4.5 Fish and Wildlife Surveillance

B. L. Tiller

Contaminants in wildlife that inhabit the Columbia River and Hanford Site are monitored because terrestrial wildlife has access to areas of the site that contain radioactive or chemical contamination, and aquatic organisms can be exposed to contamination entering the river along the shoreline. Some fish and wildlife species exposed to Hanford contaminants might be harvested for food and may potentially contribute to offsite public exposure. In addition, the level of contaminants in tissues of key organisms (ecological sentinels) may help identify changes in environmental conditions over time and may help describe the extent and degree to which Hanford Site materials are found in the environment.

A primary consideration when selecting wildlife species for routine human-exposure sampling was the likelihood that these species could be consumed by members of the public. The primary considerations when selecting ecological sentinels included (1) the likelihood that the organism would frequent contaminated areas on and near the site and accumulate contaminants in body tissues, (2) the type of organisms ecological guild (e.g., herbivore, predator, primary producer), and (3) the possibility of relating ambient contaminant levels in abiotic media (e.g., water, soil, air) to the contaminant concentrations measured in tissues of the organism. In 2003, several types of organisms were collected at locations on and around the Hanford Site (Figure 4.5.1) and analyzed for selected metals, radionuclides, and organics that are suspected or known to be present on the Hanford Site (Table 4.5.1). Samples were also collected at locations that were distant from the site to obtain reference (background) contaminant measurements.

Fish and wildlife samples for routine human-exposure pathway assessments are collected annually on or near the Hanford Site, but specific species are sampled every 2 or 3 years. Routine samples are collected approximately every 5 years at locations believed to be unaffected by Hanford Site effluents and emissions.

In 2003, all fish and wildlife samples collected were monitored for strontium-90 contamination and were analyzed by gamma spectrometry to detect a number of gamma emitters (Appendix F) including cesium-137. Cesium-137 is present in Hanford effluents and in historical atmospheric fallout. Since the 1990s, strontium-90 and cesium-137 have been the most frequently measured radionuclides in fish and wildlife samples. Strontium-90 is chemically similar to calcium and accumulates in hard tissues rich in calcium such as bones, antlers, and shells. Hard-tissue concentrations may profile an organism's exposure to strontium-90. However, strontium-90 generally does not contribute much to human dose because it does not accumulate in edible tissues. Contaminated groundwater that enters the Columbia River via shoreline springs near the 100-N and 100-H Areas is the primary Hanford source of strontium-90 to the river; however, the current contribution of this contaminant to the river, compared to historical fallout from atmospheric nuclear weapons testing, is less than 2% (PNL-8817). Cesium-137 is a gamma-emitter of special importance because it is chemically similar to potassium, which is found in edible muscle tissues.

A number of trace metals that have the potential to accumulate in certain fish and wildlife tissues have been identified in the Hanford Site environment as potential contaminants of concern (e.g., chromium, copper, lead, and mercury), particularly in areas of the site where contaminated groundwater enters the Columbia River along the shoreline (PNNL-14295). Trace metal concentrations were monitored in Canada geese (*Branta canadensis*), cottontail rabbits (*Sylvilagus nuttallii*), whitefish

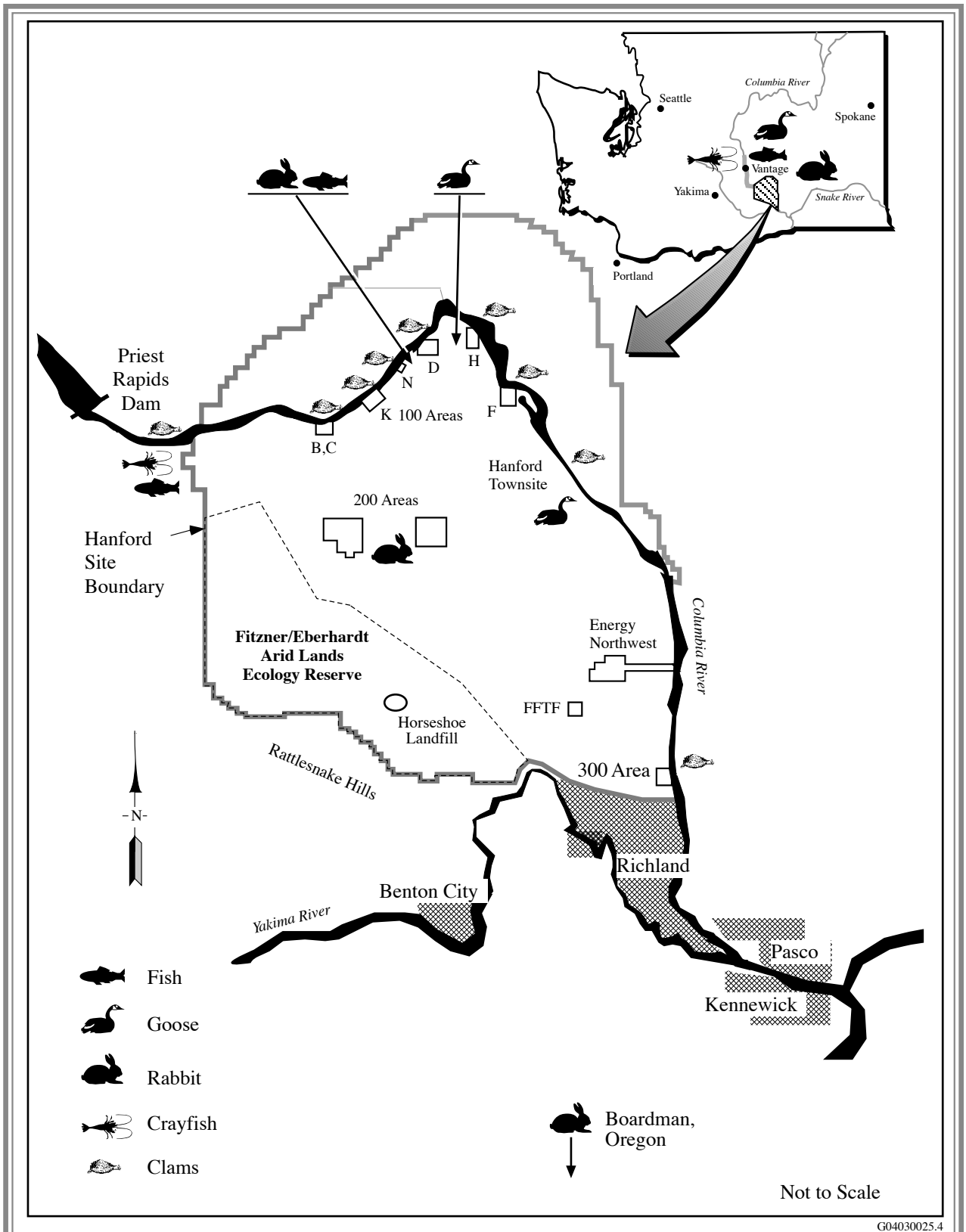

Figure 4.5.1. Fish and Wildlife Sampling Locations On and Around the Hanford Site, 2003

Table 4.5.1. Locations, Species, and Contaminants Sampled for Fish and Wildlife, 2003

Biota	No. of Offsite Locations	No. of Onsite Locations	No. of Analyses		
			Gamma	Strontium-90	Trace Metals
Fish (whitefish)	1[a]	1	6	6	6
Fish (sculpin)	2[b]	0	0	5	10
Canada goose	1[a]	2	11	11	11
Rabbits	0	1	4	4	4
Crayfish	2[b]	0	0	5	10
Asiatic clams	5[b]	18	0	18	18

(a) Samples collected at Vantage, Washington.
(b) Samples collected near Vernita Bridge.

(*Prosopium williamsonii*), crayfish (*Pacificastus leniusculus*), prickly sculpin (*Cottus asper*), and Asiatic clams (*Corbicula fluminea*) in 2003, but only the data from the Asiatic clams are discussed in this report. Trace metal data for the other organisms are not discussed because of the limited number of samples collected during 2003 and the lack of elevated levels of Hanford Site contaminants in the samples analyzed. The data are summarized in PNNL-14687, APP. 1.

For many radionuclides and metals, concentrations are below levels that can be detected by the analytical laboratory. When this occurs, the minimum detectable activity is used as an estimate of the minimum detectable amount of the contaminant. Results and minimum detectable activities for all 2003 analytical results are tabulated in PNNL-14687, APP. 1.

4.5.1 Fish and Wildlife Sampling

Routinely monitoring various fish and wildlife for uptake of, and exposure to, radionuclides both near and distant from Hanford Site operations helps to verify that the consumption of fish and wildlife obtained near the Hanford Site does not pose a threat to humans. Monitoring also provides data to map long-term contamination trends in selected ecosystem components. Terrestrial and riverine wildlife sampled and analyzed during 2003 included mountain whitefish, Canada geese, and cottontail rabbits.

4.5.1.1 Fish Sample Results and Analytes of Interest

During 2003, five mountain whitefish were collected between the 100-N and the 100-D Areas, and one whitefish was collected from an upstream reference site near Vantage, Washington (Figure 4.5.1). Fillet (muscle) samples were analyzed by gamma spectrometry for cesium-137 and other gamma-emitting radionuclides (PNNL-14687, APP. 1) and the eviscerated remains (head, skeleton, and tail) were analyzed for strontium-90 (Table 4.5.1). Cesium-137 concentrations in the fillet samples from both locations were below the analytical detection limit (0.04 pCi/g [0.0015 Bq/g] wet weight). These results were consistent with results reported throughout the 1990s.

Strontium-90 was not found above the analytical detection limit (0.02 pCi/g [0.0007 Bq/g] wet weight) in any of the six whitefish carcass samples collected and analyzed during 2003. These results were similar to levels reported for the 100 Areas in preceding years (Figure 4.5.2). The highest concentration of strontium-90 reported over the preceding 7 years was in a reference whitefish collected from the Clearwater River near Orofino, Idaho, during 1999.

4.5.1.2 Goose Sample Results and Analytes of Interest

Ten geese were collected from the Hanford Reach of the Columbia River and two were collected from a reference

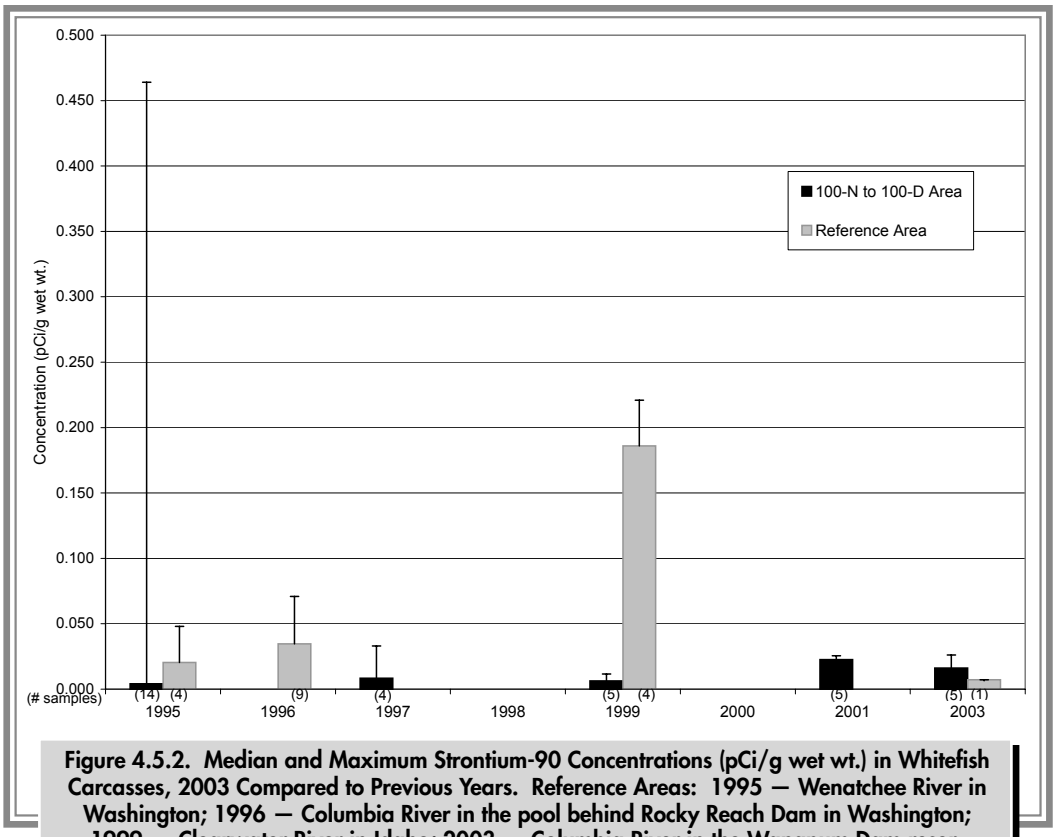

Figure 4.5.2. Median and Maximum Strontium-90 Concentrations (pCi/g wet wt.) in Whitefish Carcasses, 2003 Compared to Previous Years. Reference Areas: 1995 — Wenatchee River in Washington; 1996 — Columbia River in the pool behind Rocky Reach Dam in Washington; 1999 — Clearwater River in Idaho; 2003 — Columbia River in the Wanapum Dam reservoir in Washington. Maximum concentrations are represented by the upper bar.

location near Vantage, Washington, in the early fall of 2003 (Figure 4.5.1). All organisms were analyzed for gamma-emitting radionuclides (including cesium-137) in muscle tissue and strontium-90 in bones.

Manmade gamma-emitting radionuclides, including cesium-137, were not found in any of the muscle samples analyzed in 2003 (minimum detectable activities were 0.01 to 0.3 pCi/g [0.00037 to 0.001 Bq/g] wet weight). These results were similar to results reported for 38 goose samples collected from the Hanford Reach from 1995 through 2001. All of these analytical results suggest that Canada geese are not accumulating measurable amounts of cesium-137 along the Hanford Reach of the Columbia River.

Strontium-90 concentrations found in goose bones were all above the analytical detection limit and levels found during 2003 in all Hanford Reach and reference area samples were similar (Figure 4.5.3). Median and maximum concentrations in Hanford Reach goose samples in 2003 were similar to results reported during 2001 (median approximately 0.1 pCi/g [0.004 Bq/g] wet weight), which were higher than any reported from 1995 through 2000 (n=28), but were similar to results from reference area (background) samples obtained in 1995 (n=10), 1999 (n=3), and 2003 (n=3). While the apparent increases in strontium-90 concentrations in Hanford Site goose samples obtained in 2001 and 2003 are noteworthy, the measured concentrations in bone would need to exceed approximately 60 pCi/g (2.2 Bq/g) wet weight to be near the current DOE dose limit of 0.1 rad (0.0008 Gy) per day for terrestrial organisms (Chapter 5).

4.5.1.3 Rabbit Sample Results and Analytes of Interest

Rabbits are useful onsite for detecting localized radioactive contamination because they have relatively small home ranges, occupy burrows in potentially contaminated soil, and can enter fenced-restricted areas that contain radioactive waste materials. They may also be useful as sentinel organisms both on and off the site. In the fall of 2003,

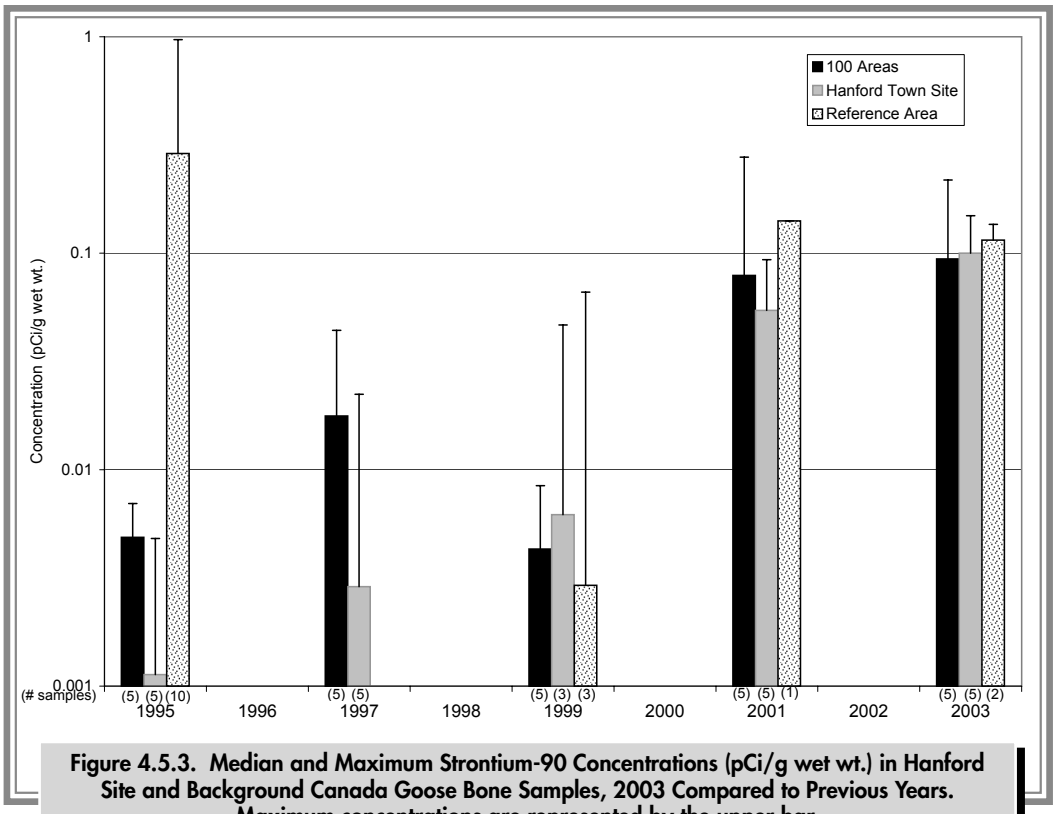

Figure 4.5.3. Median and Maximum Strontium-90 Concentrations (pCi/g wet wt.) in Hanford Site and Background Canada Goose Bone Samples, 2003 Compared to Previous Years. Maximum concentrations are represented by the upper bar.

cottontail rabbits were collected from a reference area, the 200 Areas, and 100-N Area. Four cottontail rabbits were collected near the 100-N Area, two were collected near the 200-West Area, four were collected near the 200-East Area, and one was collected from the reference area near Vantage, Washington (Figure 4.5.1). Ten reference cottontail rabbit samples were collected near Boardman, Oregon, in 1990 and the data from these organisms are used here for comparison. All rabbits were monitored for cesium-137 in muscle tissue and strontium-90 in bones.

Cesium-137 concentrations in muscle samples from seven of ten rabbits collected on the Hanford Site during 2003 were below the analytical detection limit (0.02 pCi/g [0.00074 Bq/g] wet weight). The results from the six rabbits collected near the 200 Areas were similar to those reported from the reference locations sampled in 1990 and 2003 and do not indicate elevated exposures from Hanford-derived sources. Three of the four rabbit samples collected near 100-N Area during 2003 contained detectable levels of cesium-137 ranging between 0.05 ± 0.02 pCi/g (0.002 ± 0.0007 Bq/g) wet weight and 0.9 ± 0.03 pCi/g (0.03 ± 0.0008 Bq/g) wet weight. These levels were above the detection limit but were too low to contribute substantially to any public dose if a similar rabbit with a similar contaminant burden were collected offsite and consumed (Chapter 5).

Strontium-90 concentrations in bone tissues from the ten rabbits collected onsite during 2003 were all above the analytical detection limit with median concentrations ranging from 0.4 pCi/g (0.0148 Bq/g) to 2.68 ± 0.8 pCi/g (0.10 ± 0.03 Bq/g) wet weight (Figure 4.5.4). Three of the four highest concentrations reported during 2003 were collected near the 100-N Area. Results from rabbits collected near the 100-N Area have historically been higher and more variable than results obtained from reference areas. This indicates a portion of the rabbit population near the 100-N Area has been exposed to 100-N Area sources of strontium-90. Although low sample sizes limit the ability to interpret the long-term trends, major changes in strontium-90 levels within rabbit bone tissues have not been apparent over the past decade (Figure 4.5.4). Strontium-90 concentrations in bone tissues would need to exceed approximately 60 pCi/g (2.2 Bq/g) wet weight to

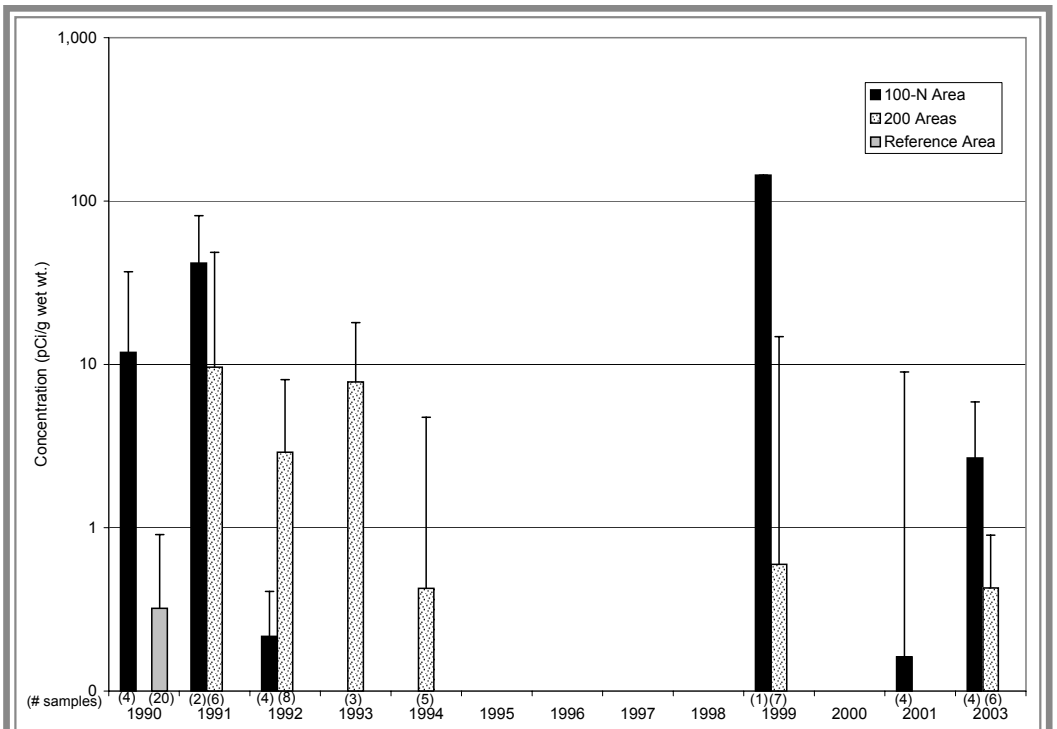

Figure 4.5.4. Median and Maximum Strontium-90 Concentrations (pCi/g wet wt.) in Hanford Site and Background Rabbit Samples, 2003 Compared to Previous Years. Maximum concentrations are represented by the upper bar.

be near the current DOE dose limit of 0.1 rad (0.0008 Gy) per day for ecological receptors such as rabbits (Chapter 5).

4.5.2 Sentinel Organisms

For environmental monitoring purposes, biological organisms can be used to (1) detect and quantify contaminants in a given ecosystem (sentinel organisms) and (2) indicate damage or injury to an ecosystem (indicator organisms). Organisms that are best suited for accumulating contaminants and serving as biological monitors of environmental contaminants are termed "sentinel species," whereas organisms (or defined assemblages of organisms) that are sensitive to damage or injury from elevated levels of environmental contaminants are referred to as "indicator species." In practice, the desirable features of both the sentinel and indicator species are often found only in a limited number of organisms present in the ecosystem. The organisms chosen for monitoring environmental health often have both sentinel and indicator species attributes.

Asiatic clams may be one of the best sentinel organisms along the Hanford Reach of the Columbia River for DOE cleanup and monitoring objectives on the Hanford Site. This organism is relatively immobile its entire life (0 to 3 years), lives in shallow shoreline areas, is a filter-feeder that feeds on phytoplankton, and is common along the Hanford Reach shoreline. These habitat and food source preferences make this organism an ideal candidate for monitoring contaminants in groundwater seeping into the Columbia River via shoreline springs. Samples of Asiatic clams were collected along the Hanford Reach during November 2002 through March 2003 to evaluate the usefulness of this species as a sentinel organism for monitoring the spatial patterns of Hanford radiological and non-radiological contaminants entering the Columbia River environments.

Sampling points were selected near the river's low-water mark, which was visually identified by the presence of persistent periphyton colonies growing on bottom substrates (during portions of the year, periphyton dries out above the low-water mark). Clam samples were collected from this point along a transect extending into the river perpendicular to the shoreline at standard water depths of 0.25 meter (0.8 foot), 0.5 meter (1.6 feet), 1 meter (3.3 feet), and 1.5 meters (4.9 feet).

Clam samples were flash-steamed for approximately 15 to 30 seconds using deionized water and shell tissues were separated from soft tissues. Shells taken from a number of individual clams from each sampling site were composited for strontium-90 and technetium-99 analyses. Soft tissues (from 2 to 50 organisms per sample) were composited and analyzed for a number of trace metals, including chromium, mercury, and uranium.

Crayfish and sculpin samples were also collected during 2003 from a reference region upstream of the Hanford Site and were analyzed for gamma-emitting radionuclides, strontium-90, technetium-99, and trace metals. A number of individuals were composited (5 to 25 individuals) for the radionuclide analyses. Liver samples from sculpins and hepatopancreas samples from crayfish were analyzed for trace metals.

4.5.2.1 Asiatic Clam Sample Results and Analytes of Interest

Concentrations of most metals and radionuclides in Hanford Reach clam samples were at or below levels found in samples collected upstream of the Hanford Site near the Vernita Bridge. Chromium concentrations were consistently elevated compared to concentrations at the Vernita Bridge (Table 4.5.2). The tissue burdens of chromium reported in clams indicate the highest exposures generally occurred in the shallowest areas and decreased as water depth increased. The few exceptions appeared to occur in areas where shorelines were relatively steep.

Strontium-90 levels in shells were highest near the 100-N and 100-H Areas, respectively (Figure 4.5.5). Technetium-99 was found in shell samples near the 100-B/C and 300 Areas at levels that were elevated compared to levels in samples collected from the upstream reference area.

4.5.2.2 Crayfish Sample Results and Analytes of Interest

Five samples of crayfish tissue were collected during 2003 and analyzed for gamma-emitting radionuclides, strontium-90, and technetium-99. Gamma-emitting radionuclides were not found above the minimum detectable activity (0.05 pCi/g [0.002 Bq/g] wet weight) in any sample. All five samples contained measurable quantities of strontium-90 with concentrations between 0.09 and 0.13 pCi/g [0.003 and 0.005 Bq/g] wet weight. Technetium-99 was not detected in any of the crayfish samples. These results indicate that crayfish may be a useful sentinel organism because they contained measurable

Table 4.5.2. Trace Metals (ppm dry wt.) and Radionuclides (pCi/g wet wt.) in Columbia River Asiatic Clams,[a] Hanford Reach Samples Compared to Reference Area Samples Collected Upstream of the Vernita Bridge, 2001-2003

Sampling Locations	Trace Metals										Radionuclides	
	Silver	Aluminum	Arsenic	Barium	Beryllium	Cadmium	Chromium	Copper	Mercury		Strontium-90	Technetium-99
100-B/C Area												
100-K Area												
100-N Area												
100-D Area												
100-H Area												
100-F Area												
Hanford town site												
300 Area												
	Nickel	Manganese	Lead	Antimony	Selenium	Thorium	Thallium	Uranium	Zinc			
100-B/C Area												
100-K Area												
100-N Area												
100-D Area												
100-H Area												
100-F Area												
Hanford town site												
300 Area												

(a) Metals analyses on soft tissues and radiological analyses on shells.

	Maximum concentrations in Hanford Reach samples below maximum concentrations reported from reference area.
	Maximum concentrations in Hanford Reach samples between 1 and 2 times the maximum concentrations reported in reference area samples.
	Maximum concentrations in Hanford Reach samples between 2 and 5 times the maximum concentrations reported in reference area samples.
	Maximum concentrations in Hanford Reach samples between 5 and 10 times the maximum concentrations reported in reference area samples.
	Maximum concentrations in Hanford Reach samples greater than 10 times the maximum concentrations reported in reference area samples.

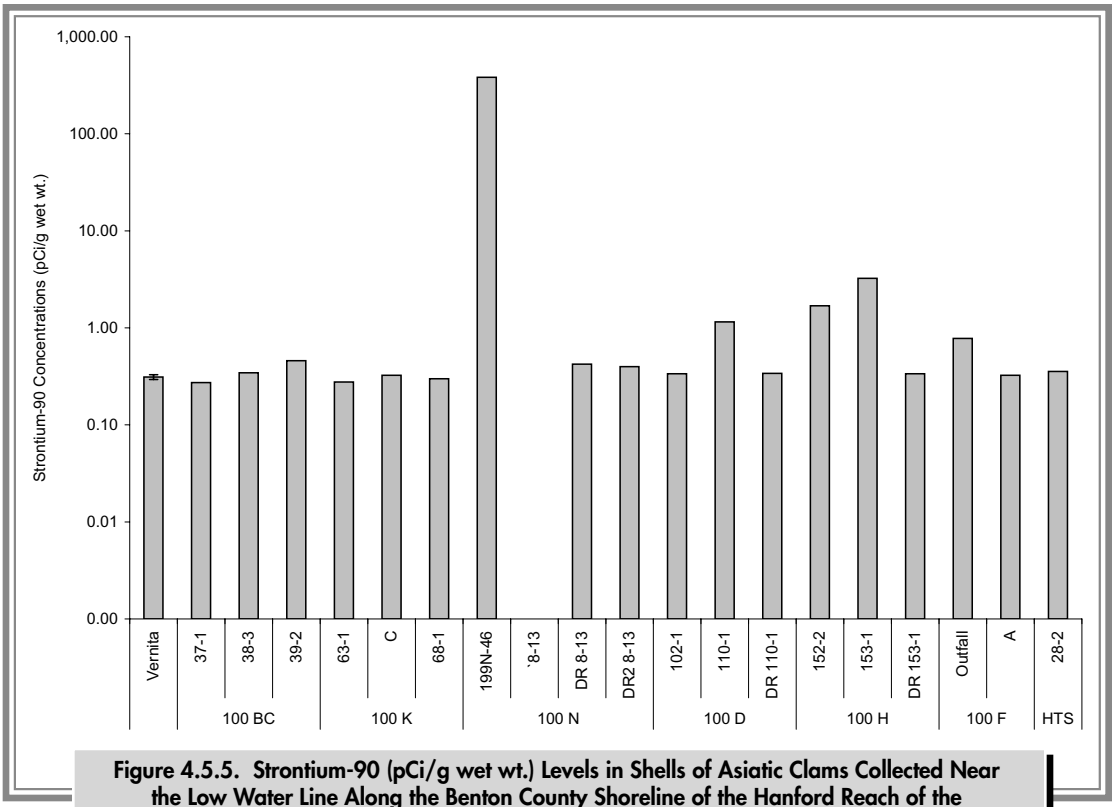

Figure 4.5.5. Strontium-90 (pCi/g wet wt.) Levels in Shells of Asiatic Clams Collected Near the Low Water Line Along the Benton County Shoreline of the Hanford Reach of the Columbia River, 2002-2003

amounts of strontium-90 and the range of results reported was relatively small. Trace metal concentrations in hepatopancreas samples are not discussed in this report because too few samples were analyzed for a valid interpretation.

4.5.2.3 Sculpin Sample Results and Analytes of Interest

Sculpins probably best represent the ideal sentinel fish along the Hanford Reach of the Columbia River because they have relatively small home ranges, eat aquatic insects, dwell on the river bottom, and are abundant. Five sculpin samples were collected and analyzed for gamma-emitting radionuclides, strontium-90, and technetium-99 in 2003. Each sample consisted of a number of individual organisms because the mass required for these analyses was larger than the weight of any individual organism. No gamma-emitting radionuclides were detected in the five samples and neither were strontium-90 and technetium-99. These results provide a baseline for future Hanford-specific assessments. Trace metal results from liver samples are not discussed in this report due to low sample sizes and the variability of the results.

4.5.3 Monitoring DDT, DDD, and DDE in the Vicinity of the Horseshoe Landfill

4.5.3.1 Background

The Horseshoe Landfill is a former CERCLA waste site that is located near the southeast boundary of the Hanford Site and within the boundaries of the Fitzner/Eberhardt Arid Lands Ecology Unit on the Hanford Reach National Monument (Figure 4.5.1). This landfill is about the size of a football field (91 by 49 meters [100 by 53 yards]) and was a solid waste disposal site used by the military in the 1950s and 1960s. The site received commercial-grade pesticides dominated by dichlorodiphenyl trichloroethane

(DDT) and its breakdown products dichlorodiphenyl dichloroethane (DDD) and dichlorodiphenyl dichloroethylene (DDE).

During the 1990s, contaminated soil was removed from the landfill by the U.S. Army Corps of Engineers. Follow-up assessments of ecological risk were conducted at the site by comparing the concentrations of DDT, DDD, and DDE in soil and biota collected near the landfill to Washington State ecological protection guidelines. The assessments (DOE/RL-2002-35) suggested that environmental conditions following soil removal were acceptable.

At the request of tribal governments, the DOE initiated a modest monitoring program at the landfill in 2003. A limited number of soil and biota samples were collected and analyzed to reconfirm concentrations of DDT and its breakdown products DDD and DDE. The results from this landfill sampling effort are compared to results from samples collected from reference locations in 2003 and to results obtained in the original follow-up assessment.

4.5.3.2 Sample Collections

Concentrations of DDT/DDD/DDE were measured in samples of soil, plants, and invertebrates and in the brain tissues of small mammals and birds collected at and near Horseshoe Landfill and from reference areas in 2003 (Figure 4.5.6). Most sampling occurred between June 19 and June 25, 2003. One soil sample was collected on July 30, 2003.

Soil samples were taken with a 7-centimeter (3-inch) diameter, 2.5 centimeters (1 inch) deep, round polyethylene container. A total of seven soil samples were collected at locations at or near the landfill (Figure 4.5.6). Four samples were obtained from the southern portion of the landfill and three samples were from the northern portion. A reference soil sample was also collected near the landfill.

Plant samples (hoary aster [*Machaeranthera canesens*]) were collected using pre-cleaned stainless steel scissors and all sample material was thoroughly rinsed with deionized water before it was placed into the sample containers. Three plant samples were obtained from the south region of the landfill, one sample was collected from the landfill's north region, and two were collected south of the landfill (Figure 4.5.6). A reference sample was also collected near the landfill.

Invertebrate samples (spiders, ants, beetles, and grasshoppers) were collected within a 5-meter (15-foot) radius of an established sampling point using pre-cleaned stainless steel tweezers. Two samples were collected from the south region of the landfill and one was collected from the north region (Figure 4.5.6). An invertebrate sample was also collected at a nearby reference location.

Small mammal samples (Great Basin pocket mouse [*Perognathus parvus*]) were collected using Sherman live traps. Three samples were obtained from Horseshoe Landfill and one was collected from a reference location near the landfill (Figure 4.5.6).

Birds (Western meadowlark [*Sturnella neglecta*] and horned lark [*Eremophila alpestris*]) were collected from the nest or by using a firearm. A Western meadowlark sample was collected from a site located west of the landfill. Reference samples of a horned lark and a Western meadowlark were also collected. No birds were collected on the landfill.

4.5.3.3 Sample Analysis Results

Each soil sample from the southern portion of the landfill contained combined concentrations of DDT and its derivatives of 6.3, 7.3, 9.2, and 19.1 ppm, respectively. These concentrations were 6,000 to 20,000 times greater than the combined concentrations in the sample from the reference site. The combined concentration of DDT and its derivatives in the reference soil sample was less than the nominal analytical detection limit of 0.002 ppm. The three soil samples collected from the northern region of the landfill contained relatively low levels of DDT/DDD/DDE that ranged between 0.01 and 0.09 ppm.

Plant samples obtained on the landfill site contained elevated levels of DDT and its derivatives compared to the concentrations in reference samples and in two samples collected south of the landfill site. The DDT/DDD/DDE concentration in the single vegetation sample collected from the reference area was less than 0.001 ppm (nominal analytical detection limit reported for result). Concentrations of DDT and its derivatives reported in three of the four vegetation samples taken on the landfill ranged between 1.0 and 9.0 ppm, approximately 1,000 to 9,000 times greater than the values seen in vegetation samples collected south of the landfill.

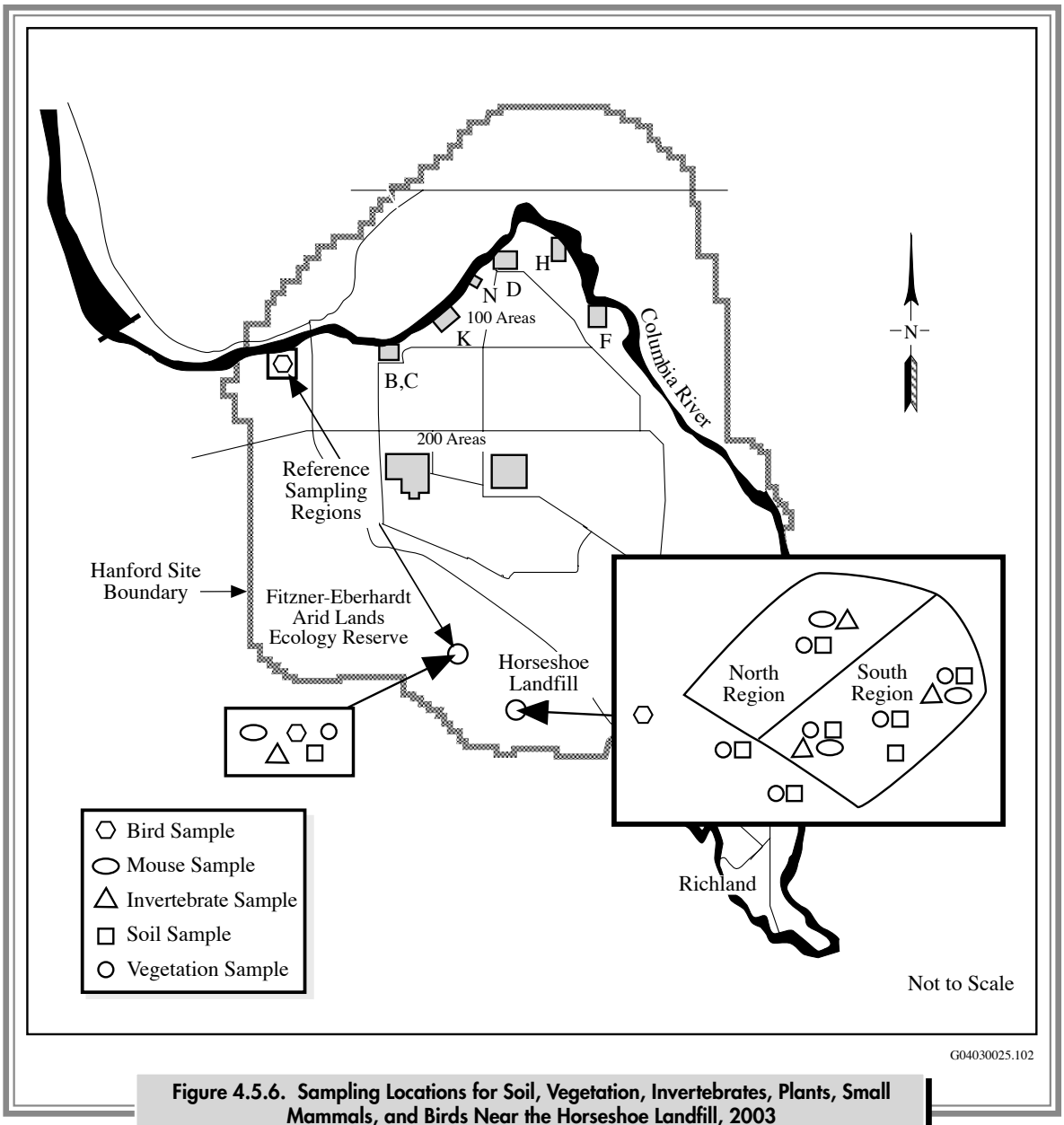

Figure 4.5.6. Sampling Locations for Soil, Vegetation, Invertebrates, Plants, Small Mammals, and Birds Near the Horseshoe Landfill, 2003

Mouse samples from the landfill contained detectable concentrations of DDT and its derivatives; results ranged between 0.01 and 0.95 ppm. These concentrations were from 2 to 188 times greater than the concentrations found in the single mouse sampled at the reference location near the landfill (Figure 4.5.7).

Results from all three invertebrate samples collected from the landfill site contained detectable concentrations of DDT and its derivatives; results ranged between 0.02 and 6.2 ppm. These concentrations were approximately 20 to 6,781 times higher than the concentration in the single invertebrate sample collected at the reference location.

The single Western meadowlark sample collected near the landfill contained 0.85 ppm of DDT and its derivatives compared to 0.03 ppm reported in horned lark and Western meadowlark samples collected from the reference regions.

The greatest concentrations of DDT/DDD/DDE measured in this study were found in invertebrate samples from the south region of the landfill site where the highest concentrations in soil, vegetation, and small mammal samples

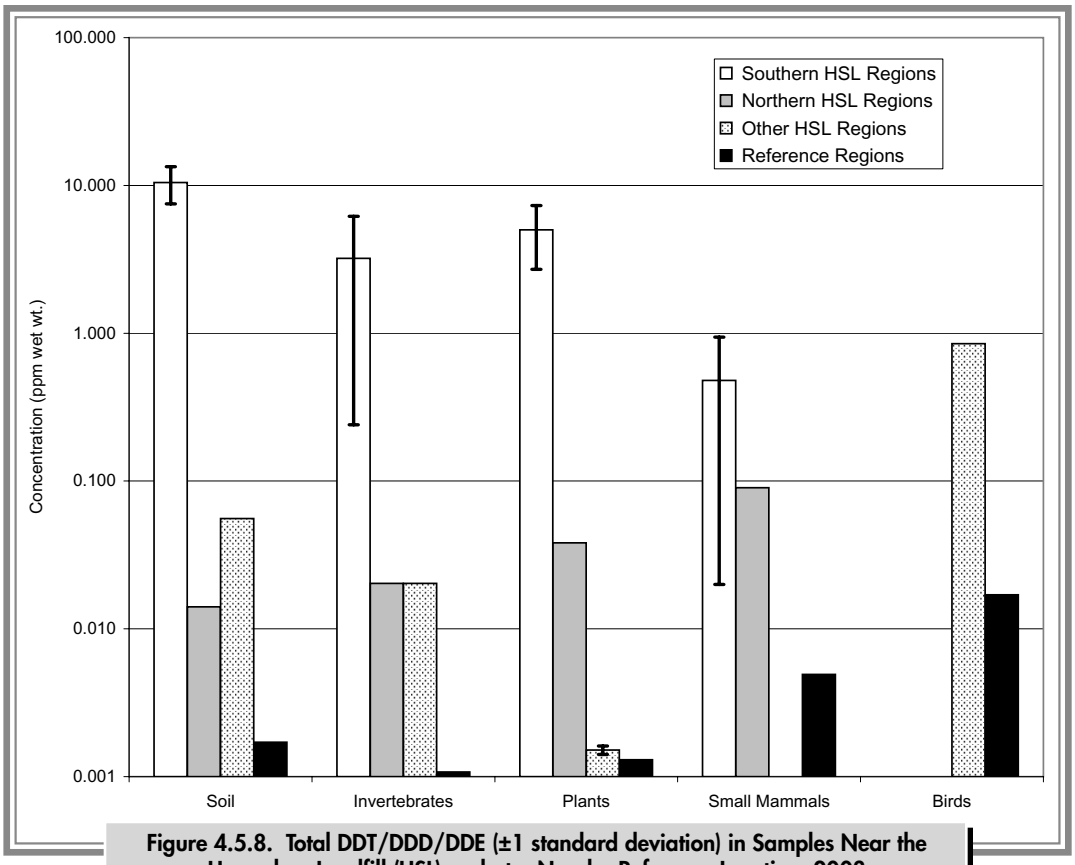

Figure 4.5.8. Total DDT/DDD/DDE (±1 standard deviation) in Samples Near the Horseshoe Landfill (HSL) and at a Nearby Reference Location, 2003

were also measured. Figure 4.5.7 illustrates the propensity of organochloride pesticides such as DDT and its derivatives to accumulate in organisms at the top of the food chain like insect-eating birds such as the Western meadowlark.

Concentrations in soil samples obtained during 2003 were consistent with concentrations measured in the previous assessment in the 1990s. All samples collected from the south region of the landfill had the highest concentrations of DDT/DDD/DDE.