Mission Support Alliance collects and analyzes wildlife samples that sportsmen or the general public may collect as foodstuff. In 2019, Canada goose, walleye and whitefish were collected and submitted to laboratories for radiological and metals analyses. A total of 31 animals were collected in 2019 for obtaining samples.

10.0 Biota Monitoring

JR Draper

The U.S. Department of Energy's (DOE) subcontractor Mission Support Alliance monitors the biota, including state and federally listed species, to assess the abundance, vigor or condition, and distribution on the Hanford Site. The associated data is used by DOE and Hanford Site contractors to support environmental cleanup and restoration activities, mitigation actions, land use planning, and to maintain compliance with ecological resource laws. Mission Support Alliance's Ecological Compliance staff conducts ecological compliance reviews for most projects on the Hanford Site to determine if the proposed scope of work will adversely impact biological resources and to provide recommendations to reduce environmental impacts.

10.1 Agricultural Monitoring

ME Hoefer

Food and farm products (i.e., alfalfa, apricots, corn, leafy vegetables, melons, milk, potatoes, tomatoes, and wine must) were collected in calendar year (CY) 2019 at locations near the Hanford Site (Figure 10-1; note not all agricultural monitoring locations shown are sampled each year due to program efficiencies, budgetary restrictions, product availability, and historical trending purposes). These foodstuffs are utilized to determine pathway-specific exposure assumptions by way of annual dose

calculations based on a 1-mrem/yr (10-microsievert [µSv]/yr) threshold and ingestion pathways for annual intake, assuming 100% of each food originated in the affected area.

Water removed from the river immediately downstream of the Hanford Site is used to irrigate a small portion of agricultural crops in Benton and Franklin counties. The majority of irrigation water utilized by Franklin County residents originates at Grand Coulee Dam and is distributed through its extensive water delivery systems (i.e., canals). Likewise, Benton County relies heavily on the Yakima River for irrigation purposes.

Samples analyzed to determine radiological contaminant concentrations were obtained from the following locations:

- Downwind (east and southeast) of the Hanford Site where airborne emissions or contaminated dust from the site potentially would be deposited
- Upwind of and distant from the Hanford Site to provide information about reference (background) contaminant levels
- From farms irrigated with water taken from the Columbia River downstream from the Hanford Site.

Sample analyses were used to assess the amounts of Hanford Site-origin contaminants in food and farm products by comparing the following:

- Analytical results obtained from similar samples collected from the same regions over long periods of time
- Samples collected at downwind locations to results from samples obtained from generally upwind or distant locations
- Samples collected in areas irrigated with water withdrawn from the Columbia River downstream of the Hanford Site to analytical results from samples obtained from locations irrigated with water from other regional sources.

Radionuclide concentrations in most food and farm product samples in CY 2019 were below the analytical laboratory detection levels; however, some potential Hanford Site-produced contaminants (e.g., tritium) were found at low levels in some milk samples and wine must. An anomaly did occur in both a corn and leafy vegetable sample from the reference area (Sunnyside), as both had detections of strontium-90. Data for potassium-40 and beryllium-7 were included to show the natural radioactive elements that exist in food products relative to concentrations of potential Hanford Site-produced contaminants. Radiological doses associated with potential Hanford Site-produced contaminants are discussed in Section 4.0. Where possible, the measured concentrations were compared to the applicable unusual concentration reporting levels. Unusual concentration reporting levels have been established based on environmental concentrations that would result in a dose of 1 mrem/yr (10 µSv/yr) (DOE/RL-91-50). Agricultural products sampled in CY 2019 are listed in Table 10-1 and are described in the following sections.

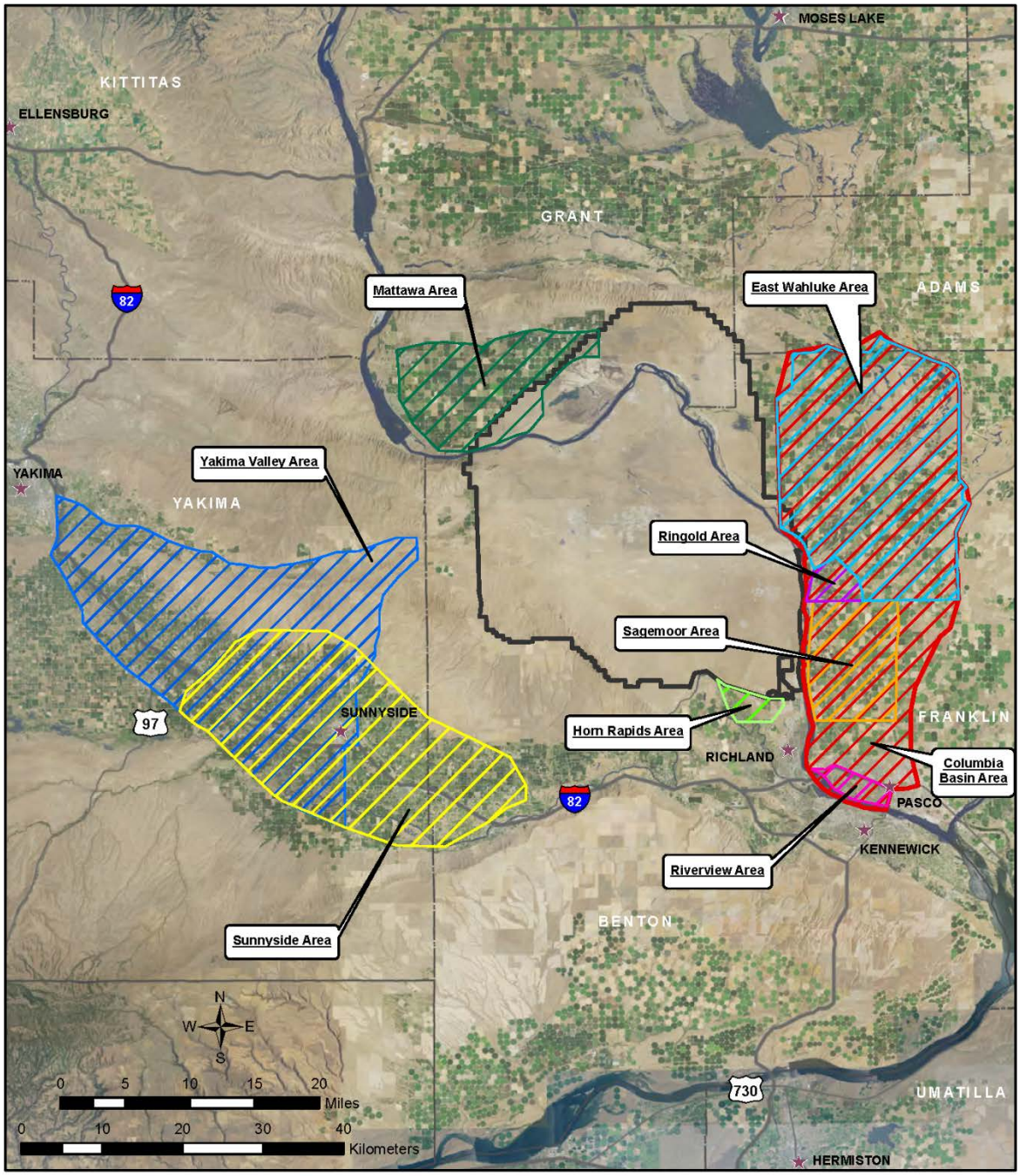


Figure 10-1. Agricultural Monitoring Locations.

Table 10-1. Agricultural Monitoring Location.

Product	Sampling Locations	Analytes
Alfalfa	East Wahluke, Riverview, Sagemoor, and Sunnyside	^{14}C, Gamma, Sr-90
Apricots	East Wahluke, Riverview, Sagemoor, and Sunnyside	^{14}C, Gamma, Sr-90
Corn	East Wahluke, Riverview, Sagemoor, and Sunnyside	^{14}C, Gamma, Sr-90
Leafy vegetables	East Wahluke, Riverview, Sagemoor, and Sunnyside	^{14}C, Gamma, Sr-90
Melons	East Wahluke, Riverview, Sagemoor, and Sunnyside	^{14}C, Gamma, Sr-90
Milk	East Wahluke and Sagemoor	^{14}C, Gamma, ^{129}I, Sr-90, Tritium (Low level)
Potatoes	East Wahluke, Riverview, Sagemoor, and Sunnyside	^{14}C, Gamma, Sr-90
Tomatoes	Riverview and Sunnyside	^{14}C, Gamma, Sr-90, Tritium
Wine must	Columbia Basin, Mattawa, and Yakima Valley	^{14}C, Gamma, ^{129}I, Tritium (Low level)

10.1.1 Milk

Milk samples were obtained quarterly in CY 2019 from several dairies in the East Wahluke and Sagemoor sampling areas. Milk was not obtained from a dairy in the Sunnyside area in 2019 due to closure of the dairy plant in late 2017. Surveillance personnel are attempting to locate a new Sunnyside-area dairy to sample. Unfortunately, a number of dairies in the lower Yakima Valley have closed in recent years due to restrictions and overhead costs, this has made it increasingly difficult to find a location to sample from.

The Sagemoor and East Wahluke sampling areas are located near the Hanford Site perimeter and could potentially be affected by airborne contaminants from the Site. The Sunnyside area is a reference location generally upwind of the Hanford Site. If milk was obtained from more than one dairy within a sampling area, the milk samples were combined and the composite sample was analyzed. All samples were analyzed for carbon-14, gamma-emitting radionuclides, strontium-90, and tritium. Milk sampling was conducted because Hanford Site-produced radionuclides have the potential to move through the air-pasture-cow-milk or water-pasture-cow-milk food chains to humans. In recent years, levels of Hanford Site-produced radiological contaminants in milk samples have diminished in conjunction with facility shutdowns and remedial efforts. Concentrations in samples obtained from dairies downwind of the Hanford Site were similar to levels measured in samples obtained from the dairy generally upwind of the Hanford Site.

10.1.1.1 Tritium.

Tritium was detected in all milk samples collected in CY 2019. Overall concentrations of the nine detections ranged from a maximum of 31.2 pCi/L (1.15 Bq/L) in a Sagemoor area sample to a minimum of 11.9 pCi/L (0.44 Bq/L) in an East Wahluke area sample. Annual average concentrations for the two sampling areas were 21.7 pCi/L (0.80 Bq/L). Specific location average was 28.2 pCi/L (1.0 Bq/L) for Sagemoor (n = 5) and 13.7 pCi/L (0.51 Bq/L) for East Wahluke (n = 4). Overall averages were similar to historical concentrations in all areas.

10.1.1.2 Strontium-90.

No detectable concentrations were found in CY 2019 milk samples.

10.1.1.3 Cesium-137.

No cesium-137 was detected in milk samples collected and analyzed in 2019.

10.1.1.4 Potassium-40.

Naturally occurring potassium-40 was detected in all milk samples collected in CY 2019. Concentrations ranged from a maximum of 1,640 pCi/L (61 Bq/L) in a Sagemoor area sample to a minimum of 1,320 pCi/L (49 Bq/L) in a Sagemoor area sample.

10.1.2 Fruit, Vegetables, and Farm Products

Alfalfa, apricot, corn, leafy vegetable (e.g., lettuce), melon, potato, tomato, and wine must samples were collected from upwind and downwind sampling areas during the CY 2019 growing season (Figure 10-1, Table 10-1). All fruit and vegetable samples were analyzed for gamma-emitting radionuclides and strontium-90. All products were analyzed for carbon-14 to support Waste Treatment Plant monitoring baseline data. Wine must was analyzed for gamma-emitting radionuclides and low-level tritium. Tomato samples were also monitored for strontium-90 and tritium (Table 10-1), but showed no detectable concentrations during 2019.

An individual leafy vegetable sample (East Wahluke) had a detectable concentration of beryllium-7; however, these concentrations were within historical range and follow typical result patterns. One additional sample of leafy vegetables (Sunnyside) had a detection of strontium-90 but the value reported (0.075 pCi/L; 0.003 Bq/L) was well below DOE project dose-based reporting limits and was within historical limits measured at this location. All remaining fruit and vegetable contaminant concentrations were reported as non-detects (with the exception of naturally-occurring potassium-40) and were well within historical range.

All wine must samples collected in CY 2019 had detectable concentrations of tritium within the historical range, but concentrations were slightly lower than those seen in CY 2018. Mattawa area wine had an average of 17.1 pCi/L (0.63 Bq/L), Columbia Basin wine had average tritium results of 55.8 pCi/L (2.1 Bq/L) and Yakima Valley had an average of 13.5 pCi/L (0.50 Bq/L). All wine must values for 2019 were well below the Washington State drinking water standard of 20,000 pCi/L (740 Bq/L).

Maximum tritium levels from irrigation water collected in the Riverview (16.0 pCi/L; 0.59 Bq/L) and the Sagemoor (18.7 pCi/L; 0.70 Bq/L) area were comparable, while the Horn Rapids (38.8 pCi/L; 1.4 Bq/L) area was slightly higher.

The 2019 irrigation results were similar to concentrations reported in the fixed-station locations in Richland, Washington, and at Priest Rapids Dam. The Columbia River Priest Rapids Dam fixed-station water average tritium concentration was 17.5 pCi/L (0.65 Bq/L), while the Columbia River Richland Pumphouse fixed-station water had an annual average of 29.7 pCi/L (1.10 Bq/L).

10.2 Fish and Wildlife Monitoring

JW Wilde

The fish and wildlife species sampled and analyzed for Hanford Site operations-produced contaminants during the CY 2019 included mountain whitefish (*Prosopium williamsoni*), walleye (*Prosopium williamsoni*), and Canada goose (*Branta canadensis*). Monitoring fish and wildlife for uptake and

exposure to Hanford Site operations-produced contaminants ensures that consumption of fish and wildlife obtained from Hanford Site environs does not pose a threat to human health and provides long-term contamination trends. These species were selected and analyzed because they provide a potential pathway for offsite human consumption. Figure 10-2 shows the locations on and around the Hanford Site where fish and wildlife were collected in 2019. Samples of fish and wildlife were analyzed for selected (suspected or known to be present at the Hanford Site) radionuclides and metals (Table 10-2). In addition, samples were collected from locations distant from the Hanford Site to obtain reference (background) contaminant measurements. All fish and wildlife samples were analyzed for strontium-90 contamination and analyzed by gamma spectrometry to detect a number of gamma emitters, including cesium-137. Since the 1990s, strontium-90 and cesium-137 have been the most frequently measured radionuclides in fish and wildlife samples.

Most fish and wildlife samples are collected on and around the Hanford Site and analyzed for human-pathway exposure every 2 to 3 years, with samples obtained at locations determined not to be affected by Hanford Site effluents and emissions approximately every 5 years.

Strontium-90 is present in Hanford Site environments because of past Hanford Site operations and waste disposal practices. Contaminated groundwater entering the Columbia River through shoreline springs in the 100-N and 100-H Areas is the primary source of measurable Hanford Site-produced strontium-90 in the Columbia River. Chemically similar to calcium, strontium-90 consequently accumulates in hard tissues rich in calcium such as bones, antlers, and eggshells. In addition, strontium-90 has a biological half-life in hard tissue from 14 to 600 days (PNL-9394, *Ecotoxicity Literature Review of Selected Hanford Site Contaminants*). Hard-tissue concentrations may profile an organism's lifetime exposure to strontium-90; however, because strontium-90 does not accumulate in edible portions of fish and wildlife, it generally does not contribute much to the human dose (NCRP 2009).
Cesium-137 is present in Hanford Site environments because of past Hanford Site operations, waste disposal practices, and from historical worldwide fallout resulting from nuclear weapons testing. Cesium-137 is particularly important to the human food chain because the isotope is chemically similar to potassium and is found in the muscle tissues of fish and wildlife. Cesium-137 is an indicator of recent exposure to radioactive materials because it has a relatively short biological half-life (less than 200 days in muscle and less than 20 days in the gastrointestinal tract [PNL-9394]).

Gamma spectrometry results for most radionuclides generally are too low to measure or the concentrations measured are considered artifacts of low background counts. Low background counts occur at random intervals during sample counting and can produce occasional spurious false-positive results. For many radionuclides, concentrations were below analytical laboratory detection levels.

A number of trace metals associated with Hanford Site operations have a potential to accumulate in certain fish and wildlife tissues. These metals are contaminants of potential concern (e.g., copper, lead, and mercury), particularly along the Hanford Site Columbia River shoreline where contaminated groundwater flows into the river. Hanford Site historical operations have resulted in the production of both radiological and non-radiological wastes, including trace-metal emissions in a variety of forms including: liquid and solid wastes that were placed in disposal sites (trenches, cribs, ditches, ponds), underground storage tanks and fly ash (produced from burning coal in coal-fired steam/power plants) released to the atmosphere. The fly ash contains trace metals and natural radionuclides that may have deposited on soil surfaces around the 100 Area reactors.

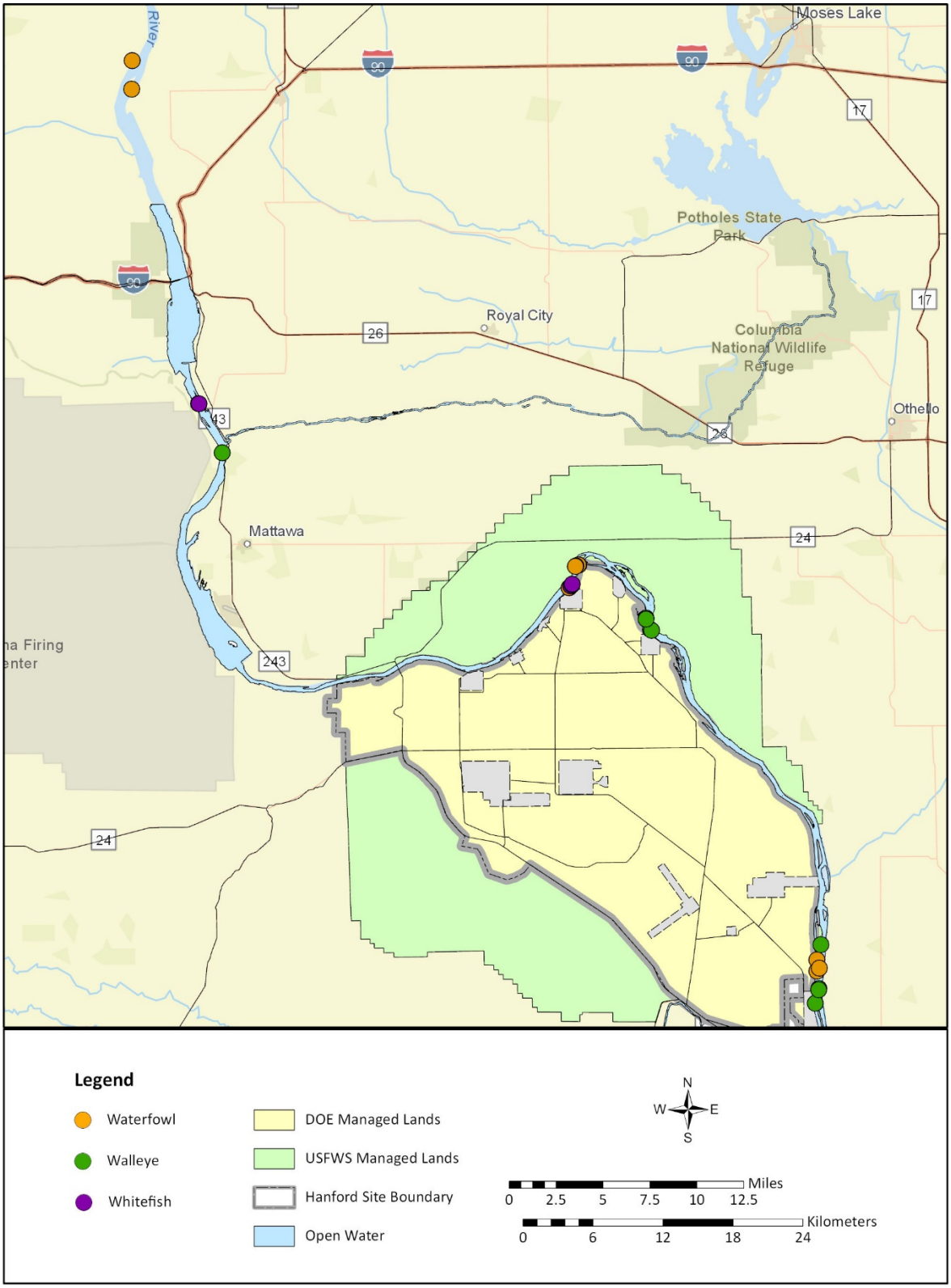


Figure 10-2. Animal Monitoring Locations.

Table 10-2. Wildlife Monitoring Analysis.

Biota	Offsite Locations	Onsite Locations	Gamma	Strontium-90	Trace Metals
Fish (mountain whitefish)	1	2	9	9	2
Fish (walleye)	1	2	10	10	2
Waterfowl (Canada goose)	1	2	10	10	0

10.2.1 Mountain Whitefish

In 2019, mountain whitefish were sampled and analyzed for radiological contaminants. Whitefish are harvested for food along the Hanford Reach of the Columbia River, and could potentially contribute to human exposure through ingestion. Many sportsmen have found that the flesh of the whitefish is of good quality, being firm, palatable, and tasty with a bony structure similar to trout.

Eight mountain whitefish were collected from two locations along the Hanford Reach, including a reference area (five along the 100-D shoreline, and three from the reference location at Priest Rapids Lake above Priest Rapids Dam). One whole fish from the 100 Areas was sent to the Washington State Department of Health (WDOH). Eight filet samples, including one duplicate, were submitted for analysis. Six carcass samples, including one duplicate, were submitted for analysis.

10.2.1.1 Cesium-137.

Manmade gamma-emitting radionuclide cesium-137 was not detected above the lab detection limit (0.092 pCi/g [0.003 Bq/g] wet weight) in any of the whitefish filet samples analyzed. The lab detection limit is well below the 0.340 pCi/g [0.013 Bq/g] DOE reporting limit. These results are consistent with those reported historically near the Hanford Site.

10.2.1.2 Strontium-90.

Manmade gamma-emitting radionuclide strontium-90 was not detected above the lab detection limit and was not detected above the far-field environmental surveillance dose-based reporting limit (0.039 pCi/g [0.001 Bq/g] wet weight) in any of the whitefish filet samples analyzed. The lab detection limit is well below the 0.14 pCi/g (0.005 Bq/g) DOE dose-based reporting limit.

10.2.1.3 Uranium.

Uranium isotopes (uranium-234, uranium-235, uranium-238) were not detected above laboratory detection limits (0.024pCi/g [0.001 Bq/g] wet weight) in any samples submitted. These results are consistent with those reported historically near the Hanford Site.

10.2.1.4 Trace Metals.

Two whitefish samples were analyzed for 19 different trace metals. Nine trace metals were detected in samples above the analytical detection limit at any location. Table 10-3 provides a summary of the 2019 metal analyses for the whitefish samples.

Table 10-3. Metals Analyses for the Mountain Whitefish Samples.

Isotope	Samples	Detects
Aluminum	2	0
Antimony	2	1
Arsenic	2	0
Barium	2	0
Beryllium	2	0
Cadmium	2	0
Chromium	2	0
Copper	2	2
Lead	2	2
Manganese	2	2
Mercury	2	2
Nickel	2	0
Selenium	2	2
Silver	2	0
Thallium	2	1
Thorium	2	0
Uranium	2	1
Zinc	2	2

Surveillance data sets for trace-metal concentrations in fish both on and near the Hanford Site are relatively small with variable results. At this time, no established federal or state adverse-effects values (i.e., benchmark criteria) are available for trace-metal concentrations in fish tissue. Identifying Hanford Site contributions to trace-metal concentrations or drawing conclusions about contribution effects are limited by the factors above. Monitoring fish for uptake and exposure to radionuclides and metals at locations both near to and distant from the Hanford Site will continue to provide important information for tracking the extent and long-term trends of contamination in the Hanford Reach environment. The WDOH lists mountain whitefish as a species retaining high concentrations of chemical contaminants and metals, and consumption should be limited to one meal per month (https://www.doh.wa.gov/CommunityandEnvironment/Food/Fish/Advisories).

10.2.2 Walleye

In 2019, walleye were sampled and analyzed for radiological contaminants. Walleye are a major game fish and a favorite food along the Hanford Reach of the Columbia River for anglers and could potentially contribute to human exposure through ingestion. Many sportsmen have found that the flesh of the walleye is one of the best eating freshwater fish anywhere.

Nine walleye were collected from three locations along the Hanford Reach, including a reference area (four from waters adjacent to the 100 Areas, four fish from waters adjacent to the Hanford Townsite through the 300 Area, and one fish from Priest Rapids Lake above Priest Rapids Dam). One whole fish was sent to the WDOH. A total of 10 filet and carcass samples (including duplicates) were submitted for analyses. The following are the radiological results for the walleye samples analyzed.

10.2.2.1 Cesium-137.

Manmade gamma-emitting radionuclides including cesium-137 was not detected in any walleye sample above the lab detection limit (0.09 pCi/g [0.003 Bq/g] wet weight) for the filet samples analyzed. These results are consistent with those reported historically near the Hanford Site.

10.2.2.2 Strontium-90.

Strontium-90 was not detected above the lab detection limit (0.04 pCi/g [0.001 Bq/g] wet weight) in any of the walleye filet samples. These results are consistent with those reported historically near the Hanford Site.

10.2.2.3 Uranium.

Uranium isotopes (uranium-234, uranium-235, and uranium-238) were not detected above lab detection limits in any of the walleye filet samples. These results are consistent with those reported historically near the Hanford Site.

10.2.2.4 Trace Metals.

Two walleye filet samples were analyzed for 18 different trace metal concentrations. Only Zinc was detected in samples that were above the analytical detection limit at any location. Table 10-4 provides a summary of the 2019 metal analyses for the whitefish samples. Uranium metal detections in these analyses are not radioactive isotopic analyses as described in the paragraph above.

Table 10-4. Metals Analyses for the Walleye Samples.

Isotope	Samples	Detects
Aluminum	2	0
Antimony	2	1
Arsenic	2	1
Barium	2	1
Beryllium	2	0
Cadmium	2	0
Chromium	2	0
Copper	2	1
Lead	2	0
Manganese	2	1
Mercury	2	0
Nickel	2	0
Selenium	2	2
Silver	2	0
Thallium	2	0
Thorium	2	0
Uranium	2	1
Zinc	2	2

Surveillance data sets for trace-metal concentrations in fish both on and near the Hanford Site are relatively small with variable results. At this time, no established federal or state adverse-effects values (i.e., benchmark criteria) are available for trace-metal concentrations in fish tissue. Identifying Hanford

Site contributions to trace-metal concentrations or drawing conclusions about contribution effects are limited by the factors above. Monitoring fish for uptake and exposure to radionuclides and metals at locations both near to and distant from the Hanford Site will continue to provide important information for tracking the extent and long-term trends of contamination in the Hanford Reach environment. The WDOH lists walleye as medium concern as a species retaining concentrations of chemical contaminants and metals within the Hanford Reach; consumption should be limited to two meals per month (https://www.doh.wa.gov/CommunityandEnvironment/Food/Fish/Advisories).

10.2.3 Waterfowl

During 2019, 14 Canada geese were collected along the Hanford Reach of the Columbia River: 5 between the Hanford Townsite and the 300 Area, 5 near the 100 Areas, and 4 geese from the reference area in the Wanapum pool area. Sampling efforts focused on young of the year birds whose entire life cycle before collection would have occurred on the Hanford Site. Two geese were submitted to WDOH, the remaining 12 geese were analyzed for cesium-137 in muscle and strontium-90 in bone. Radionuclide levels found in muscle and bone samples analyzed during 2019 were compared with levels measured in waterfowl samples collected at the Hanford Site over the past eight sample evolutions and with samples collected from reference locations, where available.

10.2.3.1 Cesium-137.

Manmade gamma-emitting radionuclides, cesium-137 were below the detection limit (0.03 pCi/g [0.001 Bq/g] wet weight) for all Canada goose muscle samples analyzed in 2019. These results are consistent with those reported over the past 15 years.

10.2.3.2 Strontium-90.

Strontium-90 results were below the analytical detection limit (0.05 pCi/g [0.0019 Bq/g] wet weight) in samples collected in 2019. Comparisons of the maximum and median strontium-90 concentrations reported for waterfowl bone samples (collected at the Hanford Site since 1999) and reference locations are consistent with these results, which do not indicate elevated strontium-90 levels. Figure 10-3 shows the median and maximum strontium-90 concentrations (pCi/g wet weight) and reference waterfowl samples for 2019 compared to previous years. Note that maximum concentrations in the figure are represented by the upper bar.

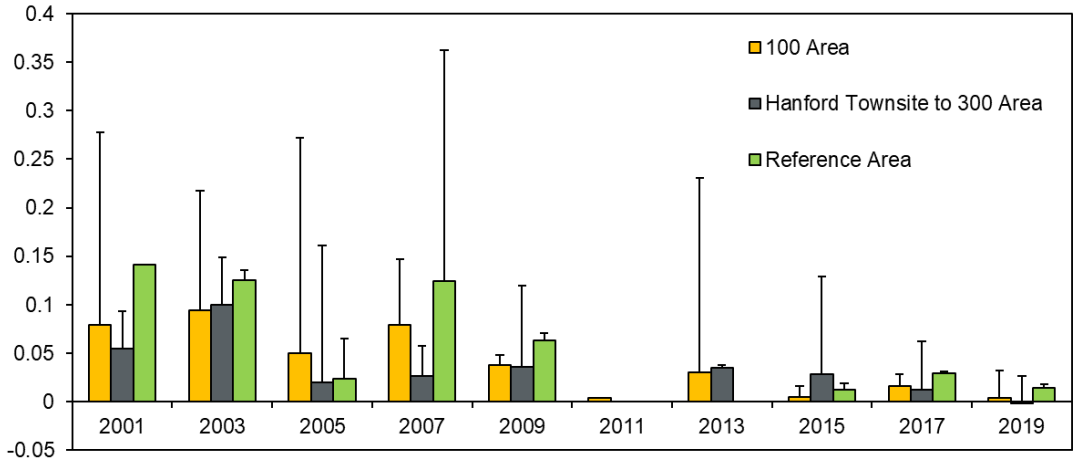


Figure 10-3. Strontium-90 Concentrations in Canada Goose Bone Samples.

10.3 Vegetation Monitoring

JE Cranna

Radiological monitoring of native vegetation is conducted from locations on or adjacent to waste disposal sites, as well as from locations downwind, near, or within the boundaries of operating facilities and remedial action sites. Vegetation sampling is also performed offsite at perimeter and distant locations, and in nearby communities. Contaminant data collected were used to:

- Determine the effectiveness of effluent monitoring and controls within facilities
- Assess the adequacy of contaminant at waste disposal sites, waste site remediation, and contamination areas
- Detect and monitor unusual conditions associated with a potential release or spread of radioactive material
- Provide long-term radionuclide contamination trends
- Provide complimentary monitoring to airborne sampling methods for atmospheric releases.

Vegetation is an integrating sample medium that accounts for contaminants released to the atmosphere either directly (gaseous effluent), indirectly (re-suspension/deposition), or through liquid effluent waste streams that are subsequently used for irrigation or from uptake of contaminants via their root system.

Deep-rooted vegetation (e.g., tumbleweeds, sagebrush) growing over underground sources of radionuclides may selectively uptake contaminants (e.g., cesium, strontium) into their tissues. When radionuclides are transported from roots to above surface portions of the plant, surface contamination may result, which poses a potential risk of environmental/biological transport or human contact. Vegetation samples have been collected on and around the Hanford Site for more than 50 years, and a significant data set exists that documents onsite and offsite levels of manmade radionuclides in and around the Hanford Site. These data provide a baseline to which unplanned releases are compared.

Vegetation samples from offsite locations are collected every 3 to 5 years and were most recently collected in CY 2019. Offsite vegetation sampling is used for long-term trend analysis and is not used in dose model calculations. The sampling frequency of every 3 to 5 years is consistent with the guidance provided in DOE-HDBK-1216-2015, *Environmental Radiological Effluent Monitoring and Environmental Surveillance*.

10.3.1 Hanford Site Vegetation Monitoring

Contamination in vegetation can occur as the result of surface deposition of radioactive materials from other radiologically contaminated sources or by absorption of radionuclides through the roots of vegetation growing on or near former waste disposal sites. The location and analyses of vegetation samples collected in CY 2019 are depicted in Table 10-5. The number of vegetation samples per operational area are summarized in Table 10-6.

Table 10-5. Hanford Site Vegetation Monitoring Locations and Sample Analyses.

Location	EDP Codes[a]	Collection Period	Analyses
100-N Area	Y719, Y724	May-June	90Sr, Pu-Iso, U-Iso, GEA
200-East Area	V053, V055, V057, V061, V063b, V065, V075, V077, V079, V141c	May-June	90Sr, Pu-Iso, U-Iso, GEA
200-West Area	V019, V025, V029, V031, V037, V039, V041, V043, V047b, V049, V051	May-June	90Sr, Pu-Iso, U-Iso, GEA
Plutonium Finishing Plant (200-West Area)	V007, V009 , V045b, V111c	May-June	90Sr, Pu-iso, U-iso, GEA, 241Am
300 Area	V123b, V132c	May-June	90Sr, Pu-Iso, U-Iso, GEA
600 Area	V081, V083, V085, V087, V089, V091b, V095, V097, V099, V101, V103, V107, V109, V113c, V143c	May-June	90Sr, Pu-Iso, U-Iso, GEA

[a] EDP Code=environmental data point code = sample location code
[b] Collocated sampling location with WDOH
[c] Quality assurance duplicate sample
GEA = Gamma Energy Analysis
90Sr = Strontium-90
241Am = Americium-241
Pu-iso = isotopic plutonium (238Pu, 239/240Pu)
U-iso = isotopic uranium (234U, 235U, 238U)
WDOH == Washington State Department of Health

Table 10-6. Number of Vegetation Samples per Operational Area.

Number of Samples	Operational Area (discrete samples analyzed)				
	100-N	200-East [a]	200-West [a]	300 Area[a]	600 Area[a]
44	2	10	15	2	15

[a] Includes one or more duplicate samples.

10.3.1.1 Sampling and Analysis.

Samples were collected and analyzed according to DOE/RL-2013-53, *Hanford Site Environmental Surveillance Master Sampling Schedule for Calendar Year 2019*. Onsite vegetation samples are collected annually. Collections in the 200 and 600 Areas are alternated between even and odd numbered years, aligning with even and odd numbered sample locations. Individual vegetation samples (approximately 17.6 oz [500 g]) consist of new-growth leaf cuttings taken from the available brushy, deep-rooted species (e.g., sagebrush and/or rabbitbrush). To avoid decimation of any individual plant through overharvesting, samples may consist of mixed biota representing several like members of the sampling site plant community. Vegetation samples are dried prior to analyses and analytical results are reported on a dry weight basis.

Vegetation samples were analyzed for strontium-90, uranium-234, uranium-235, uranium-238, plutonium-238, plutonium-239/240, and gamma-emitting radionuclides. In support of the current deactivation and decommissioning project at the Plutonium Finishing Plant (PFP) located in the 200-West Area, and especially for monitoring during the demolition of the Americium Recovery Facility,

an americium-241 alpha energy analysis was added to the analyte list at three vegetation monitoring locations (V007, V009, and V045) near the PFP complex.

10.3.1.2 Vegetation Monitoring Results.

The analytical results from Hanford Site vegetation samples collected in CY 2019 were compared with concentrations of radionuclides measured in samples collected offsite at various locations in Grant, Yakima, Walla Walla, Adams, Benton, and Franklin Counties in 2019. These comparisons are used to differentiate concentrations of Hanford Site-produced contaminants from levels resulting from natural sources and worldwide fallout.

In general, radionuclide concentrations in vegetation samples collected from or adjacent to waste disposal facilities in 2019 were similar to or slightly higher than concentrations in samples collected further away, including concentrations measured offsite in 2019. Cesium-137, strontium-90, plutonium-239/240, uranium-234, and uranium-238 were detected in the 2019 vegetation samples at locations and concentrations consistent with previous years. Figure 10-4 shows the annual average vegetation concentrations of selected radionuclides in the 100, 200, 300, and 600 Areas. There were no vegetation samples collected from the 400 Area due to lack of available vegetation. Appendix C, Table C-20 shows the annual average and maximum concentrations of radionuclides in vegetation samples by area during 2019 and for the preceding 5 years.

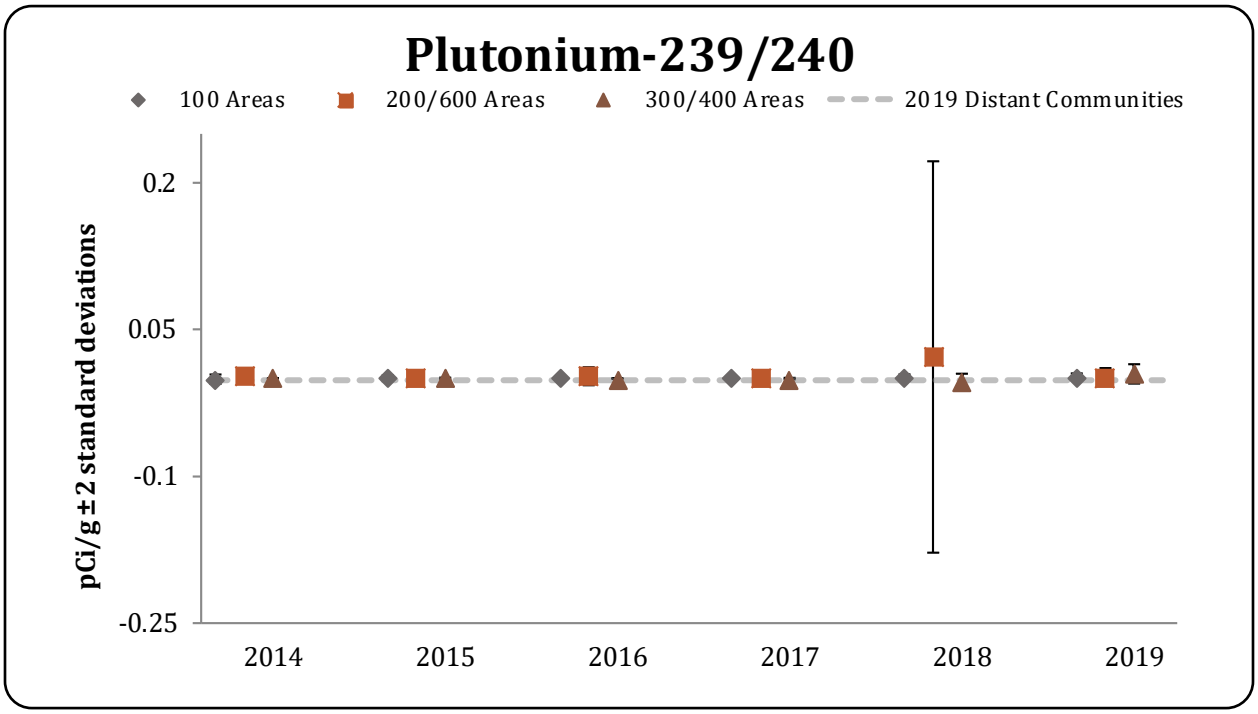
Uranium. Uranium-234 and uranium-238 concentrations were similar to historical levels, however, the frequency of detection was lower than what had been observed in previous years.

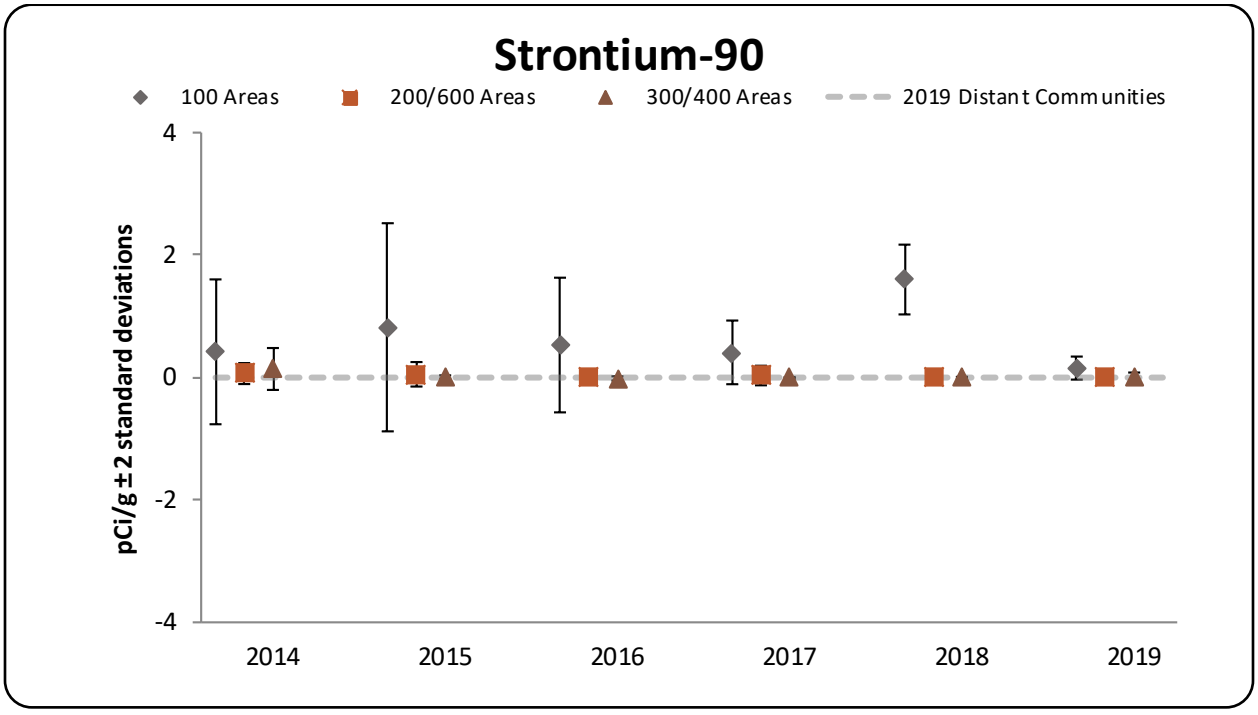
Plutonium. Plutonium-239/240 was detected in 33% of the vegetation samples collected in the 200-West Area. The concentrations measured were within historical ranges.

Strontium-90. Strontium-90 was detected in both of the samples collected at 100-N and in approximately 40% of the samples collected in the 200-East Area. Concentrations of strontium-90 were within historical ranges.

Cesium-137. Cesium-137 was detected in approximately 16% of the samples collected in the 200 and 600 at concentrations similar to those seen in historical data.

Americium-241. In support of the deactivation and decommissioning project at the PFP, and especially for monitoring during the demolition of the Americium Recovery Facility, an americium-241 alpha energy analysis was added to the analyte list at three vegetation monitoring locations (V007, V009, and V045, plus a duplicate sample collected at V045) near the PFP complex. Americium-241 was detected in two of the four samples analyzed for americium-241. The americium 241 concentrations were lower than what has been seen in the previous 3 years of analyzing for americium-241.


Plutonium-239/240
100 Areas
200/600 Areas
300/400 Areas
2019 Distant Communities
pCi/g ± 2 standard deviations
0.2
0.05
-0.1
-0.25
2014
2015
2016
2017
2018
2019


Strontium-90
100 Areas
200/600 Areas
300/400 Areas
2019 Distant Communities
pCi/g ± 2 standard deviations
4
2
0
-2
-4
2014
2015
2016
2017
2018
2019

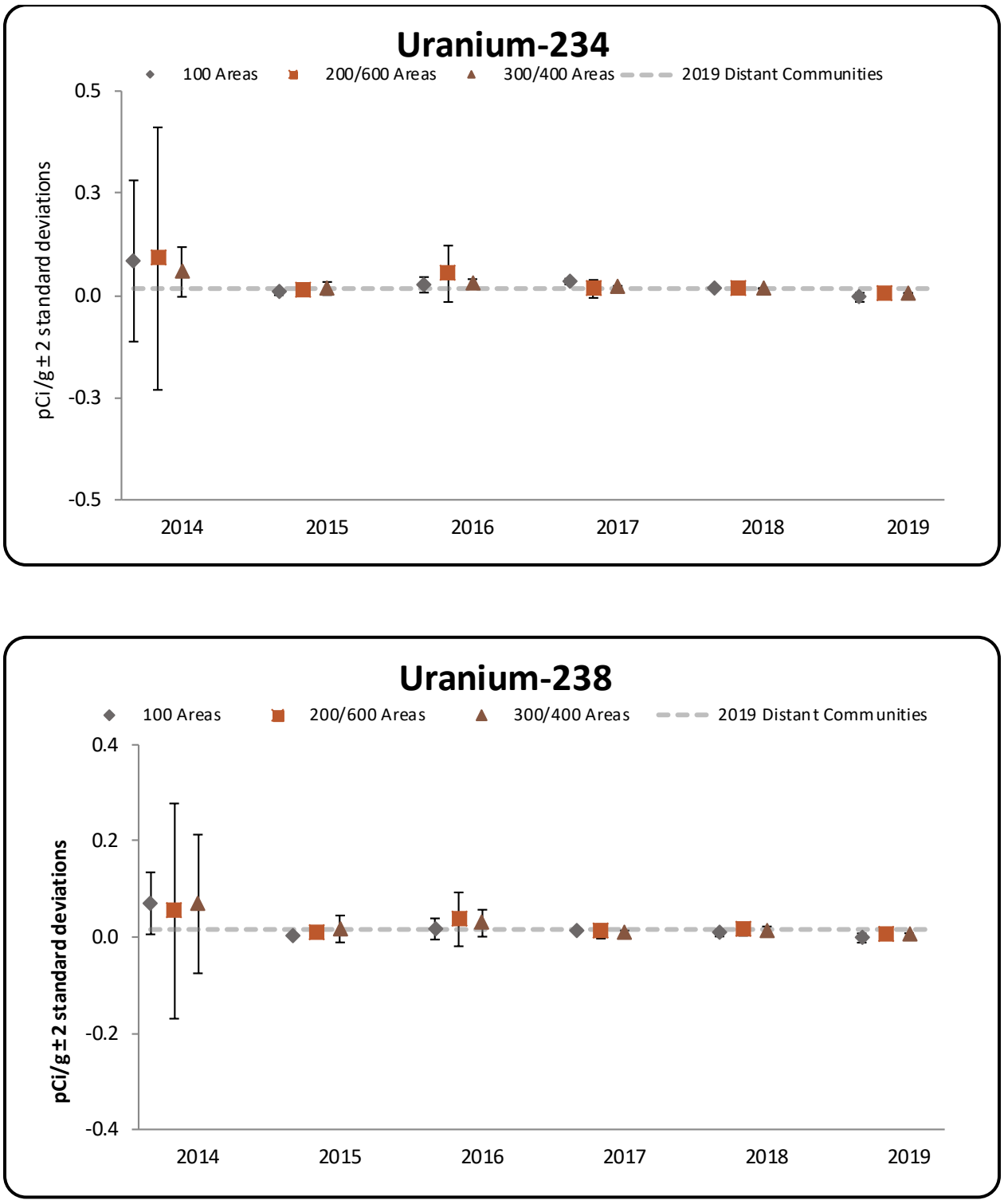


Figure 10-4. Hanford Site Vegetation Average Concentrations of Selected Radionuclides.

10.3.2 Offsite Vegetation Sampling

Vegetation samples from offsite locations are collected every 3 to 5 years. Offsite vegetation sampling is used for long-term trend analysis and is not used in dose model calculations. The sampling frequency of every 3 to 5 years is consistent with the guidance provided in the handbook DOE-HDBK-1216-2015, *Environmental Radiological Effluent Monitoring and Environmental Surveillance*.

During 2019, vegetation samples were collected from eight locations around the perimeter of the Hanford Site and nearby and distant communities. The locations and analyses of offsite vegetation samples collected in CY 2019 are depicted in Table 10-7.

Table 10-7. Offsite Vegetation Monitoring Locations and Sample Analyses.

Soil Monitoring Location[a, b]	EDP Codes[c]	Analyses
Ringold	V427	GEA, ^{90}Sr, U-iso, Pu-iso
Sagemoor Farms	V430, V493[d]	GEA, ^{90}Sr, U-iso, Pu-iso
Byers Landing	V431	GEA, ^{90}Sr, U-iso, Pu-iso
Sunnyside	V434	GEA, ^{90}Sr, U-iso, Pu-iso
George	V439[e]	GEA, ^{90}Sr, U-iso, Pu-iso
Othello	V440[e]	GEA, ^{90}Sr, U-iso, Pu-iso
Wanapum	V441[e]	GEA, ^{90}Sr, U-iso, Pu-iso

[a] Samples are collected approximately every 3 to 5 years
[b] Samples were collect in June 2019
[c] EDP Code=environmental data point code = sample location code
[d] Quality assurance duplicate sample
[e] Collocated sampling location with WDOH
GEA = Gamma Energy Analysis
^{90}Sr = strontium-90
Pu-iso = isotopic plutonium (plutionium-238, plutonium-239/240)
U-iso = isotopic uranium (uranium-234, uranium-235, uranium-238)
WDOH = Washington State Department of Health

10.3.2.1 Offsite Vegetation Sampling Results

The analytical results from vegetation samples collected from around the perimeter of the Hanford Site and nearby and distant communities in CY 2019 are summarized in Appendix C, Table C-21. Radionuclide concentrations in vegetation samples collected in CY 2019 at offsite locations were compared to results from 2001, 2004, 2008, and 2015. In 2019, the observed average and maximum concentrations in vegetation samples for all isotopes were generally similar to their respective averages and maximums from 2001, 2004, 2008, and 2015. With the exception of uranium, the Hanford sitewide average vegetation concentrations in 2019 were similar to or slightly higher than those seen at site perimeter and distant locations for the radionuclides measured (Appendix C, Table C-22). The average concentration for uranium was slightly higher in samples collected from offsite locations, with the maximum concentration measured in a sample collected from Othello.

10.3.3 Radiological Contamination Surveys

Radiological surveys were performed in and near Hanford Site operational areas to monitor the presence or movement of radioactive materials or to verify radiological conditions at specific project sites. All sites are field surveyed for alpha and beta-gamma radiation.

Radiological surveys performed in CY 2019 identified 29 instances of radiological contamination in vegetation. All 29 were Russian thistle (*Salsola tragus*) plants or fragments. Of the 29 instances, 2 locations were posted as a contamination areas and 27 were cleaned up and disposed of at a licensed facility.

Section 10.3.4 provides a discussion of the vegetation control on the Hanford Site. Table 10-8 summarizes the general locations of vegetation contamination incidents discovered in CY 2019. Table 10-9 provides the number of contamination incidents from 2000 to 2019.

Table 10-8. Hanford Site Vegetation Contamination Occurrences Discovered in Calendar Year 2019.

Location	2019 Incidents
100 Area	0
200-East Area	
Tank farms	5
Burial grounds	4
Cribs, ponds, and ditches	3
Fence lines	0
Roads and railroads	1
Unplanned release sites	0
Underground pipelines	0
Liquid Effluent Treatment Facility/Effluent Treatment Facility	6
Miscellaneous	0
200-West Area	
Tank farms	1
Burial grounds	2
Cribs, ponds, and ditches	4
Fence lines	0
Roads and railroads	0
Unplanned release sites	0
Underground pipelines	0
Miscellaneous	3
Cross-site transfer line	0
200-North Area	0
300 Area	0
400 Area	0
600 Area	0
Total	**29**

Table 10-9. Hanford Site Vegetation Contamination Occurrences from 2000 through 2019.

Year	Incidents
2000	66
2001	20
2002	16
2003	32
2004	60
2005	66
2006	75
2007	62
2008	127
2009	109
2010	36
2011	10
2012	18
2013	35
2014	50
2015	48
2016	45
2017	23
2018	38
2019	**29**

10.3.4 Vegetation Control

JM Rodriguez, RC Roos

The purpose of vegetation control at the Hanford Site is effective control and minimization of noxious weeds, industrial weeds, and other vegetation to ensure protection of Hanford Site workers, the public, facilities, property, and the Hanford Site's cultural and environmental (including biological) resources. Risks that are mitigated through effective vegetation control are the spread of contamination, wildfire fuel loading, harborage of vermin and insect pests around facilities, damage and destruction of native plant communities, damage to facilities, and interference with work and transportation.

Approximately 6,365 ac (2,576 ha) were treated with herbicides in 2019 on radiological waste sites, around operations areas, and along roadways to keep areas free of deep-rooted vegetation (e.g., Russian thistle, also known as tumbleweed). Follow-up treatments were included in the total treated acres; several areas received more than one herbicide application.

10.3.4.1 Noxious Weeds.

Noxious weeds were controlled at the Hanford Site to prevent their spread and eliminate populations. A noxious weed is a legal and administrative category designated by federal or state regulatory agencies (e.g., the U.S. Department of Agriculture, Washington State Department of Agriculture). Noxious weeds are non-native, aggressively invasive, and hard to control. Noxious weed plant communities degrade ecosystems unless control measures are taken. Control measures can be mechanical, chemical, cultural, or biological. Approximately 72 ac (29 ha) of noxious weeds on the Hanford Site were treated with herbicides in 2019. These control measures were focused on revegetation and restoration sites including cleaned-up waste sites and revegetated mitigation sites. Noxious weed species that were

controlled in 2019 included: diffuse knapweed (*Centaurea diffusa*), rush skeletonweed (*Chondrilla juncea*), Saltcedar (*Tamarix spp.*), Tackweed (*Tribulus terrestris*), and phragmites (*Phragmites spp.*).

10.4 Waste Site Remediation and Revegetation

RC Roos, JM Rodriguez

In 2019, 125 ac (51 ha) across the Hanford Site were revegetated in an effort to restore native plant communities on revegetation and restoration sites including cleaned-up waste sites and revegetated mitigation sites. Revegetation efforts were uniquely planned for each site depending on condition of the site and expectations. Work at the sites may have included soil preparation, seeding of grass and forb species, mulching, and hand planting forb and shrub seedlings. Sites where revegetation efforts were performed include the following: 600-30, 100-N Reactor, C9L3 Road, 100-N South, 128-D-2 East, 128-D-2 West, 628-3, 600-356, 600-100, 600-301, 600-370, 600-120, 100-K-95, 600-385, 600-358, 124-N-10, 130-N-1, 100-N-CTA, 116-C-5 Retention Basin, and 116-B/C-Misc. Approximately 47,000 seedlings were hand planted as part of the revegetation effort.

10.5 References

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NCRP. 2009. *Ionizing Radiation Exposure of the Population of the United States*. Report No. 160. National Council on Radiation Protection and Measurements, Washington, D.C.

PNL-9394. 1994. *Ecotoxicity Literature Review of Selected Hanford Site Contaminants*. Pacific Northwest Laboratory, Richland, Washington. Online at http://www.osti.gov/bridge/servlets/purl/10136486-6slptz/native/10136486.pdf.

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