

# Hanford Site

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## ENVIRONMENTAL REPORT for Calendar Year 2011





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# Hanford Site

## Environmental Report for Calendar Year 2011

Prepared for the U.S. Department of Energy  
Assistant Secretary for Environmental Management



**P.O. Box 550**  
**Richland, Washington 99352**

**Approved for Public Release;  
Further Dissemination Unlimited**

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Richland Operations  
Office

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**APPROVED**

*By G. E. Bratton at 9:01 am, Sep 17, 2012*

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## Executive Summary

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The U.S. Department of Energy (DOE) prepares this Hanford Site Environmental Report in accordance with DOE O 231.1B, *Environment, Safety and Health Reporting*. This report is written to inform the public, regulators, stakeholders, and other interested parties about Hanford Site environmental performance during calendar year (CY) 2011. Individual sections provide detail on the following:

- Hanford Site and its mission
- Hanford Site compliance with all applicable DOE, federal, state, and local regulations
- Hanford Site environmental management performance
- Potential radiation doses to onsite Hanford Site staff and the public residing in the vicinity
- Status and results of Hanford Site restoration and waste management activities
- Hanford Site environmental and groundwater monitoring programs and data
- Data quality assurance methods.

DOE has prepared the annual Hanford Site Environmental Report since 1959. All the annual environmental reports are available on the Internet through the Mission Support Alliance, LLC (MSA), available at [http://msa.hanford.gov/msa/index.cfm/Environmental\\_Reports](http://msa.hanford.gov/msa/index.cfm/Environmental_Reports). The following is a brief summary of the *Hanford Site Environmental Report for Calendar Year 2011*.

**SECTION 1, INTRODUCTION.** This section describes the Hanford Site and its current mission — to preserve the Hanford legacy, reduce the footprint (amount of land directly controlled by DOE), enable the cleanup, and manage post cleanup land use. The Hanford Meteorology Station is located at the Hanford Site Central Plateau. Researchers take meteorological measurements to support Hanford Site operations, emergency preparedness and response, and atmospheric dispersion calculations for dose assessments. Activities include weather forecasting and maintaining and distributing climatological data. Average temperature and precipitation totals were below normal. The average temperature for 2011 was 52.3°F (11.3°C), which was 1.6°F (0.9°C) below normal (53.9°F [12.2°C]). Precipitation totaled 4.45 inches (11.3 centimeters), which is 62 percent of normal precipitation (7.14 inches [18.1 centimeters]). Snowfall for 2011 totaled 3.1 inches (7.9 centimeters), compared to normal snowfall of 15.2 inches (38.6 centimeters). Average wind speed was 8.0 miles per hour (3.6 meters per second), which was 0.5 mile per hour (0.2 meter per second) above normal.

DOE is responsible for operating the Hanford Site. RL and the DOE Office of River Protection (ORP) jointly manage the Hanford Site through several contractors and their subcontractors. Each contractor is responsible for safe, environmentally sound maintenance and management of its activities or facilities; waste management; evaluation and determination of all discharges to the environment; and for monitoring any potential effluent to ensure environmental regulatory compliance. RL serves as property owner of the Hanford Site and manages cleanup of legacy waste, related research, and other programs. DOE, the U.S. Fish and Wildlife Service, and the Washington Department of Fish and Wildlife each manage portions of the Hanford Reach National Monument.

DOE encourages information exchange and public involvement in discussions and decision making regarding Hanford Site cleanup and remediation actions. Active stakeholders include the public; Native American tribes; local, state, and federal government agencies; advisory boards; activist groups; and other entities in the public and private sectors. The *National Historic Preservation Act of 1966* requires DOE to consult with the Washington State Historic Preservation Officer, Native American tribes, local government representatives, the public, and other interested parties on cultural and historic resource matters. Regulations require that DOE

solicit and gather input from Native American tribes and interested parties, obtain concurrence from the Washington State Historic Preservation Officer on the identification of cultural resources, evaluate the significance of these resources, and assess impacts of DOE activities on cultural resources. The *Hanford Cultural Resources Management Plan* (DOE/RL-98-10) provides guidance to DOE on cultural and historic resources issues.

Several federal, state, and local regulatory agencies are responsible for monitoring and enforcing compliance with applicable environmental regulations at the Hanford Site. These agencies include the U.S. Environmental Protection Agency (EPA), Washington State Department of Ecology (Ecology), Washington State Department of Health, and the Benton Clean Air Agency. EPA is the primary federal regulatory agency that develops, promulgates, and enforces environmental regulations and standards as directed in statutes enacted by Congress. In some instances, EPA has delegated authority to the state or authorized the state program to operate in lieu of the federal program when the state's program meets or exceeds EPA requirements. In other activities, the state program is assigned direct environmental oversight of the DOE program, as provided by federal law. Where federal regulatory authority is not delegated or only partially authorized to the state, the EPA Pacific Northwest Regional Office (Region 10) is responsible for reviewing and enforcing compliance with EPA regulations as they pertain to the Hanford Site. EPA periodically reviews state environmental programs and may directly enforce federal environmental regulations. In addition, the Tri-Party Agreement commits DOE to comply with the remedial-action provisions of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) as well as with the *Resource Conservation and Recovery Act of 1976* (RCRA) treatment, storage, and disposal unit regulations and corrective-action provisions, including Washington State's implementing regulations (WAC 173-303, *Dangerous Waste Regulations*). The Tri-Party Agreement is an agreement among Ecology, EPA, and DOE to achieve compliance with the remedial action provisions in CERCLA and with treatment, storage, and disposal unit regulations and corrective action provisions in RCRA. The Tri-Party Agreement has evolved to meet changing conditions as Hanford Site cleanup requirements have progressed. During 2011, there were 38 specific Tri-Party cleanup milestones scheduled for completion: 37 were completed ahead of their scheduled date and one was completed on time. Thirty-seven negotiated change control forms to the Tri-Party Agreement were approved in 2011; these changes can be viewed at the Tri-Party Agreement website: <http://www.hanford.gov/c.cfm/tpa/>.

**SECTION 2, COMPLIANCE SUMMARY.** This section describes the Hanford Site compliance with federal, state, and local laws and regulations. DOE directs that all activities be performed in compliance with applicable federal, state, and local laws and regulations; DOE orders; Secretary of Energy Notices; and directives, policies, and guidelines from DOE Headquarters. In addition to Hanford Site permits, a key feature in the Hanford Site compliance program is the *Hanford Federal Facility Agreement and Consent Order*, also known as the Tri-Party Agreement (see [Section 1.6.1](#)). No permit violations on the Hanford Site were reported in 2011. Compliance with federal, state, and local laws and regulations include the following:

- **CERCLA Compliance.** Field inspections of institutional controls were conducted in 2011 at waste sites on the Hanford Site. No public trespass events occurred and all approved excavation permits are in place for all active remediation activities.
- **RCRA Compliance.** Ecology performed 17 RCRA inspections on the Hanford Site in 2011 to assess compliance with applicable requirements. The Hanford Site received no notices of violation or warning letters of noncompliance that were based on those inspections.



- The Washington State Department of Health, Ecology, and the Benton Clean Air Agency conduct regular inspections of Hanford Site emission sources to verify compliance with applicable *Clean Air Act* requirements. Hanford Site contractors and DOE actively work to resolve any potential compliance issues identified during these inspections. During 2011, the regulatory agencies conducted over 25 *Clean Air Act* inspections at the Hanford Site; those inspections did not result in any violations being issued by regulatory agencies.
- **Pollution Prevention Program.** The Pollution Prevention Program ([Section 2.6.2](#)) is an organized and continuing effort to reduce the quantity and toxicity of hazardous, radioactive, mixed, and sanitary waste generated at the Hanford Site. In fiscal year (FY) 2011, over 2127 tons (1,930 metric tons) of sanitary and hazardous wastes were recycled through Hanford Site-wide programs administered through the Mission Support Contract.
- **Environmental Occurrences.** Environmental releases of radioactive and regulated materials from the Hanford Site are reported to DOE and other federal and state agencies as legally required. The following categories have been established: Operational Emergency; Recurring; Category 1 (significant impact), Category 2 (moderate impact), Category 3 (minor impact), and Category 4 (some impact). In 2011, one Category 2, four Category 3, and one Category 4 events occurred at the Hanford Site ([Section 2.7](#)).

**SECTION 3, ENVIRONMENTAL MANAGEMENT SYSTEM.** This section describes the Hanford Site Environmental Management System. Hanford Site environmental performance measures address the goals of DOE O 436.1, *Departmental Sustainability*; Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*; and Executive Order 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*. Measures include regulated waste reduction; toxic and hazardous material reduction; sustainable acquisition; compliance with Electronic Product Environmental Assessment Tool standards; sanitary waste diversion; construction waste diversion; electricity use; facility fuel use; water use; vehicle fuel use; numbers of alternative fuel vehicles; on-time environmental deliverables; environmental inspections; and environmental non-compliances. Objectives for 2011 were achieved for the majority of performance measures; however, the electricity use and petroleum-based fuel use did not meet their targets ([Section 3.1](#)). This section also provides information on the Hanford Site awards and recognition for environmental stewardship. The Hanford Site received an EPA Federal Electronic Challenge Gold Award for its FY2011 efforts in successfully managing the lifecycle of electronic equipment in a sustainable manner, and the Bronze Green Buy award from DOE for FY2011 efforts in purchasing sustainable products. In addition, the Hanford Site was awarded three DOE EM Best In Class awards and eight Honorable Mention Awards ([Section 3.2](#)).

**SECTION 4, RADIOLOGICAL INFORMATION.** This section provides information on Hanford Site radiological program and doses, and cleanup activities as DOE progresses toward site closure and the likely transfer of property to other entities. The dose calculations are provided in Appendix D. Potential radiological doses from 2011 Hanford Site operations were evaluated in detail to determine compliance with pertinent regulations and limits ([Section 4.2](#)). Doses were assessed in terms of 1) total dose (multiple pathways) to the hypothetical, maximally exposed individual at an offsite location, evaluated by using a multimedia pathway assessment (DOE O 458.1, Section 4.1.1); 2) average dose to the collective population living within 50 miles (80 kilometers) of Hanford Site operating areas ([Section 4.2.2](#)); 3) dose to a maximally exposed individual for air pathways using EPA methods ([Section 4.2.3](#)); 4) doses from recreational activities including hunting and fishing ([Section 4.2.4.1](#)); 5) Dose to a worker consuming drinking water on the Hanford Site ([Section 4.2.4.2](#)); 6) doses from non-DOE industrial sources on and near the Hanford Site ([Section 4.2.5](#)).

**External Radiation Measurements.** During 2011, external radiation fields were monitored in the 100-K Area, 100-N Area, 100-N shoreline area (N Springs), the 200 Area, 300 Area, 400 Area, and 618-10 Burial Ground were similar to levels measured in 2010 ([Section 4.1.1](#)).

*100-K Area.* Dose-rate levels measured in 2011 at monitoring stations in the K-West Area were, overall, 20 percent higher than in 2010. This was primarily due to second and third quarter increases measured at the monitoring station located near the 105-K West facility where radioactively contaminated waste containers were temporarily staged prior to transport to the Environmental Restoration Disposal Facility (ERDF). Dose rate levels at this location returned to typical levels during the 4th-quarter of the year.

*100-N Area.* Average dose-rate levels observed in the 100-N Area during 2011 showed an overall increase (approximately 20 percent) compared to 2010 levels. This was primarily due to second and third quarter increases measured at the monitoring station located along/near the transportation route for disposal of radioactive waste. Dose-rate levels at this location returned to typical levels during the 4th-quarter of the year.

*100-N Area Shoreline (N Springs).* Dose rates were measured along the Columbia River shoreline in the 100-N Area (N Springs) to determine potential external radiation doses to onsite workers and to the public accessing the Columbia River. Cleanup activities at the retired 116-N-1 and 116-N-3 Trenches (located near the river) have decreased dose rates notably over the past few years. The 2011 average dose rate was unchanged compared to 2010, and was less than 100 millirem (1 millisievert) per year.

*200 East and 200 West Areas.* Dose rate levels measured during 2011 in the 200 East and 200 West Areas were slightly decreased compared to 2010. Average dose rates measured in 2011 at ERDF (located near the 200 West Area) were comparable to 2010 levels.

*200 North Area.* One thermoluminescent dosimeter (TLD) monitoring site, located in the 200 North Area at the contaminated 212-R Railroad Car Disposition Area, showed a significant annual average dose rate decrease of 80 percent in 2011 compared to 2010 levels. This TLD location was established in 2000 to monitor expected high radiation levels emitted from contaminated railroad cars. During the fourth quarter of 2010, dose rate levels began to fall as the radiologically contaminated railroad cars were dispositioned.

*300 and 400 Areas.* The average dose rates in 2011 in the 300 and 400 Areas and at the 300 Area Treated Effluent Disposal Facility was comparable to 2010 levels.

*618-10 Burial Ground.* TLD monitoring was initiated during late-February 2010 at four locations at this project. The average dose rates in 2011 were comparable to 2010 levels.

*Integrate Disposal Facility.* The average dose rates in 2011 were unchanged from 2010 levels.

**Active and Inactive Waste Disposal Sites Radiological Surveys.** During 2011, 8,022 environmental radiological surveys were conducted at active and inactive waste disposal sites and the surrounding terrain to detect and characterize radioactive surface contamination. Vehicles equipped with radiation detection devices and global positioning systems were used to accurately measure the extent of contamination. Area measurements were entered into the Hanford Geographical Information System, a computer database maintained by MSA. Routine radiological survey locations included former waste disposal cribs and trenches, retention basin perimeters, ditch banks, solid waste disposal sites (e.g., burial grounds), unplanned release sites, tank farm perimeters, stabilized waste disposal sites, roads, and firebreaks in and around the Hanford Site operational areas. These sites were posted as underground radioactive material areas, contamination areas, and soil contamination areas. The external dose rate at 80 percent of the outdoor contamination areas was



estimated to be less than 1 millirem (0.01 millisievert) per hour, although direct dose-rate readings from isolated radioactive specks could have been higher ([Section 4.1.2](#)).

**Dose for the Maximally Exposed Individual.** Dose for the maximally exposed individual was 0.09 millirem (0.9 microsievert) per year ([Section 4.2.1](#)). The average individual dose from Hanford Site operations in 2011, based on the 50-mile (80-kilometer) radius population exposed to air emissions and the Tri-Cities populations exposed to water pathways releases to the Columbia River, was approximately 0.0044 millirem (0.044 microsievert). To place the average individual estimated dose into perspective, it may be compared with doses received from other routinely encountered sources of radiation. The National Council on Radiation Protection issued Report 160 in March 2009 that estimated the overall average exposure to ionizing radiation for the average American to be 620 millirem (6,200 microsievert) per year (National Council on Radiation Protection and Measurements, 2009). Approximately 50 percent of the 620 millirem (6,200 microsievert) per year average annual dose is related to natural sources, with the remaining 50 percent attributable primarily to medical procedures.

**Radiological Release of Property from the Hanford Site.** No property with detectable residual radioactivity above authorized levels was released in 2011 from the Hanford Site. The site contractors prepared for transitioning from DOE O 5400.5, Chg 2, *Radiation Protection of the Public and the Environment*, to the new order, DOE O 458.1, *Radiation Protection of the Public and the Environment*, which is scheduled for 2012 implementation ([Section 4.3](#)).

*Radiological Clearance for Ion-Exchange Resin for Offsite Shipment and Regeneration.* Ion-exchange resin is currently in use to remove hexavalent chromium from groundwater. Once saturated, the spent resin—which may contain radioactive elements—is removed and readied for shipment to an offsite facility for regeneration and reuse. Approximately 127,440 pounds (57,800 kilograms) of resin was shipped offsite in 2011 for regeneration under these approved authorized limits ([Section 4.3.2](#)).

*Radiological Clearance for Granular Activated Carbon for Offsite Shipment and Regeneration.* A soil-vapor extraction system that uses granular activated carbon to remove carbon tetrachloride from groundwater in the unconfined aquifer has been operational for over 10 years. When the granulated activated carbon canister has reached volatile organic compound saturation, it is removed from the system and shipped to an offsite facility for regeneration and reuse. Approximately 17,280 pounds (7,840 kilograms) of granular activated carbon was shipped offsite in 2011 for regeneration under these approved modified authorized limits ([Section 4.3.3](#)).

**SECTION 5, ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT.** This section describes ongoing Hanford Site environmental restoration and mitigation, facility decommissioning activities, waste management, underground waste storage tank status, construction of the Waste Treatment and Immobilization Plant (WTP) and its associated facilities, and research activities related to waste cleanup. Hanford Site cleanup activities began in 1996, the primary focus was on former liquid effluent sites. Progress has reduced the number of liquid effluent sites requiring remediation, allowing current cleanup activities to shift to the remediation of waste burial grounds. The volume of contamination in waste burial grounds is generally less than at liquid effluent waste sites; however, identification, characterization, and disposal of the wastes may involve additional time and scope. During 2011, remediation activities continued in the 100, 200, and 300 Areas, and for Hanford Site groundwater and vadose zone sediments.

**River Corridor.** The River Corridor includes the Hanford Site 100 and 300 Areas, which border the Columbia River. The River Corridor includes nine deactivated plutonium-production reactors, numerous support facilities, and liquid and solid waste disposal sites. The *Remedial Investigation Work Plan for*

*Hanford Site Releases to the Columbia River* ([DOE/RL-2008-11](#)) was issued in September 2008 and the associated field investigation has been completed. Results from the field investigation and historical data are being used to develop risk assessments to evaluate potential impacts to the Columbia River from Hanford Site releases. The *Columbia River Component Risk Assessment, Volume II, Baseline Human Health Risk Assessment, Part 1* (DOE/RL-2010-117, [Vol. II, Part 1](#)) was issued in August 2011; and *Columbia River Component Risk Assessment, Volume II, Baseline Human Health Risk Assessment, Part 2* (DOE/RL-2010-117, [Vol. II, Part 2](#)), was issued in December 2011. The ecological risk assessment portion, *River Corridor Baseline Risk Assessment, Volume I: Ecological Risk Assessment* (DOE/RL-2007-21, Volume I, [Part 1](#) and [Part 2](#), Rev. 0), was issued in March 2012. These reports present a comprehensive assessment of the River Corridor, addressing all relevant sources of contamination, exposure pathways, and contaminants. The reports also provide an analysis of relevant uncertainties and recommendations. Preliminary remediation goals that are protective of human health and the environment are proposed to support development of final action cleanup decisions through the remedial investigation/feasibility study (RI/FS) process for the River Corridor. The risk assessment results are being reflected in the River Corridor RI/FS reports.

**River Corridor RI/FS Process.** In 2011, field investigation activities and development of draft integrated source and groundwater RI/FS reports and proposed plan documents for the six River Corridor decision areas (100-B/C, 100-K, 100-N, 100-D/H, 100-F/IU-2/IU-6, and 300 Area) continued. Draft RI/FS reports for the 100-K ([DOE/RL-2010-97](#)) and 300 Area ([DOE/RL-2010-99](#)) decision areas were submitted for regulatory review in September and December 2011, respectively. Draft RI/FS reports for the four remaining decision areas are scheduled to be submitted to the regulators for review by the end of CY2012 in accordance with Tri-Party Agreement Milestone [M-015-00D](#). Public review of proposed actions and development of final action records of decision (ROD) for the six decision areas are anticipated to range from 2012 to 2014.

**Long-Term Stewardship.** The long-term stewardship task is focused on achieving interim closure and transition of surveillance and maintenance responsibilities within the River Corridor from the cleanup contractor to the site service contractor, which administers the long-term stewardship program for DOE. Elements include risk assessment activities, orphan site evaluations, remedial action reports, and long-term stewardship plans that will provide a basis for independent closure reviews of the 100 and 300 Areas by independent experts. Transition and turnover packages were prepared in 2011 for Segments 1 and Segment 2 of the 100-F/IU-2/IU-6 Area. These packages describe the completion of site assessment activities, removal of facilities, removal of miscellaneous debris, and site remediation to interim action RODs for a specific parcel of land. Interim remedial action reports also were prepared and issued for the 100-BC-1 Operable Unit ([DOE/RL-2011-49](#)) and Segment 1 of the 100-F/IU-2/IU-6 Area ([DOE/RL-2011-48](#)). The orphan site evaluation process was completed in 2011 with the issuance of the following reports: Segment 3 of the 100-F/IU-2/IU-6 Area ([OSR-2010-0004](#)), Segment 4 of the 100-F/IU-2/IU-6 Area ([OSR-2011-0001](#)), and Segment 5 of the 100-F/IU-2/IU-6 Area ([OSR-2011-0002](#)) ([Section 5.1.2](#)).

**K Basins Closure Activities.** For nearly 30 years, the K Basins stored 2,300 tons (2,100 metric tons) of Hanford N Reactor spent fuel and a small quantity of irradiated fuel from older Hanford Site reactors. The fuel was removed by 2004, but fuel corrosion over the years left behind sludge and debris. In 2009, the K-East Basin was demolished and the structure and basins removed. During 2011, K Basins cleanup continued with the demolition of multiple buildings, basins, and storage facilities, as well as debris removal from the K-West Basins. Construction of the 189-K Water Treatment Facility was completed and brought on line, leading the way to the deactivation and demolition of the much larger water treatment facilities used originally to support



the operation of the K Reactors. Further information on K Basins remediation and closure activities is in [Section 5.2.1.3](#).

A total of 1,315,200 tons (1,193,100 metric tons) of contaminated soil from 100 Area remediation activities during 2011 were disposed at ERDF. This centralized disposal facility is the primary disposal pathway, but other disposal options are available if the material does not meet the waste acceptance criteria for the facility.

**Central Plateau.** The Central Plateau is a 75-square-mile (194-square-kilometer) region near the center of the Hanford Site that includes the area designated in the *Hanford Comprehensive Land Use Plan Environmental Impact Statement* (DOE/EIS-0222) and ROD ([64 FR 61615](#)) as the Industrial-Exclusive Area, a rectangular area of about 20 square miles (52 square kilometers) in the center of the Central Plateau. The Industrial-Exclusive Area contains the 200 East and 200 West Areas, used primarily for the Hanford Site nuclear fuel processing and waste management and disposal activities. The Central Plateau also encompasses the CERCLA 200 Area National Priorities List site. The Central Plateau has a large physical inventory of chemical processing and support facilities, tank systems, liquid and solid waste disposal and storage facilities, utility systems, administrative facilities, and groundwater monitoring wells. As a result of the goals established in [DOE/RL-2009-10](#), the Tri-Party Agencies developed changes to the Tri-Party Agreement that reflect the path forward for Central Plateau cleanup.

The Central Plateau component of cleanup includes two principal areas:

- **Inner Area.** This area contains major nuclear fuel processing, waste management, and disposal facilities, and is defined as the final footprint area of the Hanford Site that will be dedicated to permanent waste management and containment of residual contamination. The Inner Area is anticipated to be approximately 10 square miles (26 square kilometers) or less in size and will remain under federal ownership and control for as long as potential hazards exist.
- **Outer Area.** This area is defined as areas of the Central Plateau beyond the boundary of the Inner Area. Completing cleanup for the approximately 65-square-mile (168-square-kilometer) Outer Area will reduce the active footprint of cleanup for the Central Plateau to the Inner Area.

The Central Plateau Operable Unit structure is depicted in [Section 5.0](#), Table 5.1.

**Facility Decommissioning Activities.** Decommissioning activities during 2011 continues in the 100, 200, 300, and 400 areas of the Hanford Site ([Section 5.3](#)).

**100 Areas Facilities Decommissioning.** Deactivation, decontamination, decommissioning, and demolition activities in the 100 Area included demolition actions at 100-N Area, 100-D Area, and 100-H Area, which were conducted as non-time-critical removal actions under CERCLA. Construction actions also were completed to support non-time-critical removal actions planned for 2012 ([Section 5.3.1](#)).

**200 Area (Central Plateau) Facilities Decommissioning.** Central Plateau facilities include buildings and waste sites in the 200 East, 200 West, and 200 North Areas, as well as those on the adjoining Fitzner/Eberhardt Arid Lands Ecology Reserve Unit. The transition toward decommissioning encompasses surveillance, maintenance, and deactivation activities ([Section 5.3.2](#)).

Workers at the PFP complex completed a large and multi-faceted effort in 2004 to stabilize, immobilize, repackage, and/or properly dispose of nearly 19.8 tons (18 metric tons) of plutonium-bearing materials in the plant. Workers then focused on decontaminating and deactivating the processing facilities while still providing for the safe and secure storage of nuclear materials until final disposition. All special nuclear materials and remaining stored fuel elements were removed from the plant by the end of 2009, and security was downgraded.

In addition, the removal and disposal of process equipment, chemicals, glove boxes, and hoods from the buildings began, continuing through 2011.

Other Central Plateau facilities include interim-status RCRA treatment, storage, and disposal units awaiting closure are the: 1) Canyon buildings (Plutonium Uranium Extraction [PUREX] Plant, B Plant, Reduction-Oxidation [REDOX] Plant, and U Plant); 2) three operating major air emission stacks; and 3) one operating minor emission stack.

**300 Area Facilities Decommissioning.** Deactivation, decontamination, decommissioning, and demolition activities in the 300 Area continued to focus on removing physical barriers to perform remedial actions in the 300-FF-2 Operable Unit. These activities were conducted as non-time-critical removal actions under CERCLA in accordance with *Action Memorandum #1 for the 300 Area Facilities* ([DOE and EPA 2005](#)), *Action Memorandum #2 for the 300 Area Facilities* ([DOE and EPA 2006a](#)), and *Action Memorandum #3 for the 300 Area Facilities* ([DOE and EPA 2006b](#)). Additionally, the *Memorandum for General Hanford Site Decommissioning Activities* ([DOE/RL-2010-22](#)) authorized deactivation, decontamination, decommissioning, and demolition activities for a portion of the 337 Complex ([Section 5.3.3](#)).

**400 Area Facilities – Fast Flux Test Facility (FFTF) Deactivation.** After multiple studies, a decision was made to complete facility deactivation, including removing all nuclear fuel, draining the sodium systems, and deactivating systems and equipment to place the facility in a low-cost, long-term surveillance and maintenance condition, which was completed in June 2009. FFTF remains in a long-term surveillance and maintenance condition. Routine surveillances are performed on an annual basis. Final decommissioning of FFTF depends on the outcome of the *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* ([DOE/EIS-0391](#)). The resultant ROD will determine the final end state for FFTF ([Section 5.3.4.1](#)).

**Waste Management.** Hanford Site cleanup activities generate non-regulated, radioactive, nonradioactive, mixed, and hazardous waste. Mixed waste contains both radioactive and hazardous nonradioactive substances. Hazardous waste contains either dangerous waste or extremely hazardous waste, or both. This waste is handled and prepared for safe storage onsite or shipped to offsite facilities for treatment and disposal.

In addition to newly generated waste, significant quantities of legacy waste remain from years of nuclear materials production and waste management activities. Most legacy waste from past operations at the Hanford Site resides in RCRA-compliant waste sites or is stored in places pending treatment and ultimate safe storage or disposal. Examples include high-level radioactive waste stored in single-shell and double-shell underground waste storage tanks, and transuranic waste stored in vaults and on storage pads.

**Solid Waste Management.** Solid waste management includes the treatment, storage, and/or disposal of solid waste produced as a result of Hanford Site operations or received from offsite sources authorized by DOE to ship waste to the site. Onsite solid waste facilities include the Central Waste Complex, Waste Receiving and Processing Facility, T Plant Complex, Low-Level Burial Grounds, Waste Encapsulation and Storage Facility, and ERDF. These facilities are operated and maintained in accordance with state and federal regulations and facility permits and are discussed in [Section 5.4.3](#).

*Central Waste Complex.* Located in the 200 West Area, the Central Waste Complex receives waste from Hanford Site sources and any offsite sources authorized by DOE to ship waste to the site for treatment, storage, and disposal. Ongoing cleanup and research and development activities at the Hanford Site generate most of the waste received at the Central Waste Complex. Waste received includes low-level, transuranic, or mixed waste, and radioactive waste contaminated with polychlorinated biphenyls. The Central Waste Complex can



store as much as 735,000 cubic feet (20,800 cubic meters) of low-level mixed waste and transuranic waste ([Section 5.4.3.1](#)). The volume of waste stored at this complex in 2011 totaled approximately 364,870 cubic feet (10,330 cubic meters).

*Waste Receiving and Processing Facility.* Located in the 200 West Area, this facility stores waste in addition to generating new waste from current Hanford Site cleanup activities. The waste consists primarily of contaminated cloth, paper, rubber, metal, and plastic. This facility, which began operating in 1997, dispositioned and shipped 50 cubic yards (38 cubic meters) of low-level waste offsite. In addition to these shipments, 933 cubic yards (713 cubic meters) of transuranic waste were sent to the Waste Isolation Pilot Plant for disposal, and 78 cubic yards (60 cubic meters) were sent to the Advanced Mixed Waste Treatment Facility in Idaho for treatment, certification, and subsequent shipment to the Waste Isolation Pilot Plant ([Section 5.4.3.2](#)).

*T Plant Complex.* Located in the 200 West Area, T Plant provides waste treatment, storage, and decontamination services for the Hanford Site, as well as for offsite facilities ([Section 5.4.3.3](#)). In 2011, repackaged 233 containers (55-gallon [208-liter] drum equivalents) of transuranic waste to meet offsite waste acceptance criteria and eventual disposal at the Waste Isolation Pilot Plant.

*Low-Level Burial Grounds.* The low-level burial grounds consist of eight burial grounds located in the 200 East and 200 West Areas that are used for disposal of low-level waste and mixed waste (i.e., low-level radioactive waste with a dangerous waste component). The low-level burial grounds have been operational under a RCRA Part A permit since 1985. Transuranic waste has not been placed in the low-level burial grounds without specific DOE approval since August 19, 1987. In 2011, 62,960 cubic feet (1,783 cubic meters) of retrievably stored waste were retrieved from the low-level burial grounds ([Section 5.4.3.4](#)). One defueled U.S. Navy reactor compartment was received in 2011 and placed in low-level waste burial ground, Trench 94 (218-E-12B Burial Ground), bringing the total number of reactor compartments received to 123 ([Section 5.4.3.4.2](#)).

*Waste Encapsulation and Storage Facility.* Located in the 200 East Area, this facility stores strontium and cesium encapsulated salts in double containment stainless-steel capsules in underwater pool cells, providing safe storage. The water provides cooling and shielding for the capsules that are considered sealed sources. As a storage-only unit, the Waste Encapsulation and Storage Facility did not generate regulated wastes in 2011 ([Section 5.4.3.5](#)).

*Integrated Disposal Facility* (currently not operational). Located in the south-central 200 East Area, this facility is an expandable RCRA hazardous waste-compliant landfill. The facility will receive immobilized low-activity tank waste and other low-level radioactive waste from the WTP. The process design disposal capacity listed in the RCRA permit is 2.89 million cubic feet (82,000 cubic meters) ([Section 5.3.3.6](#)).

*ERDF.* Located near the 200 West Area, ERDF is a massive landfill regulated by the EPA. ERDF serves as the central disposal site for contaminated waste removed during Hanford Site cleanup operations conducted under CERCLA regulations. During 2011, approximately 1,500,200 tons (1,360,895 metric tons) of remediation waste were disposed at ERDF ([Section 5.4.3.7](#)).

**Liquid Waste Management.** Facilities are operated on the Hanford Site to store, treat, reduce, and dispose of various types of liquid effluent generated by site cleanup activities. Liquid waste management facilities include 200 Area Effluent Treatment Facility, Liquid Effluent Retention Facility, 200 Area Treated Effluent Disposal Facility, and the 242-A Evaporator. Liquid effluent is managed in facilities to comply with federal and state regulations and facility permits ([Section 5.4.4](#)).

**200 Area Effluent Treatment Facility.** Located in the 200 East Area, the facility treats liquid effluent to remove toxic metals, radionuclides, and ammonia, in addition to destroying organic compounds. The treated effluent is stored in tanks, sampled and analyzed, and discharged to the State-Approved Land Disposal Site (also known as the 616-A Crib). The volume of wastewater treated and disposed in 2011 was approximately 19.9 million gallons (75.3 million liters). This wastewater was primarily CERCLA-regulated wastewater (groundwater from the 200-UP-1 and 200-ZP-1 Operable Units in the 200 West Area) ([Section 5.4.4.1](#)).

**Liquid Effluent Retention Facility.** Located in the 200 East Area, the facility consists of three RCRA-compliant surface basins used to store temporarily process condensate from the 242-A Evaporator, groundwater from various operable unit pump-and-treat systems, leachate from ERDF and from low-level waste burial ground Trenches 31 and 34, and other aqueous waste. The volume of wastewater received for interim storage in 2011 was approximately 18.3 million gallons (69.3 million liters). The volume of wastewater being stored in the Liquid Effluent Retention Facility at the end of 2011 was 16.8 million gallons (63.6 million liters) ([Section 5.4.4.2](#)).

**200 Area Treated Effluent Disposal Facility.** Located east of the 200 East Area, the 200 Area Treated Effluent Disposal Facility is a collection and disposal system for non-RCRA waste streams that consists of approximately 11 miles (18 kilometers) of buried pipelines connecting three pumping stations, the 6653 Building (known as the disposal sample station), and 5-acre (2-hectare) disposal ponds. The volume of unregulated effluent disposed in 2011 was 14.2 million gallons (53.8 million liters) ([Section 5.4.4.3](#)).

**242-A Evaporator.** Located in the 200 East Area, the 242-A Evaporator concentrates dilute liquid tank waste by evaporation. This process reduces the volume of liquid waste sent to double-shell tanks for storage and reduces the potential need for additional double-shell tanks. Waste volume reduction activities at the 242-A Evaporator are managed in accordance with the *Hanford Facility Dangerous Waste Permit* ([WA7890008967](#)); however, in CY2011 the 242-A Evaporator did not perform waste volume reduction activities ([Section 5.4.4.4](#)). Table ES-1 provides the waste summary data for 2011.

**Table ES-1. Hanford Site Waste Summary for 2011**

Activity	Waste Type	Amount
Solid waste generated during onsite cleanup activities	Solid mixed waste	522 tons (474,000 kilograms)
	Radioactive waste	4022 tons (3,649,000 kilograms)
Solid waste received at the Hanford Site from offsite (includes Hanford Site generated waste treated by an offsite contractor and returned to the site as newly generated waste)	Solid mixed waste	195 tons (177,000 kilograms)
	Radioactive waste	185 tons (168,000 kilograms)
Dangerous waste shipped off the Hanford Site	See Table 5.4	242 tons (219,000 kilograms)
Waste volume pumped from underground single-shell waste storage tanks to double-shell waste storage tanks (includes flush/dilution water)	Liquid waste	560,000 gallons (2,120,000 liters)
Waste volume in underground single-shell waste storage tanks at the end of 2011	Liquid waste	29.5 million gallons (112 million liters)
Waste added to underground double-shell waste storage tanks	Liquid waste	1,560,000 liters (412,000 gallons)

**Table ES-1. Hanford Site Waste Summary for 2011**

Activity	Waste Type	Amount
Waste volume in underground double-shell waste storage tanks at the end of 2011	Liquid waste	26 million gallons (98 million liters)
Waste dispositioned and shipped offsite from the Waste Receiving and Processing Facility	Solid waste	50 cubic yards (713 cubic meters)
Waste disposed of in Trenches 31 and 34	Mixed low-level solid waste	62,960 cubic feet (1,783 cubic meters)
Waste disposed of at the Environmental Restoration Disposal Facility	Solid waste	1,500,200 tons 1,360,895 metric tons)
Aqueous waste volume received at the Liquid Effluent Retention Facility	Wastewater containing low levels of organic compounds and tritium	16.8 million gallons (63.6 million liters)
Volume of waste water treated and disposed at the 200 Area Effluent Treatment Facility	Wastewater containing toxic metals, radionuclides, ammonia, and organic compounds	19.9 million gallons (75.3 million liters)
Wastewater volume treated (evaporated) at the 242-A Evaporator	Liquid waste from single-shell tanks	0 gallons (0 liters)
Effluent volume disposed of at the 200 Area Treated Effluent Disposal Facility	Uncontaminated, treated liquid waste	14.2 million gallons (53.8 million liters)

**Underground Waste Storage Tanks.** Most Hanford Site waste is stored in 149 large underground single-shells (single-walled) and 28 double-shell (double-walled) tanks located on the Central Plateau near the center of the site. A grouping of tanks is referred to as a farm.

*Single-Shell Tank System.* There are 149 single-shell tanks, 83 single-shell tanks are located in the 200 West Area, with another 66 single-shell tanks in the 200 East Area. As part of the Tri-Party Agreement, crews must remove at least 99 percent of the material in every tank, or at least as much waste that can be removed based on available technology. Approximately 569,600 gallons (2,156,155 liters) of radioactive and hazardous waste were removed from single-shell tanks C-104, C-107, C-108, and C-111 in 2011 and transferred to safer double-shell tank storage, leaving approximately 29.5 million gallons (112 million liters) of waste in the single-shell tanks ([Section 5.5.1](#)).

*Double-Shell Tank System.* There are 29 double-shell tanks; 3 double-shell tanks are in the 200 West Area, with another 25 double-shell tanks in the 200 East Area. At the end of 2011, there were 26 million gallons (98 million liters) of waste in the double-shell tanks ([Section 5.5.2](#)).

**Waste Treatment and Immobilization Plant (WTP).** The WTP is being built on 65 acres (26 hectares) located on the Central Plateau in the 200 East Area to treat radioactive and hazardous waste currently stored in 177 underground tanks. The WTP comprises four major facilities under construction (Pretreatment Facility, High-Level Waste Vitrifaction Facility, Low-Activity Waste Vitrifaction Facility, and Analytical Laboratory), along with 20 support buildings and the associated underground utilities (balance of facilities). Construction of the WTP is managed in accordance with the *Hanford Facility Dangerous Waste Permit (WA7890008967)* ([Section 5.6](#)).

**Scientific and Technical Contributions to Hanford Site Cleanup.** Scientific and technical contributions addressing Hanford Site challenges in chemical and nuclear waste processing and subsurface science and remediation included performing evaluations, analyzing data, providing reviews, preparing and operating

special facilities, and creating new technologies to address site cleanup challenges. The 2011 contributions to Hanford Site Cleanup are provided in [Section 5.7](#).

**SECTION 6, AIR MONITORING.** This section provides information on the Hanford Site monitoring and compliance with environmental, public health, and resource protection laws, regulations, and DOE orders.

**Air Emissions.** Most facility radioactive air emission units are actively ventilated stacks that are sampled either continuously or periodically. Airborne emissions with a potential to contain radioactive materials at prescribed threshold levels are measured for gross alpha and gross beta concentrations and, as warranted, specific radionuclides. Nonradioactive constituents and parameters are monitored directly, sampled and analyzed, or estimated based upon inventory usage. DOE annually submits to EPA and the Washington State Department of Health a report of Hanford Site radionuclide air emissions (e.g., DOE/RL-2012-19 for CY2011) in compliance with Subpart H of 40 CFR 61, *National Emission Standards for Emissions of Radionuclides other than Radon from Department of Energy Facilities* and with WAC 246-247, "Radiation Protection – Air Emissions".

A 9.0-magnitude earthquake struck northern Japan on March 11, 2011. The epicenter of the powerful earthquake was under the Pacific Ocean, approximately 80 miles (129 kilometers) east of Sendai, where the Fukushima Daiichi nuclear power plant is located. The plant's automatic earthquake detectors successfully inserted all the control rods into the three reactors that were operating at the time; however, 46 minutes later, a massive tsunami inundated the Fukushima power plant, causing widespread destruction and knocking out the reactors' emergency cooling systems. The reactors overheated, damaging the nuclear fuel and producing chemical explosions which breached the reactor buildings and allowed radioactive elements to escape into the environment. The Fukushima incident led to trace amounts of radiation, including cesium-134 and cesium-137, being observed around the world. No protective actions were ever needed in the United States or its Pacific Territories and by early May 2011, air monitoring results showed declining levels of radiation in ambient air samples. Cesium-134 and cesium-137 were consistently detected at levels far below levels of public-health concern in composite air samples collected at/near the Hanford Site during the first half of 2011. During the air sampling period from late-March through early-April 2011, ambient air monitoring stations onsite and offsite showed slight increases in gross beta measurements in the biweekly samples. Gross beta measurements returned to typical levels during the sample period immediately following. Peaks in gross beta concentrations during the fall and winter months are the result of a seasonal pattern of natural radioactivity fluctuation.

**Ambient-Air Monitoring.** A network of continuously operating samplers at 84 locations across the Hanford Site was used during 2011 to monitor radioactive materials in air near site facilities and operations: ([Section 6.2.1](#)). For most specific radionuclide analyses, the amount of radioactive material collected on a single filter during a 2-week period was too small to be measured accurately. The samples were combined into either quarterly or semiannual composite samples for each location to increase the accuracy of the analysis. Composite samples were routinely analyzed for gamma-emitting isotopes, strontium-90, uranium-234, uranium-235, plutonium-238, uranium-238, and plutonium-239/240. Americium-241 and plutonium-241 were analyzed at locations associated with spent nuclear fuel processing. In addition, thorium-228, thorium-230, and thorium-232 were analyzed in composite samples collected at the 100-F Field Remediation Project. The 2011 data indicate a large degree of variability by location. Air samples collected from locations at or directly adjacent to Hanford Site facilities had higher radionuclide concentrations than samples collected farther away. In general, analytical results for most radionuclides were at or near Hanford Site background levels, which are much less than EPA concentration values but greater than those measured offsite. The data also show that



concentrations of certain radionuclides were higher and widely variable within different onsite operational areas ([Section 6.2.1](#)).

Air sampling was conducted at 25 locations in the 200 West Area during 2011. Generally, radionuclide levels measured in the 200 West Area were similar to results for previous years. Air monitoring results from the 200 North, U Canyon, and BC Controlled Area decontamination and demolition project stations were at or below typical Hanford Site levels for 2011. Air sampling in support of remediation work in the 300-FF-2 Operable Unit (near the 300 Area) and decontamination and decommissioning activities at the 300 Area deactivation, decommission, decontamination and demolition project continued in 2011. Uranium-234 and uranium-238 were detected consistently and at levels similar to those measured in previous years. Air sampling was conducted at five locations in 2011 at ERDF (200 West Area). Generally, radionuclide levels measured at this site were similar to typical Hanford Site levels. Uranium-234 and uranium-238 were detected in 100 percent of the samples while plutonium-239/240 was detected in approximately 50 percent of the samples.

Beginning in March 2011, air monitoring was conducted at four locations at the 618-10 Burial Ground Project (north of the 300 Area). The analytical results showed that uranium-234, uranium-238, plutonium-239/240, and americium-241 were detected consistently. During the second-half of 2011, two air monitoring results from one station located at the 618-10 Field Remediation project were greater than 10% of EPA's concentration values (40 CFR 61, Appendix E, "Compliance Procedures Methods for Determining Compliance with Subpart I", Table 2) and were reported to EPA and Washington State Department of Health. Americium-241 and plutonium-239/240 at station N548 were elevated and no contributing cause was specifically identified for these elevated concentrations.

**SECTION 7, WATER MONITORING.** This section discusses the drinking water systems on the Hanford Site. Nine DOE-owned, contractor-operated, public water systems supplied drinking water during 2011 to DOE facilities on the Hanford Site. Drinking water for the 200 East Area is supplied from the 200 West Area facility. Eight of the nine systems used water from the Columbia River. The 400 Area system used groundwater from the unconfined aquifer beneath the site. The city of Richland supplied water for the 300 Area. In addition to the 300 Area, the city of Richland provided drinking water to the Richland North Area and the Hazardous Materials Management and Emergency Response Training Facility (HAMMER). Samples at all three drinking water treatment facilities were collected monthly and analyzed quarterly or annually for radiological contaminants. All were samples of treated water collected before the water was distributed for general use.

"Group A Public Water Supplies" (WAC 246-290) requires that all drinking water analytical results be reported routinely to the Washington State Department of Health. Radiological results for Hanford Site drinking water samples are reported to the state through this annual environmental report. Process monitoring reports are provided directly to the state each month by the contractor responsible for operating the water system. Chemical, physical, and microbiological data are reported to the state directly by the state-accredited laboratory performing the analyses, as well as to MSA, but are not published.

All DOE-owned Hanford Site drinking water systems were in compliance with drinking water standards for radiological, chemical, and microbiological contaminant levels during 2011. Contaminant concentrations measured during the year were similar to those observed in recent years ([PNNL-20548](#); [PNNL-19455](#)).

**Radiological Monitoring.** Scientists conducted radiological monitoring of Hanford Site drinking water at one DOE-owned pump and three water treatment facilities during 2011. In addition, routine chemical, physical,

and microbiological monitoring of onsite drinking water and process monitoring (including chemical and physical sampling) at the water treatment plants and distribution systems to determine compliance with applicable regulations was performed. Annual average concentrations of all monitored radionuclides in Hanford Site drinking water in 2011 were below state and federal maximum allowable contaminant levels ([Section 7.1.3](#)). The gross alpha, gross beta, tritium, and strontium-90 results from the two facilities where drinking water was obtained from the Columbia River were all below their minimum detectable concentrations (i.e., concentrations were too low to measure). The 400 Area source of drinking water for 2011 was well 499-S1-8J (P-16). Gross beta and tritium were found in all 400 Area water samples, but still below the maximum allowable contaminant level. Gross alpha and strontium-90 were not detected in 400 Area water samples (Table 7.2).

A tritium plume originating in the 200 East Area and extending under the 400 Area historically has affected tritium concentrations in all of the 400 Area drinking water wells. In previous years, the Soil and Groundwater Remediation Project personnel would collect and analyze raw (untreated) water samples from all three 400 Area drinking water wells (one primary well and two backup wells); however, this sampling did not occur in 2011. PNNL scientists collected raw (untreated) water samples in 2011 from backup well 499-S0-8 (P1-14). Samples were collected quarterly, composited for a single annual tritium analysis, and fell below the 20,000-pCi/L (740-Bq/L) state and federal annual average drinking water standard.

**Surface Water Monitoring.** Samples of surface water at and near the Hanford Site were collected and analyzed to determine concentrations of radiological and chemical contaminants from the site. Surface water bodies included the Columbia River, onsite ponds, and offsite irrigation sources.

*Columbia River Water.* Pollutants from multiple sources are present in the Columbia River as it passes through the Hanford Reach ([Section 7.2](#)). These sources include upstream industry, atmospheric fallout that collects in the river's drainage basin, runoff from agricultural operations, and discharge from the aquifers on either side of the river. Hanford Site pollutants, both radiological and chemical, enter the Columbia River along the Hanford Reach. Effluent from each direct discharge point is monitored routinely and reported by the responsible operating contractor. Columbia River water samples were collected from fixed-location monitoring stations at Priest Rapids Dam and the city of Richland in 2011 and then analyzed for radionuclides. Cross-river transects and near-shore locations near Vernita Bridge, 100-N Area, Hanford town site, 300 Area, and the city of Richland were analyzed for both radionuclides and chemicals. Samples were collected upstream from the Hanford Site at Priest Rapids Dam and Vernita Bridge to provide data from locations unaffected by site operations. Samples were collected from all other locations, including a municipal drinking water supply and points of withdrawal for irrigation water downstream of the Hanford Site, to identify any increase in contaminant concentrations attributable to the site. The fixed-location monitoring stations at Priest Rapids Dam and the city of Richland consist of an automated sampler and a continuous flow system.

*Fixed-Location Samples.* Results of radiological analyses of Columbia River water samples collected at Priest Rapids Dam and the city of Richland in 2011 and for the previous 5 years are summarized in Appendix C. All individual radiological contaminant concentrations measured in Columbia River water during 2011 were less than 1/25 of the concentrations comparable to the DOE-derived concentration guides (Appendix D).

*Radionuclide Results.* Radionuclide concentrations monitored in Columbia River water were low throughout 2011. Tritium, uranium-234, uranium-238, and naturally occurring beryllium-7 and potassium-40 were measured consistently in river water at levels greater than their reported minimum detectable concentrations. Strontium-90, uranium-235, plutonium-238, and plutonium-239/240 were occasionally detected, but all values were near the minimum detectable concentrations. Concentrations of all other radionuclides were typically

less than the minimum detectable concentrations. Tritium, strontium-90, and plutonium exist in worldwide nuclear fallout as well as in effluent from Hanford Site facilities. Tritium and uranium occur naturally in the environment in addition to being present in Hanford Site effluent.

**Columbia River Sediment Monitoring.** Samples of Columbia River sediment samples were collected along the Hanford Reach and analyzed for Hanford Site-associated radiological and chemical contaminants present in groundwater beneath the site ([Section 7.5](#)).

*Radionuclide Results.* Radionuclides consistently detected in river sediment adjacent to and downstream of the Hanford Site during 2011 included beryllium-7, potassium-40, cesium-137, uranium-234, uranium-235, uranium-238, plutonium-239/240, and decay products from naturally occurring radionuclides. The concentrations of all other radionuclides, including strontium-90, were below the reported minimum detectable concentrations for most samples. Cesium-137 and plutonium isotopes exist in worldwide fallout as well as in effluent from Hanford Site facilities. Beryllium-7, potassium-40, and uranium isotopes occur naturally in the environment, and uranium isotopes are also present in Hanford Site effluent. No federal or state freshwater sediment criteria are available to assess the sediment quality of the Columbia River ([EPA 822-R-96-001](#)). Uranium concentrations were slightly elevated at the White Bluffs Slough and McNary Dam locations as compared to values measured in 2006 through 2010. Other radionuclide concentrations reported in river sediment during 2011 were similar to those reported for previous years, with the exception of cesium-137 (Appendix D), and there were no obvious differences between locations. The 2011 values for cesium-137 at the White Bluffs Slough were slightly elevated compared to Priest Rapids Dam but lower than elevated values measured in 2004 through 2007. Previous studies of soils from the White Bluffs Slough detected elevated concentrations of cesium-137. Average, maximum, and minimum concentrations of selected radionuclides measured in Columbia River sediment (2006 through 2011) are presented in Figures 7.11, 7.12 and 7.13.

*Chemical Results.* Detectable amounts of most metals were found in all river sediment samples (Figure 7.14). Maximum and average concentrations of most metals were higher for sediment collected in the reservoir upstream of Priest Rapids Dam than in sediment from either the Hanford Reach or McNary Dam. The concentrations of cadmium, copper, nickel, and zinc differed the most between locations, which may be associated with upstream mining activities. Currently, there are no Washington State freshwater sediment quality criteria to compare with the measured value.

**Pond Water and Sediment.** Two onsite ponds, West Lake and the FFTF Pond, were sampled in 2011. Water samples were collected quarterly in 2011 from the FFTF Pond (water) and from West Lake [water (3 collections) and biannual sediment]. All water samples were analyzed for tritium. Water samples from the FFTF Pond were analyzed for gross alpha and gross beta concentrations as well as gamma-emitting radionuclides. With the exceptions of uranium-234 and uranium-238 concentrations in samples from West Lake, radionuclide concentrations in onsite pond water samples were less than applicable DOE-derived concentration guides and Washington State ambient surface-water quality criteria. Concentrations in sediment samples are similar to previous measurements reported ([Section 7.5](#)).

**Offsite Irrigation Water.** Water samples were collected in 2011 from an irrigation canal located east of the Columbia River and downstream from the Hanford Site at Riverview. Samples of the water supply from the Horn Rapids irrigation pumping station were collected from the irrigation valve at the Battelle sporting complex. Most radionuclide concentrations measured in irrigation water in 2011 were at the same levels detected in Columbia River water samples collected upstream of the Hanford Site. At the Horn Rapids irrigation pumping station, the tritium results were slightly higher than Columbia River water samples

collected upstream of the Hanford Site. All radionuclide concentrations were less than their respective DOE-derived concentration guides and Washington State ambient surface-water quality criteria ([Section 7.6](#)).

*Liquid Effluent Monitoring.* Liquid effluents were discharged from a few facilities in 2011 at the Hanford Site. Effluent streams are sampled for gross alpha and gross beta concentrations, as well as for concentrations of selected radionuclides and nonradioactive hazardous materials. Facilities in the 200 Areas discharged radioactive liquid effluent to the ground at a single location in 2011, the 616-A Crib, also known as the State-Approved Land Disposal Site. Liquid effluent discharged in the 100 Areas, generally, this effluent consists of secondary cooling water discharged from the 100-K Area to the Columbia River via the National Pollutant Discharge Elimination System (NPDES)-permitted 1908-K Outfall, which permanently ceased operation in March 2011 ([Section 7.7](#)).

**SECTION 8, GROUNDWATER MONITORING.** At the Hanford Site, liquid waste released to the ground over many years has reached the groundwater. Hazardous chemicals in the groundwater include carbon tetrachloride, chromium, and cyanide. Radioactive contaminants include tritium, strontium-90, technetium-99, iodine-129, and uranium. This section provides a summary of vadose zone monitoring, investigation results; well installation, remediation, and decommissioning activities. DOE publishes details on CERCLA remediation activities (e.g., pump-and-treat operations) in separate reports that are summarized and referenced in this report. The data presented in this section—and information on well locations, construction, and screened intervals—can be found through the DOE’s Environmental Dashboard Application at <http://environet.hanford.gov/EDA/>. Since the 1990s, DOE has worked to characterize, remove, treat, and dispose of contamination from past operations. DOE developed a plan to address groundwater and vadose (unsaturated) zone contamination in consultation with the EPA and Ecology. Key elements associated with managing the Hanford Site’s groundwater and vadose zone contamination are to: 1) Protect the Columbia River and groundwater, 2) Develop a cleanup decision process, and 3) Achieve final cleanup ([DOE/RL-2007-20](#), *Hanford Integrated Groundwater and Vadose Zone Management Plan*).

**SECTION 9, SOIL MONITORING.** This section summarizes soil monitoring efforts conducted in 2011 at and around the Hanford Site. In 2011, soil samples were collected near facilities and operations at the Hanford Site to detect potential contaminant migration, to monitor the deposition of onsite facility emissions, and to evaluate long-term trends in the environmental accumulation of radioactive materials. Samples were analyzed for radionuclides expected to occur in the areas sampled. In general, radionuclide concentrations in soil samples collected from or adjacent to waste disposal facilities in 2011 were higher than the concentrations in samples collected farther away, including concentrations measured offsite. The data also show, as expected, that concentrations of certain radionuclides in 2011 were higher in different operational areas when compared to concentrations measured in distant communities in previous years. Generally, the predominant radionuclides detected were activation and fission products in the 100 Areas, fission products in the 200 and 600 Areas, and uranium in the 300 and 400 Areas ([Section 9.3](#)).

**SECTION 10, BIOTA MONITORING.** This section summarizes the agricultural; and plant and animal communities contaminant monitoring on the Hanford Site. Results of sample analyses are used to assess the amounts of Hanford Site contaminants. Plant and animal species on the Hanford Site are monitored to assess abundance, condition, and population distributions. Data collection and analysis are integrated with environmental monitoring of biotic and abiotic media and analytical results are used to characterize potential risks or impacts.

*Agricultural Monitoring.* Food and farm products (alfalfa, cherries, leafy vegetables, milk, potatoes, tomatoes, and wine) were collected in 2011 at locations near the Hanford Site. Samples were analyzed to determine



radiological contaminant concentrations. Radionuclide concentrations in most food and farm product samples in 2011 were below levels that could be detected by analytical laboratories; however, some contaminants that potentially could have originated from the Hanford Site (e.g., tritium and uranium) were found at low levels in some samples ([Section 10.1](#)). Radiological doses associated with possible site-produced contaminants are discussed in [Section 4.0](#). Where possible, the measured concentrations are compared to the applicable unusual concentration reporting levels.

***Animal Monitoring.*** Plant populations and habitats that occur on the Hanford Site are surveyed and monitored to assess the abundance, vigor or condition, and distribution of populations and species. Fish and wildlife on and around the Hanford Site are monitored for site-produced contaminants. Monitoring various biota for uptake and exposure to radionuclides both near and distant from Hanford Site operations continues to ensure that consumption of fish and wildlife obtained from the site environs does not pose a threat to humans. Four fish and wildlife species on the Hanford Site were monitored in 2011: Smallmouth bass, Mountain whitefish, Nuttall's cottontail, and Canada goose ([Section 10.2](#)). Several types of wildlife and fish were collected in 2011 from locations at and around the Hanford Site as part of routine monitoring for site-produced contaminants (Figure 10.2). Samples from these organisms were analyzed for selected radionuclides and metals that are suspected or known to be present at the Hanford Site. Samples also were collected from locations distant from the site to obtain reference (background) contaminant measurements. Most fish and wildlife samples collected on or near the Hanford Site for routine human-exposure pathway assessments are obtained annually, but specific species are sampled only every 2 or 3 years. Samples obtained at locations believed to be unaffected by Hanford Site effluents and emissions are collected approximately every 5 years.

***Plant Monitoring.*** Vegetation near onsite facilities and operations is monitored for radiation to determine the effectiveness of effluent monitoring and controls within facilities, assess the adequacy of containment at waste disposal sites, and detect and monitor unusual conditions. Hanford Site and offsite vegetation samples are analyzed for information about atmospheric deposition of contaminants in uncultivated areas offsite and around operational areas onsite. Vegetation samples have been collected on and around the Hanford Site for more than 50 years. Data from these samples are maintained to document onsite and offsite levels of manmade radionuclides in vegetation at specific locations. These data provide a baseline against which unplanned releases can be compared ([Section 10.3](#)).

***Monitoring Results.*** Vegetation samples were collected on or adjacent to waste disposal sites and from locations downwind and near or within the boundaries of operating facilities and remedial action sites. Samples were collected to evaluate long-term trends in environmental accumulation and potential migration of radioactive material. 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 number and location of Hanford Site vegetation samples collected during 2011 are summarized in Table 10.6. Only those radionuclides with concentrations consistently above analytical detection limits are discussed in this section. Vegetation samples from offsite locations are collected every 3 to 5 years, and were last collected in 2008 ([PNNL-18427](#)). Monitoring of rabbitbrush and sagebrush leaves and stems provides information about atmospheric deposition of radioactive materials in uncultivated areas and at site-wide locations that potentially could be affected by contaminants from Hanford Site operations. Vegetation samples have been collected on and around the Hanford Site for more than 50 years.

*Vegetation Control.* Vegetation control at the Hanford Site consists of cleaning up contaminated plants that can be a threat to site workers or the public, controlling or preventing the growth or regrowth of plants in contaminated or potentially contaminated areas onsite, and monitoring and removing unwanted (noxious) plant species. Approximately 5,443 acres (2,203 hectares) were treated with herbicides in 2011 on radiological waste sites, around operations areas, and along roadways to keep them clean of deep-rooted noxious vegetation (e.g., Russian thistle, also known as tumbleweed). Follow-up treatments are included in the total treated acres; several areas received three or four treatments per year.

*Waste Site Remediation and Revegetation.* Many waste sites are planted with perennial grass to inhibit the growth of deep-rooted noxious vegetation (e.g., tumbleweed) and control erosion. Native vegetation is replanted following a potential wildfire to control erosion and reestablish native vegetation to areas degraded by historical practices; however, in 2011 revegetation was not required ([Section 10.3.3](#)).

**SECTION 11, RESOURCE PROTECTION.** This section summarizes the ecological monitoring, endangered and threatened species, and cultural and historic resources at the Hanford Site. DOE orders require that environmental monitoring programs be conducted at the Hanford Site to verify protection of the public and site workers, comply with government regulations, and protect environmental and cultural resources at the site.

*Ecological Protection.* The Hanford Site is a relatively undisturbed area of shrub steppe that supports a rich diversity of plant and animal species adapted to the semiarid environment of the Columbia Plateau. Ecological monitoring personnel collect ecological data and information needed to monitor, assess, and conserve resources; ensure DOE is in compliance with legal and regulatory requirements for the biological resources; and protect sensitive resources and habitats found at the Hanford Site. Project personnel survey and monitor resources and key biota to assess the abundance, health, and distribution of populations and species at the Hanford Site. Data collection and analysis are integrated with environmental surveillance monitoring of biotic and abiotic media and analytical results are used to characterize any potential risk or impact to the biota.

Inventory and monitoring activities help protect natural resources within the DOE-operated portions of the Hanford Site including the DOE-managed portion of the Hanford Reach National Monument. Such activities also provide information useful to the Hanford Site natural resource stakeholders and the public on the status of some of the site's most highly valued biological resources. The Hanford Site contains biologically diverse shrub-steppe plant communities that have been protected from most disturbances, except for fire, for more than 65 years. This protection has allowed plant and animal species to thrive at the Hanford Site that are displaced elsewhere in the Columbia Basin by agriculture and development. Population level surveys are conducted to monitor fish, wildlife, and plants in order to develop baseline information and monitor any changes resulting from Hanford Site operations.

*Endangered and Threatened Species.* Endangered species are those in danger of extinction within all or a significant portion of their range. Threatened species are those likely to become endangered in the near future. Sensitive species are species that are vulnerable or declining and could become endangered or threatened without active management or removal of threats. The federal list of endangered and threatened species is maintained by the U.S. Fish and Wildlife Service in 50 CFR 17.11 and 50 CFR 17.12. State lists are maintained by the Washington Natural Heritage Program ([WNHP 2011](#)) and Washington Department of Fish and Wildlife ([WDFW 2011](#)).

Two fish species (spring-run Chinook salmon [*Oncorhynchus tshawytscha*] and steelhead [*Oncorhynchus mykiss*]) on the federal list of endangered and threatened species are known to occur regularly on the Hanford Site (Table 11.2). One additional fish species (bull trout [*Salvelinus confluentus*]) was recorded at the Hanford

Site but scientists believe this species is transient. No other plants or animals known to occur on the Hanford Site are currently on the federal list of endangered and threatened species (50 CFR 17), but two plant species, one mammal species, and one bird species are currently candidates for listing under the *Endangered Species Act of 1973* (Table 11.2). A proposal to formally list the two candidate plant species is expected in 2012. In addition, 13 plant species and 4 bird species have been listed as either endangered or threatened by Washington State. Numerous additional species of animals and plants are listed as candidate or sensitive species by Washington State. There are 32 state-level sensitive and candidate species of insects and animals and 14 sensitive plant species occurring or potentially occurring on the Hanford Site (Table 11.2).

*Cultural and Historic Resource Protection.* The Hanford Cultural and Historic Resources Program, which is managed by DOE, ensures cultural and historic resources entrusted to DOE are managed responsibly and in accordance with applicable regulatory requirements. Pursuant to 36 CFR 800, Section 106 reviews must be completed before a federally funded, federally assisted, or federally licensed ground disturbance or building alteration/demolition project can occur. During 2011, Hanford Site archaeologists completed Section 106 reviews for 186 undertakings on the Hanford Site; an additional 91 undertakings were reviewed in 2011 with the potential to affect cultural resources. Of the 91 undertakings, 66 were identified as *no historic properties affected*; 22 had no adverse effects to historic properties; and 3 resulted in adverse effects. Adverse effects were avoided by taking specific actions to minimize impacts, including avoidance, following treatment plan guidelines, and archaeological monitoring. The three undertakings resulting in adverse effects to historic properties required mitigation measures as documented in a project-specific Memorandum of Agreement. Approximately 1,689 acres (684 hectares) of new ground was surveyed for cultural resources because of 50 of the undertakings with the potential to affect cultural resources. In addition, some undertakings required National Register of Historic Places eligibility evaluations, including archaeological testing.

**SECTION 12, QUALITY ASSURANCE:** This section summarizes the comprehensive quality assurance programs, which include various quality control practices and methods to verify data, are maintained by monitoring and surveillance projects to ensure data quality. The programs are implemented through quality assurance plans designed to meet requirements of the American National Standards Institute, the American Society of Mechanical Engineers, and DOE orders. Quality assurance plans are maintained for all activities, and certified auditors verify conformance. Samples are collected and analyzed according to documented standard procedures. Analytical data quality was verified by a continuing program of internal laboratory quality control, participation in interlaboratory crosschecks, replicate sampling and analysis, submittal of blind standard samples and blanks, and splitting samples with other laboratories.

## Acronyms

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AEA	Atomic Energy Act
AR/PIR	Administrative Record/Public Information Repository
ARAR	applicable or relevant and appropriate requirement
ASME	American Society of Mechanical Engineers
BNI	Bechtel National, Inc.
CCV	continuing calibration verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CHPRC	CH2M HILL Plateau Remediation Company
CHRP	Cultural and Historic Resources Program
CLUP-EIS	Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement, DOE/EIS-0222-F
CREHST	Columbia River Exhibition of History, Science, and Technology
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CVS	calibration verification standard
CY	Calendar Year
DOE	U.S. Department of Energy (also USDOE)
DOE-CAP	DOE Consolidated Audit Program
DOE-ORP	U.S. Department of Energy, Office of River Protection
DOE-HQ	U.S. Department of Energy, Headquarters
DOE-RL	U.S. Department of Energy, Richland Operations Office
DWS	Drinking Water Standard
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FFTF	Fast Flux Test Facility
FONSI	Finding of No Significant Impact
FR	Federal Register
FY	fiscal year
HAMMER	Hazardous Materials Management and Emergency Response Training Facility
HPAV	Hydrogen in Piping and Ancillary Vessels
ICRP	International Commission on Radiological Protection
IRT	independent review team
km	kilometer
kg	kilogram
LLWMA	Low-Level Waste Management Area



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MAPEP	Mixed Analyte Performance Evaluation Program
MRAD	Environmental Resource Associates
MSA	Mission Support Alliance, LLC
mg/L	milligrams per liter
mrem	millirem
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NCR	Nuclear Regulatory Commission
NRWDL	Non-Radioactive Dangerous Waste Landfill
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated Biphenyls
pCi/L	picocuries per liter
PFPP	Plutonium Finishing Plant
ppm	parts per million
PQL	practical quantitation limit
PUREX	Plutonium/Uranium Extraction (Plant)
RCRA	Resource Conservation and Recovery Act of 1976
RCW	revised code of Washington
RD/RA	Remedial Design/Remedial Action
REDOX	reduction/oxidation (Plant)
RI/FS	remedial investigation/feasibility study
RFI/CMS	RCRA facility investigation/corrective measures study
RL	reporting limit
ROD	record of decision
RPD	relative percent difference
SDWA	Safe Drinking Water Act
SOP	standard operating procedure
SWL	Solid Waste Landfill
TARC	Tri-Cities Asset Reinvestment Company
TEDF	Treated Effluent Disposal Facility
TLD	thermoluminescent dosimeter
TPA	Hanford Federal Facility Agreement and Consent Order, aka Tri-Party Agreement
TRIDEC	Tri-Cities Economic Development Council
TSD	treatment, storage, and disposal
µg/L	micrograms per liter
USC	United States Code
WAC	Washington Administrative Code
WCH	Washington Closure Hanford, LCC
WMA	waste management area
WRPS	Washington River Protection Solutions, LLC
WSCF	Waste Sampling and Characterization Facility
WTP	Waste Treatment and Immobilization Plant

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## 1.0 Introduction

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SA Thompson

This environmental report provides information and analytical data related to the Hanford Site for calendar year (CY) 2011 and includes a brief history of the Hanford Site and its mission; compliance with applicable federal, state, and local environmental laws, regulations, permits, executive orders, U.S. Department of Energy (DOE) policies and directives; and descriptions and summary data from environmental-related programs.

Reports from 1959 through 2000 may be accessed at

<http://msa.hanford.gov/msa/index.cfm/Env. Reports 1959 - 2000>; and reports from 2001 to 2010 are available at <http://msa.hanford.gov/msa/index.cfm/Env. Reports 2001 - Latest>. The reports include sections that describe the following:

- Site compliance with local, state, and federal environmental standards and requirements
- Site operations, including environmental restoration efforts and cleanup and closure activities
- Environmental management performance
- Environmental occurrences and responses
- Effluent and emissions from site facilities
- Results of onsite and offsite environmental and groundwater monitoring efforts
- Cultural and biological resource assessments.

Additional detail is provided in Section 13, References, and descriptions of specific analytical and sampling methods used in the monitoring efforts are provided in the *Environmental Monitoring Plan, United States Department of Energy, Richland Operations Office* ([DOE/RL-91-50](#)).

### 1.1 Hanford Site Mission

Prior to 1988, the primary Hanford Site mission was the production of plutonium for national defense. With the signing of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement, [Ecology et al. 1989](#)) by the three parties (DOE, U.S. Environmental Protection Agency [EPA] and Washington State Department of Ecology [Ecology]) the primary mission shifted to cleanup of the extensive contamination remaining due to the legacy of production. The Hanford Site's mission now focuses on environmental restoration, which includes remediation of contaminated areas, decontamination and decommissioning of Hanford Site facilities, waste management, and related scientific and environmental research and development of waste management technologies.

### 1.2 Hanford Site Location

The Hanford Site is located within the semiarid Pasco Basin of the Columbia Plateau in southeastern Washington State (Figure 1.1). The site occupies an area of approximately 586 square miles (1,517 square kilometers) north of the city of Richland ([DOE/EIS-0222-F](#)). This area has restricted public access and provides a buffer for areas on the site that were used for nuclear materials production, waste storage, and waste disposal. The Columbia River flows eastward through the northern part of the site and then turns south, forming part of the eastern site boundary.

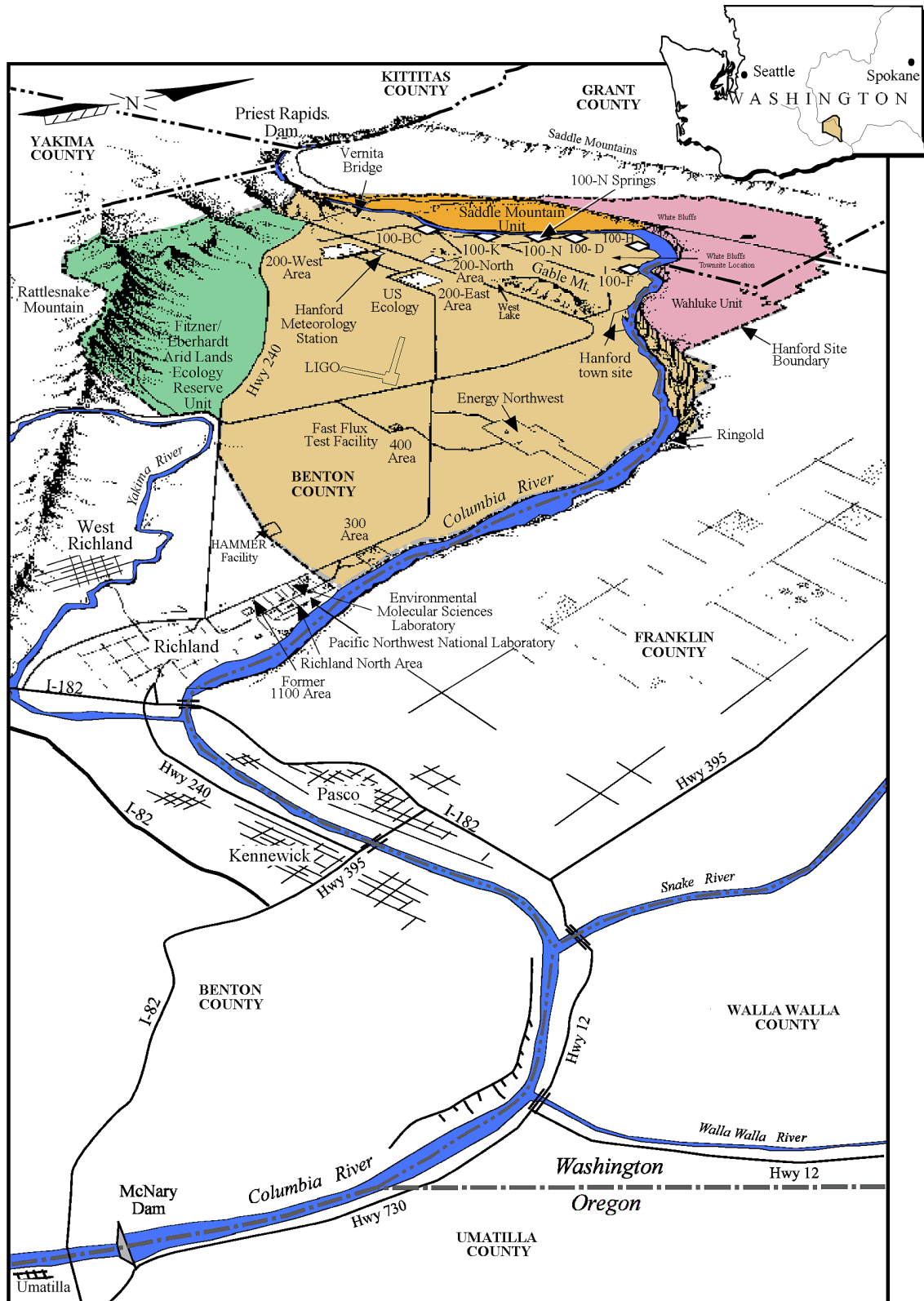
### 1.2.1 Operational, Research, and Administrative Areas

Areas within and surrounding the Hanford Site include the following:

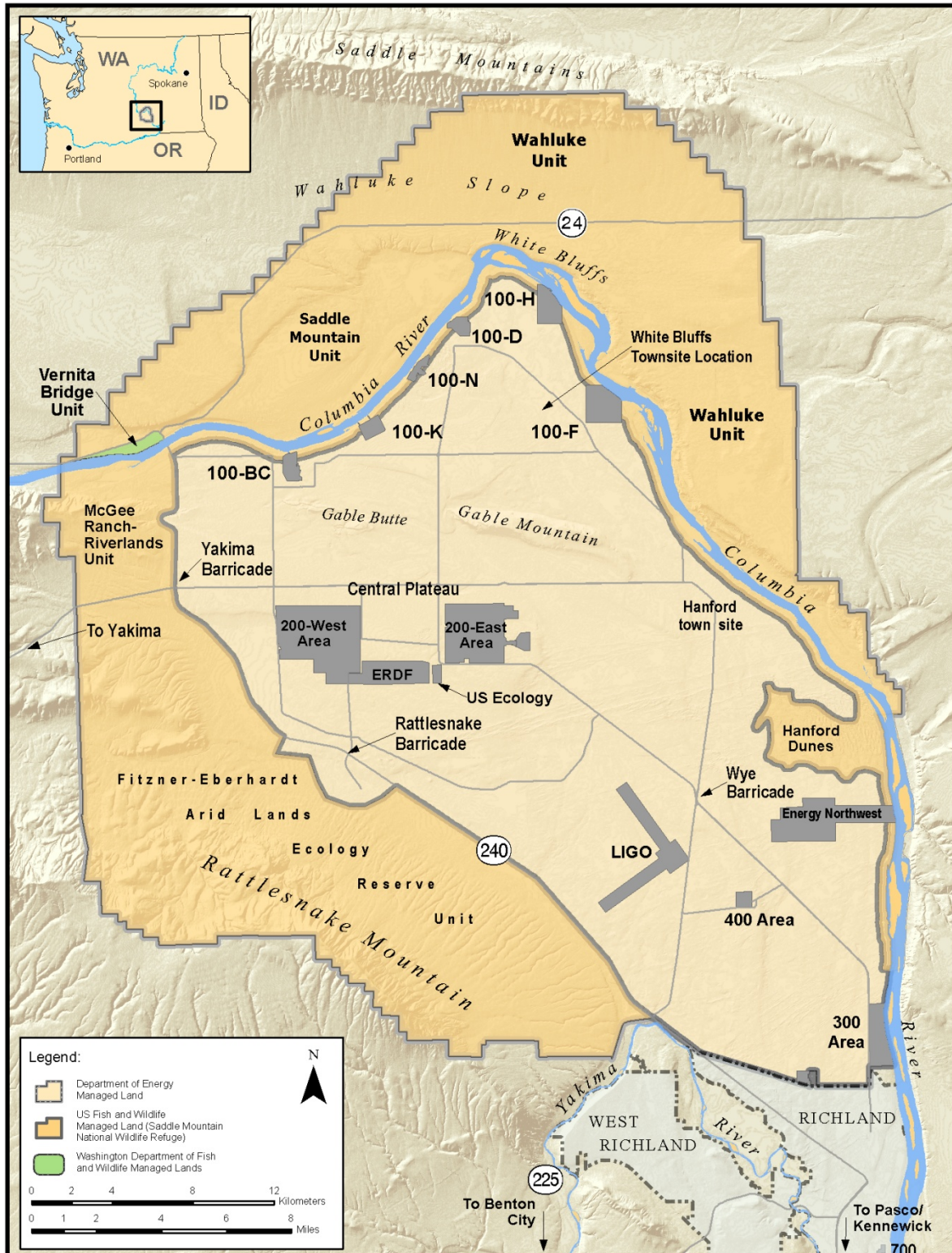
- **100 Area** – The 100 Areas consist of four distinct sites (100-BC, 100-K, 100-N, 100-DH) that are located along the shore of the Columbia River in the northern portion of the Hanford Site. These areas were the location of nine nuclear reactors that have since been retired. Collectively, the 100 Areas occupy approximately 4 square miles (11 square kilometers). The B Reactor, a National Historic Landmark, is located in the 100-B Area. As the world's first industrial-scale nuclear reactor, B Reactor produced plutonium for the first atomic explosion (Trinity Test) and the atomic bomb that was detonated over Nagasaki, Japan. DOE offers scheduled tours of the B Reactor facility.
- **200 Area** – The 200 East and 200 West Areas cover approximately 6 square miles (16 square kilometers) and are located on the Central Plateau, approximately 5 and 7 miles (8 and 11 kilometers) south and west, respectively, of the Columbia River. The plateau surface is approximately 328 feet (100 meters) above the level of the Columbia River and about 280 feet (85 meters) above the underlying water table. These areas contain underground waste storage tanks and housed facilities (known as separations plants) that extracted plutonium from dissolved irradiated fuel. The 200 North Area, now considered part of the 600 Area, is located near Gable Mountain, north of the 200 Areas and approximately 4 to 7.5 miles (7 to 12 kilometers) south of the 100 Areas. The 200 North Area covers approximately 58.6 acres (23.7 hectares) and operations were mainly related to irradiated nuclear fuel interim storage. Thermal cooling of the spent fuel required water, which was disposed at several sites within the 200 North Area. Remediation of these sites is ongoing.
- **300 Area** – The 300 Area is located just north of the city of Richland and covers approximately 0.6 square mile (1.5 square kilometers). From the early 1940s until the advent of the environmental contamination cleanup mission in 1989, nuclear fuel fabrication and research and development activities were performed at the 300 Area. Remediation of waste sites and decommissioning of 300 Area facilities is ongoing.
- **400 Area** – The 400 Area is located northwest of the 300 Area, and covers approximately 0.23 square mile (0.61 square kilometer). This area includes the Fast Flux Test Facility (FFTF), a nuclear reactor designed and used to test various types of nuclear fuel, produce medical and industrial isotopes, and conduct cooperative international research. The FFTF operations were discontinued in 1992, and the facility is now in a low-cost long-term surveillance and maintenance condition.
- **600 Area** – The 600 Area includes all of the Hanford Site not occupied by the 100, 200, 300, and 400 Areas.
- **1100 Area** – The 1100 Area is located between the 300 Area and the city of Richland and covers 1.2 square miles (3.1 square kilometers). In October 1998, this area was transferred to the Port of Benton as part of DOE's Richland Operations Office (RL) economic diversification efforts and is no longer part of the Hanford Site. However, DOE contractors continue to lease facilities in this area.
- **Richland North Area** (offsite) – This area includes the Environmental Molecular Sciences Laboratory, the Pacific Northwest National Laboratory (PNNL) site, and other DOE and contractor facilities (mostly office buildings), generally located in the northern part of the city of Richland.
- **700 Area** (offsite) – The 700 Area includes DOE administrative buildings in the central region of the city of Richland.

- **Volpentest Hazardous Materials Management and Emergency Response Training and Education Center** (known as HAMMER) – This worker safety training facility is located on the Hanford Site near the city of Richland and is used by site contractors, federal and state agencies, tribal governments, and private industry. The facility consists of a 0.12-square-mile (0.31-square-kilometer) main site and a 15.6-square-mile (40.4-square-kilometer) law enforcement and security-training site.
- **Non-DOE Operations and Activities on Hanford Site Leased Land** – Operation of commercial power production by Energy Northwest at the Columbia Generating Station, located north of the 300 Area, consists of 1,090 acres (440 hectares). Operation of a commercial low-level radioactive waste burial site, located west of the 200 East Area, consists of 99 acres (40 hectares), and is operated by US Ecology Washington, Inc. The Laser Interferometer Gravitational-Wave Observatory, located west of the 400 Area, consists of 148 acres (60 hectares), is sponsored by the National Science Foundation and operated jointly by the California Institute of Technology and the Massachusetts Institute of Technology.
- **Non-DOE Nuclear Operations Near the city of Richland** – AREVA NP, Inc., operates a commercial nuclear fuel fabrication facility and Perma-Fix Northwest, Inc., operates a low-level and mixed low-level radioactive waste processing facility located immediately adjacent to the southern boundary of the Hanford Site, and consists of 53 acres (21 hectares). Westinghouse Electric Company operates the Richland Service Center, located in north Richland, and provides chemical cleaning, chemical decontamination, and related chemical and waste processing services to the nuclear industry.
- **Hanford Reach National Monument** – The Hanford Reach National Monument (Figure 1.2), established by a Presidential Proclamation in June 2000 ([65 FR 37253](#)), covers 305 square miles (789 square kilometers) along the River Corridor. The purpose of the monument is to protect the nation's only non-impounded stretch of the Columbia River upstream of Bonneville Dam and to protect the remaining shrub-steppe ecosystem that once blanketed the Columbia River Basin. The U.S. Fish and Wildlife Service manage regions of the Hanford Reach National Monument, to include Rattlesnake Mountain, under an agreement with DOE.



**Figure 1.1 Hanford Site and Surrounding Areas**

G01020114.2

**Figure 1.2 Management Units on the Hanford Reach National Monument***(Monument boundaries are approximate)*

### 1.3 Climate and Meteorology

*KW Burk*

The Hanford Meteorology Station is located at the Hanford Site Central Plateau. Researchers take meteorological measurements to support Hanford Site operations, emergency preparedness and response, and atmospheric dispersion calculations for dose assessments. Support is provided through weather forecasting and by maintaining and distributing climatological data. Forecasting is provided to help manage weather-dependent operations. Climatological data are provided to help plan weather-dependent activities and to assess the environmental effects of site operations.

Hanford Meteorology Station staff relies on data provided by the Hanford Meteorological Monitoring Network. This network consists of 30 remote monitoring stations that transmit data to the Hanford Meteorology Station through radio telemetry every 15 minutes. There are 27 towers that are 30 feet (9 meters) high and 3 towers that are 200 feet (61 meters) high. Meteorological information collected at these stations includes wind speed, wind direction, temperature, precipitation, atmospheric pressure, and relative humidity; however, not all of these data are collected at all stations.

Regional temperatures, precipitation, and winds are affected by mountain barriers. The Cascade Range, beyond Yakima to the west, greatly influences the climate of the Hanford Site because of its rain-shadow effect. The Rocky Mountains and ranges in southern British Columbia in Canada protect the region from severe, cold polar air masses moving southward across Canada and winter storms associated with them.

Prevailing wind direction in the Central Plateau is from the northwest all year long. The secondary wind direction is from the southwest. Summaries of wind directions indicate that winds from the northwestern quadrant occur most often during winter and summer. During spring and fall, the frequency of southwesterly winds increases, with a corresponding decrease in the northwesterly flow. Monthly average wind speeds are lowest during winter months, averaging about 6 to 7 miles per hour (3 meters per second), and highest during summer, averaging about 8 to 9 miles per hour (4 meters per second). Wind speeds well above average are usually associated with southwesterly winds. However, summertime drainage winds are generally northwesterly and frequently exceed 30 miles per hour (13 meters per second). These winds are most prevalent over the northern portion of the Hanford Site. Figure 1.3 shows the 2011 wind roses (i.e., diagrams showing direction and frequencies of wind) measured at a height of 30 feet (9 meters) for the 30 meteorological monitoring stations located at and around the Hanford Site.

Atmospheric dispersion is a function of wind speed, wind duration and direction, atmospheric stability, and mixing depth. Dispersion conditions are generally good if winds are moderate to strong, the atmosphere is of neutral or unstable stratification, and there is a deep mixing layer. Good dispersion conditions associated with neutral and unstable stratification exist approximately 57 percent of the time during summer. Less-favorable conditions may occur when wind speed is light and the atmospheric dispersion-mixing layer is shallow. These conditions are most common during winter, when moderate to extremely stable stratification exists (approximately 66 percent of the time). Occasionally, there are extended periods of poor dispersion conditions, primarily during winter, that are associated with stagnant air in stationary high-pressure systems.

### 1.3.1 Historical Climatological Information

Daily and monthly averages and extremes of temperature, dew point temperature, and relative humidity for 1945 through 2004 are reported in *Climatological Summary 2004 with Historical Data* (PNNL-15160). From 1945 through 2011, the record maximum temperature was 113.0° Fahrenheit (F) [45° Celsius (C)] recorded in August 1961, July 2002, and July 2006. The record minimum temperature was -23.1°F (-30.6°C) in February 1950. Normal monthly average temperatures ranged from a low of 31.1°F (-0.5°C) in December to a high of 77.1°F (25.1°C) in July. During winter, the highest monthly average temperature at the Hanford Meteorology Station was 44.4°F (6.9°C) in February 1991, and the record lowest was 12.1°F (-11.1°C) in January 1950. During summer, the record maximum monthly average temperature was 82.2°F (27.9°C) in July 1985, and the record minimum was 63.0°F (17.2°C) in June 1953. The normal annual relative humidity at the Hanford Meteorology Station is 55 percent. Humidity is highest during winter, averaging approximately 76 percent and lowest during summer, averaging approximately 36 percent. Normal annual precipitation at the Hanford Meteorology Station is 7.14 inches (18.1 centimeters). The wettest year on record, 1995, received 12.31 inches (31 centimeters) of precipitation; the driest, 1976, received 2.99 inches (7.6 centimeters). Most precipitation occurs during late autumn and winter, with more than half of the annual amount occurring from November through February. The record snowfall in 1992-1993 was 56.1 inches (142.5 centimeters).

### 1.3.2 Monitoring

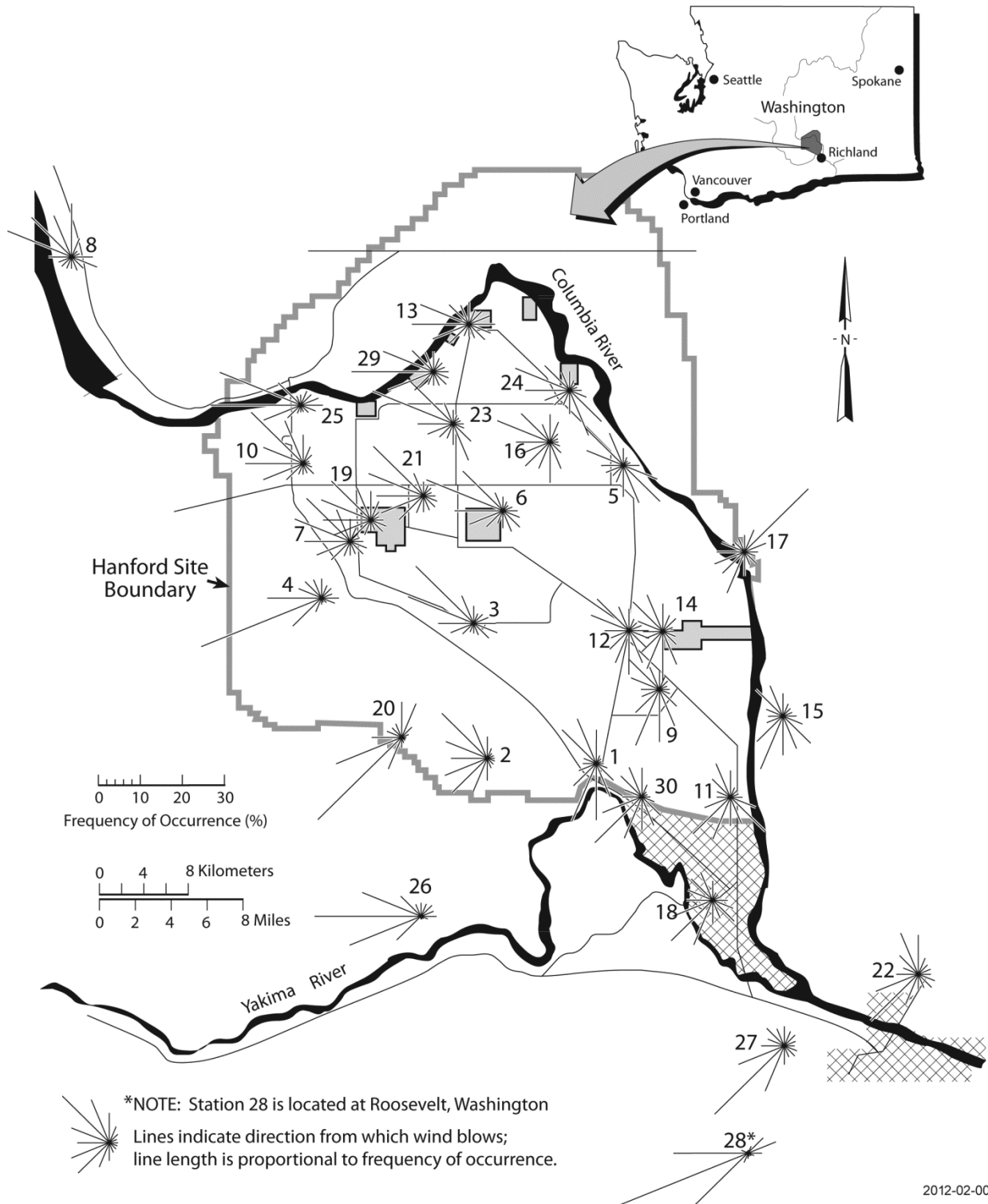
Average temperature and precipitation totals in 2011 were below normal. The average temperature for 2011 was 52.3°F (11.3°C), which was 1.6°F (0.9°C) below normal (53.9°F [12.2°C]). Four months during 2011 were warmer than normal; eight months were cooler than normal. September had the greatest positive departure at 3.0°F (1.7°C). April had the greatest negative departure at 5.0°F (2.8°C) below normal.

Precipitation totaled 4.45 inches (11.3 centimeters), which is 62 percent of normal precipitation (7.14 inches [18.1 centimeters]). Snowfall for 2011 totaled 3.1 inches (7.9 centimeters), compared to normal snowfall of 15.2 inches (38.6 centimeters).

Average wind speed was 8.0 miles per hour (3.6 meters per second), which was 0.5 mile per hour (0.2 meter per second) above normal. The peak gust for the year was 68 miles per hour (30.4 meters per second) on February 12, 2011. In addition, three dust storms were recorded at the Hanford Meteorology Station; the Hanford Meteorology Station has averaged four dust storms per year since the entire period of record (1945-2011).

Monthly and annual climatological data collected at the Hanford Meteorology Station is provided in Table 1.1. Real-time and historical data from the Hanford Meteorology Station are available at <http://www.hanford.gov/page.cfm/HMS>. The website data includes hourly weather observations, 15-minute data from the Hanford Meteorological Monitoring Network, monthly climatological summaries, and historical data.



**Figure 1.3. Meteorological Monitoring Network Wind Roses (2011)***Measured at a height of 30 feet [9 meters])*

2012-02-0033



**Table 1.1. Meteorology Station Monthly and Annual Climatological Data (2011)**

*Hanford Meteorology Station, 25 miles (40 kilometers) northwest of Richland, Washington*  
*latitude 46° 34'N, longitude 119° 35'W, elevation 733 feet (223 meters)*

Temperatures, °C										Precipitation (centimeters)				Relative Humidity (percent)		15-m Wind <sup>(a)</sup>			
Month	Averages				Extremes				Total		Snowfall		Average		Departure <sup>(b)</sup>		Peak Gusts		
	Daily Maximum	Daily Minimum	Monthly	Departure <sup>(b)</sup>	Highest	Date	Lowest	Date	Departure <sup>(b)</sup>	Total	Departure <sup>(b)</sup>	Total	Average	Departure <sup>(b)</sup>	Average Speed, m/sec	Departure <sup>(b)</sup>	Speed m/sec	Direction	Date
J	4.7	-2.9	0.9	0.1	17.2	16	-13.3	3	1.3	-1.1	3.0	-8.7	79.9	+0.1	2.8	0	25.0	WSW	17
F	7.6	-4.1	1.7	-1.7	18.9	12	-16.7	26	0.1	-1.7	T <sup>(c)</sup>	-5.8	61.6	-9.1	3.7	+0.6	30.4	SW	12
M	12.8	0.6	6.7	-1.3	22.2	31	-5.0	5	2.2	+0.8	T <sup>(c)</sup>	-1.0	64.8	+7.6	3.8	+0.3	22.3	WSW	10
A	16.0	2.2	9.1	-2.8	23.9	1	-3.3	12	0.6	-0.8	0	0	47.1	-1.2	4.6	+0.8	21.5	WNW	21
M	21.6	6.3	14.0	-2.7	28.3	20	-1.1	1	3.1	+1.8	0	0	49.2	+6.0	4.0	+0.1	19.7	WSW	11
J	27.1	11.9	19.5	-1.4	33.9	28 <sup>(d)</sup>	5.6	3	1.0	-0.3	0	0	42.5	+2.9	4.5	+0.5	19.2	WNW	6
J	31.4	14.6	23.0	-2.1	37.2	6	10.0	9 <sup>(d)</sup>	0.3	-0.3	0	0	36.5	+2.4	4.0	+0.2	21.5	WNW	7
A	34.0	15.5	24.7	0.4	37.8	28 <sup>(d)</sup>	11.1	14	T <sup>(c)</sup>	-0.5	0	0	33.1	-2.6	3.6	0	22.3	SW	28
S	29.9	11.7	20.8	+1.7	37.8	12 <sup>(d)</sup>	6.7	26	0.1	-0.7	0	0	38.2	-4.8	3.1	-0.2	20.1	WSW	25
O	17.9	6.7	12.3	+0.6	27.2	1	-5.0	26	2.0	+0.7	0	0	63.8	+7.7	3.3	+0.3	17.0	SW	22 <sup>(d)</sup>
N	9.8	-2.7	3.6	-1.1	17.8	23	-7.8	16	0.3	-2.1	4.1	-1.0	66.8	-7.1	3.2	+0.2	24.1	S	22
D	3.5	-4.9	-0.7	-0.2	15.0	28	-12.2	22	0.3	-2.7	0.8	-14.2	82.6	+1.4	2.3	-0.3	21.5	SW	29
Y <sup>(e)</sup>	18.0	4.6	11.3	-0.9	37.8	Sep 12 <sup>(d)</sup>	-16.7	Feb 26	11.3	-6.8	7.9	-30.7	55.5	+0.3	3.6	+0.2	30.4	SW	Feb 12

Note: Refer to Appendix A, Table A.2, Conversion Table, in the Helpful Information section for unit conversion information.

(a) Measured on a tower 50 feet (15 meters) above ground

(b) Departure columns indicate positive or negative departure of meteorological parameters from 30-year (1981-2010) climatological normals

(c) Trace

(d) Latest of multiple occurrences

(e) Yearly averages, extremes, and totals.

## 1.4 Hanford Site Management

DOE is responsible for operating the Hanford Site. RL and the DOE Office of River Protection (ORP) jointly manage the Hanford Site through several contractors and their subcontractors. Each contractor is responsible for safe, environmentally sound maintenance and management of its activities or facilities; waste management; evaluation and determination of all discharges to the environment; and for monitoring any potential effluent to ensure environmental regulatory compliance. DOE, the U.S. Fish and Wildlife Service, and the Washington Department of Fish and Wildlife each manage portions of the Hanford Reach National Monument.

RL serves as property owner of the Hanford Site and manages cleanup of legacy waste, related research, and other programs. The principal contractors for RL and their respective responsibilities include the following:

- Mission Support Alliance, LLC (MSA). This contractor was awarded the Mission Support Contract for the Hanford Site in 2009. Work scope includes Hanford Site infrastructure and support services including safety, security, and environment; site infrastructure and utilities; site business management; information resources and content management; portfolio management; and managing the HAMMER facility. MSA is a limited liability company operated by Lockheed Martin, LLC; Jacobs Engineering Group, Inc.; and Wackenhut Services, Inc., with subcontractors Abadan; Akima Facilities Management; Computer Science Corporation; Dade Moeller & Associates; HPM Corporation; Lampson International; Lockheed Martin Services, Inc.; Longenecker and Associates; Protection Strategies; R. J. Lee Group; Vivid Learning Systems; and Westech International.
- Washington Closure Hanford, LLC (WCH). This contractor was awarded the River Corridor Closure Contract in March 2005. WCH is a limited liability company owned by Washington Division of URS Corporation; Bechtel National, Inc. (BNI); and CH2M HILL Hanford Group, Inc. Work scope includes cleanup of waste sites and environmental restoration along the Columbia River Corridor, an area roughly 210 square miles (544 square kilometers) along the Benton County side of the Columbia River's Hanford Reach. Work includes emplacing the remaining deactivated plutonium-production reactors in interim safe storage (known as cocooning), continuing cleanup of the remaining waste sites located near the Columbia River, demolishing contaminated facilities, and operating the Environmental Restoration Disposal Facility. The principle subcontractor to WCH is Eberline Services Hanford, Inc.
- CH2M HILL Plateau Remediation Company (CHPRC). This contractor was awarded the Plateau Remediation Contract in 2008 and is responsible for safe environmental cleanup of the Central Plateau. The work scope includes environmental remediation, groundwater monitoring and remediation, waste site characterization, non-tank farm waste disposal, FFTF maintenance and shutdown, environmental monitoring and maintenance, and completion of the Plutonium Finishing Plant (PFP) closure project. The CHPRC team includes AREVA Federal Services, LLC; East Tennessee Materials and Energy Corporation, Inc.; Fluor Federal Services, Inc.; ARES Corporation; Babcock Services; GEM Technology International; INTERA, Inc.; ENREP, Inc.; Ascendent Engineering and Safety Solutions; Cavanagh Services Group; and Project Services Group.
- CSC Hanford Occupational Health Services. This contractor is the occupational health contractor for the Hanford Site. The company provides occupational medicine and nursing; medical surveillance and evaluations; ergonomics assessment; exercise physiology; case management; psychology counseling and evaluations; fitness-for-duty evaluations; health education; infection control; immediate health care; industrial hygiene; and health, safety, and risk assessments.

RL also manages portions of the Hanford Reach National Monument. The portion of the monument administered by RL includes the 14-square-mile (36.4-square-kilometer) McGee Ranch/Riverlands Unit (north and west of State Highway 24 and south of the Columbia River) in Benton County, and the Columbia River Corridor Unit, which includes the Hanford Reach islands in Benton County and a 0.25-mile- (0.4-kilometer-) wide strip of land along the Hanford Reach shoreline from the Vernita Bridge to just north of the 300 Area. This 39-square-mile (101-square-kilometer) unit in Benton, Franklin, and Grant Counties also includes the 9.9-square-mile (25.6-square-kilometer) Hanford Site dunes area north of Energy Northwest (Figure 1.2).

ORP was established by Congress in 1998 as a field office to manage Hanford Site tank waste storage, retrieval, treatment, and disposal. The principal contractors for ORP and their respective responsibilities include the following:

- BNI. This contractor's mission is to design, build, and initiate the operation of the Waste Treatment and Immobilization Plant (WTP), located on a 0.1-square-mile (0.26-square-kilometer) site on the Central Plateau of the Hanford Site. This facility is designed to convert liquid radioactive waste into a stable glass form (vitrification). The 10-year contract for this work was awarded in December 2000. In 2009, the WTP contract was modified and extended to August 15, 2019. The principle subcontractor to BNI is the URS Corporation.
- Washington River Protection Solutions LLC (WRPS). This contractor was awarded the Tank Operations Contract for the Hanford Site in 2008. The work scope includes base operation of the tanks, analytical laboratory support, single-shell tank retrieval and closure, WTP support, and supplemental treatment. Hanford Site tank farms contain 56 million gallons (210 million liters) of radioactive and chemically hazardous waste stored in 177 underground tanks generated from more than three decades of plutonium production. WRPS was formed by the Washington Division of URS Corporation and EnergySolutions, with AREVA Federal Services, LLC serving as a subcontractor.
- Advanced Technologies and Laboratories International, Inc. This contractor provides analytical services to Hanford Site cleanup and restoration contractors. Located in the 200 West Area, this laboratory is equipped and staffed to receive, analyze, and store samples and report analytical results to the appropriate contractor.

DOE Office of Science. The DOE Office of Science manages DOE's science and technology programs, goals, and objectives. The principal contractor for the DOE Office of Science and their respective responsibilities included the following:

- PNNL. This contractor is operated by Battelle Memorial Institute for and is located in Richland, Washington. Work scope includes delivering scientific solutions from multiple scientific disciplines to solve energy, environmental, and national security challenges.
- U.S. Fish and Wildlife Service. This agency, through permits and a memorandum of understanding with DOE, manages regions of the Hanford Reach National Monument, including administering three major management units (Figure 1.2) totaling about 258 square miles (668 square kilometers). These included the following:
  - ‡ Fitzner/Eberhardt Arid Lands Ecology Reserve Unit, a 120-square-mile (311-square-kilometer) tract of land in Benton County with no general public access, is located in the southwestern portion of the Hanford Site
  - ‡ Saddle Mountain Unit, a 50-square-mile (130-square-kilometer) tract of land in Grant County with no general public access, is located north-northwest of the Columbia River

- ‡ Wahluke Unit, an 89-square-mile (230-square-kilometer) tract of land with access, is located north of the Columbia River and adjacent to (east of) the Saddle Mountain Unit.

These land units have served as a safety and security buffer zone for Hanford Site operations since 1943, resulting in an ecosystem that has been relatively untouched for more than 60 years. Together, these units comprise the Saddle Mountain National Wildlife Refuge.

Washington Department of Fish and Wildlife. This department manages the Vernita Bridge Unit of the Hanford Reach National Monument. This unit occupies approximately 1.25-square-miles (3.2-square-kilometers) along the north side of the Columbia River, west of the Vernita Bridge, and south of State Highway 243 in Grant County. This unit is open to the public year round.

## 1.5 Stakeholder Involvement

DOE encourages information exchange and public involvement in discussions and decision making regarding Hanford Site cleanup and remediation actions. Active participants include the public; Native American tribes; local, state, and federal government agencies; advisory boards; activist groups; and other entities in the public and private sectors. The roles and involvement of selected stakeholders are described in the following sections.

### 1.5.1 Role of Native American Tribes

*JA Conrad*

The role of Native American tribes at the Hanford Site is guided by DOE O 144.1, *Department of Energy American Indian Tribal Government Interactions and Policy*, which communicates departmental, programmatic, and field responsibilities for interacting with American Indian governments. This order incorporates both policy and consultation guidance in working with Native American tribes. DOE will consult with any American Indian or Alaska Native tribal government with regard to any property to which that tribe attaches religious or cultural importance, which might be affected by a DOE action. The policy outlines the trust relationship that DOE has with Native American tribes and commits the agency to institute government-to-government relations with the tribes. DOE O 144.1, Attachment 3, *Framework to Provide Guidance for Implementation of U.S. Department of Energy's American Indian & Alaska Native Tribal Government Policy* ([DOE 2006](#)) provides additional guidance on how tribal consultation is to be conducted.

The U.S. Government has a unique political and legal relationship with tribal governments as defined by treaties, the U.S. Constitution, court decisions defining the federal trust responsibility, and executive orders. Additional federal laws and regulations requiring DOE to consult with Native American tribes on certain issues include the *American Indian Religious Freedom Act*, the *National Environmental Policy Act of 1969* (NEPA), the *Archaeological Resources Protection Act of 1979*, the *National Historic Preservation Act of 1966*, and the *Native American Graves Protection and Repatriation Act of 1990*. As Hanford Site cleanup progresses, Native American tribes review various aspects of cleanup activities, including how these activities will affect cultural, natural, and biological resources, and the tribes' future ability to use and consume the resources that once existed at the site.

DOE works primarily with four Native American tribes due to their prior occupation and/or use of Hanford Site lands. The Confederated Tribes and Bands of the Yakama Nation, Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe negotiated treaties with the U.S. government in 1855 (*Treaty with the Nez Perce, 1855*; *Treaty with the Walla Walla, Cayuse, etc., 1855*; *Treaty with the Yakama, 1855*). The

Yakama and the Umatilla tribes ceded land to the U.S. Government and the Nez Perce ceded rights on the Columbia River. Each of the treaties established in 1855 includes provisions that the Native American tribes reserve the right to fish at all usual and accustomed places, to hunt, gather roots and berries, and to pasture horses and cattle on open and unclaimed land. The Wanapum Band, now located in Priest Rapids, once resided on the lands that are now the Hanford Site, have historic ties to the site, and participates in discussions regarding Hanford Site cleanup.

DOE provides financial assistance through cooperative agreements with the Confederated Tribes and Bands of the Yakama Nation, Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe to support tribal involvement in environmental management, restoration, and remediation activities. Funding enables Native American tribes to retain staff to facilitate reviews and comment on site-related draft documents and plans, as well as participate in meetings and activities. Tribal experts in tribal culture, history, and resources often contribute their insight and expertise to Hanford Site decision-making processes and activities. Further information regarding the Tribal Affairs and Cultural Resources Program is available on the following website: [www.hanford.gov/page.cfm/INP](http://www.hanford.gov/page.cfm/INP).

### **1.5.2 Cultural and Historic Resource Consultations**

*MK Wright*

The *National Historic Preservation Act of 1966* requires DOE to consult with the Washington State Historic Preservation Officer, Native American tribes, local government representatives, the public, and other interested parties on cultural and historic resource matters. Regulations require that DOE solicit and gather input from Native American tribes and interested parties, obtain concurrence from the Washington State Historic Preservation Officer on the identification of cultural resources, evaluate the significance of these resources, and assess impacts of DOE activities on cultural resources. The *Hanford Cultural Resources Management Plan* (DOE/RL-98-10) provides guidance to DOE on cultural and historic resources issues.

DOE's Cultural and Historic Resources Program consults with the Washington State Historic Preservation Officer, the Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, and the Wanapum through individual meetings and discussions, field walk-downs, and project comment resolution. Tribal cultural experts discuss project scope and design monthly with DOE, tribal representatives, and other interested parties.

DOE also consults with the Washington State Historic Preservation Officer and other parties that express an interest in historic resources located on the Hanford Site, including groups such as the B Reactor Museum Association, the White Bluffs Pioneers, Benton County Historical Society, East Benton County Historical Museum, and Franklin County Historical and Museum Society.

### **1.5.3 Hanford Natural Resource Trustee Council**

*DC Ward*

CERCLA and implementing regulations in 40 CFR 300, *National Oil and Hazardous Substances Pollution Contingency Plan*, establish DOE as both the CERCLA lead response agency at departmental facilities and a trustee for natural resources under its jurisdiction. As the lead response agency, DOE is mandated to conduct response actions to correct or mitigate threats to human health and the environment that result from the release of hazardous substances during the execution of its assigned missions. CERCLA also provides authority for assessment and restoration of natural resources that have been damaged by a hazardous substance release or response.

Under CERCLA (as amended), the United States is liable for damages or injury to, destruction of, or loss of natural resources resulting from release of hazardous substances or from removal or remedial activities made necessary because of such releases, including the cost of assessing such damage. The President of the United States, by Executive Order 12580, *Superfund Implementation* (52 FR 2923), appointed the Secretary of Energy as the primary trustee for all natural resources located on, over, or under land administered by DOE, including the Hanford Site.

Natural resource trustees are government officials who act on behalf of the public when there is injury to, destruction of, loss of, or threat to natural resources (for which they have management responsibility) because of the release of a contaminant. Federal, State, and Tribal entities are authorized to act as trustees pursuant to CERCLA, Section 301(c), which covers Natural Resource Damage Assessment.

The trustees for the Hanford Site include:

- DOE on behalf of the U.S. Federal Government
- U.S. Department of Interior through the U.S. Fish and Wildlife Service
- U.S. Department of Commerce through the National Oceanic and Atmospheric Administration
- State of Washington (through Ecology) in consultation with the Washington Department of Fish and Wildlife
- State of Oregon through the Oregon Department of Energy
- Confederated Tribes and Bands of the Yakama Nation (Yakama Nation)
- Confederated Tribes of the Umatilla Indian Reservation (CTUIR)
- Nez Perce Tribe.

The Hanford Natural Resource Trustee Council was established in 1996 via a Memorandum of Agreement, and is a voluntary association of trust organizations. Members collaborate and coordinate on many issues, documents, and actions concerning natural resources. The primary purpose of the council is to facilitate the coordination and cooperation of the trustees in their efforts to mitigate effects to natural resources that result from either hazardous substance releases on the Hanford Site or remediation of those releases. The council has adopted bylaws to direct the process of arriving at consensus on all substantive decisions.

The trustees transitioned from bi-monthly to monthly formal council meetings in 2011 and scheduled numerous conference calls to conduct business and discuss CERCLA natural resource issues for the Hanford Site. The senior trustees (upper-management level representatives from each trust organization) met once in person and conducted three conference calls to discuss policy, management, and budget issues.

The Hanford Natural Resource Trustee Council performed the following actions in 2011:

- Continued to perform Phase II of the injury assessment process with their selected contractor, Industrial Economics Incorporated. The key deliverable of this phase is a Hanford Site Injury Assessment Plan. Supporting products and tasks under Phase II in 2011 included the following:
  - ‡ Completion of injury assessment plan outline
  - ‡ Completion of the data gap report
  - ‡ Completion of the data management plan
  - ‡ Completion of the data management system conceptual framework
  - ‡ Completion of quality assurance management plan
  - ‡ Completion of public involvement plan



- ‡ Completion of resource review reports and injury study recommendations for aquatic, groundwater and terrestrial resources
- ‡ Completion of 12 species and eco-toxicological profiles.
- Held routine (typically monthly) meetings for each of six technical work groups (Restoration, Aquatic Resources, Groundwater, Terrestrial Resources, Source/Pathway, and Human Uses)
- Established a seventh technical work group for Data Management and Quality Assurance
- Initiated development of a geographic information system database for Hanford Natural Resource Damage Assessment activities
- Developed a list of 53 potential injury studies and approved the initiation of four studies including the compilation of existing Hanford data on contamination in biota, effects of hexavalent chromium and other stressors on native mussels, regeneration of Hanford groundwater contaminant plume maps and calculation of plume volumes, and integration/summarization of data associated with aquatic resources
- Hired a project coordinator to assist the Hanford Natural Resource Trustee Council in planning and managing the Hanford Natural Resource Damage Assessment effort
- Developed Hanford Natural Resource Trustee Council budgets for natural resource injury assessment activities
- Supported funding for injury assessment in the President's budget request to Congress
- Received periodic briefings from DOE staff on ongoing and planned cleanup activities, including remedial investigation/feasibility study (RI/FS) work plans and results
- Provided comments to DOE, as representatives of the individual Hanford Natural Resource Trustee organizations, on cleanup activities including draft plans.

Information about the Hanford Natural Resource Trustee Council, including its objectives, history, and projects, is available on the following website: <http://www.hanford.gov/page.cfm/HNRTC>.

#### **1.5.4 Public Involvement in Hanford Site Decisions**

##### *PK Call*

RL and ORP believe public involvement is essential to the ultimate success of Hanford Site cleanup. Both field offices have staff that coordinate, plan, and schedule public participation activities for DOE on the Hanford Site.

The *Hanford Site Tri-Party Agreement Public Involvement Community Relations Plan* ([TPA 89-10](#), 2002) outlines the public participation processes used by the Tri-Party Agencies (Ecology, EPA, and DOE) and outlines ways the public can be involved in Hanford Site cleanup decision-making processes and serves as the overall guidance document for public participation and outreach activities at Hanford. The first plan was developed and approved with public input in 1990 and was last revised in 2002. In October 2011, the Tri-Party Agencies issued a revised plan for a 45-day public comment period. The proposed changes will be the fifth revision to the 2002 plan. The 2002 plan is available online at: <http://www.hanford.gov/?page=89>. Presently, the Tri-Party Agencies are reviewing comments received on the draft plan, revising the plan where necessary, and is scheduled to issue the final plan and the Response to Comment document in CY2012.

A key goal of public involvement is to facilitate broad-based participation and obtain stakeholder and public perspectives on Hanford Site cleanup decisions. DOE uses various forums to inform the public of upcoming public involvement and participation opportunities. These include, but are not limited to, the following:

- Hanford Cleanup Line – Staff administrating the Hanford Cleanup Line (800) 321-2008 respond to information requests about the Tri-Party Agreement cleanup activities. The Tri-Party Agencies strive to provide a timely response to all requests. The line is advertised frequently in a variety of ways, including all Tri-Party Agreement announcements; media information such as newspaper articles, brochures, and meeting notices; and Hanford Site fact sheets.
- Mailing List – The Tri-Party Agencies maintain a mailing list of about 2,500 individuals who have expressed interest in Hanford Site cleanup issues. The mailing list is used to provide information on upcoming public comment periods, cleanup decisions, and public forums. Information can be received by mail or electronically. To be placed on the mailing list to obtain Tri-Party Agreement information, call the Hanford Cleanup Line at (800) 321-2008 or send an e-mail to [hanford-info@listserv.wa.gov](mailto:hanford-info@listserv.wa.gov).
- Hanford Site Public Involvement Activities – Hanford Site Events Calendar is available at the following website: <http://www.hanford.gov/pageaction.cfm/calendar>. The calendar provides an overview of public involvement opportunities for the coming months and identifies current forums and emerging opportunities to inform and involve stakeholders and the public.
- Tri-Party Agencies Public Involvement Calendar for the Hanford Site is available at the following website: [http://www.ecy.wa.gov/programs/nwp/PI/pdf/TPA\\_PI\\_Calendar.pdf](http://www.ecy.wa.gov/programs/nwp/PI/pdf/TPA_PI_Calendar.pdf). This calendar provides a 12-month overview of upcoming key public involvement activities, including Hanford Advisory Board meeting dates and locations.
- Hanford Site Informational Links – Information concerning Hanford Site events, issues, cleanup activities, and public involvement opportunities is available at the following website: <http://www.hanford.gov/>.
- Comment and Response Documents – Following a DOE or Tri-Party Agreement public comment period, a comment and response document is developed to record public comments received on an issue. Comment and response documents are distributed to members of the public who provide comments or request a copy. These documents are available at the DOE Public Reading Room (Washington State University Tri-Cities Consolidated Information Center, 2710 University Drive, Richland, Washington); on the Tri-Party Agreement Administrative Record website: <http://www5.hanford.gov/arpir/>; and for proposed changes to the Tri-Party Agreement that underwent public comment, on the Tri-Party Agreement website: [www.hanford.gov/?page=86](http://www.hanford.gov/?page=86).
- Informational Public Meetings – All Tri-Party Agreement quarterly public involvement planning meetings, semiannual meetings, special meetings, and workshops are open to the public. In addition, the Tri-Party Agencies welcome opportunities for co-sponsoring meetings organized by local, state, and tribal governments and citizen groups.

Hanford Site cleanup documents are also available to the public through the Tri-Party Agreement's Administrative Record and Public Information Repository available on the following website: <http://www5.hanford.gov/arpir/>.

The public is provided a variety of opportunities to offer input and influence Hanford Site cleanup decisions. These opportunities include informal and formal public comment periods, such as those described in the Tri-Party Agreement ([Ecology et al. 1989](#)), CERCLA, RCRA, and the NEPA; Hanford Advisory Board meetings; State of the Hanford Site presentation; and other Hanford Site-related public involvement and information meetings, workshops, or activities.

### **1.5.5 State of Oregon**

DOE recognizes the state of Oregon's unique role and interests at the Hanford Site, and its concerns to protect Columbia River resources. DOE is interested in sharing, facilitating, and accommodating the exchange of

information with the state of Oregon. RL and ORP entered into a [Memorandum of Understanding](#) in 2004, with the state of Oregon to consult, and whenever possible, cooperate on Hanford Site environmental issues. DOE will consult with and include the Oregon Department of Energy in planning and conducting Hanford Site-related public involvement activities in the state of Oregon.

For more information about Hanford Site cleanup activities, contact the Tri-Party Agencies at the following contact numbers:

RL (509) 376-7501

ORP (509) 372-8656

Hanford Site Cleanup Line/Ecology (800) 321-2008

EPA (509) 376-8631

For more information about Hanford Site public involvement, visit the Hanford Site website:

<http://www.hanford.gov>.

### **1.5.6 Hanford Advisory Board**

#### *PK Call*

The Hanford Advisory Board is a broadly representative body consisting of a balanced mix of members that represent diverse interests affected by Hanford Site cleanup decisions. The Hanford Advisory Board was created in 1994 by the Tri-Party Agencies and ultimately chartered as one of nine environmental management site-specific advisory boards across the country. The Hanford Advisory Board is comprised of 31 members and their alternates, including representatives from the Nez Perce Tribe and the Confederated Tribes and Bands of the Yakama Nation. A representative of the Confederated Tribes of the Umatilla Indian Reservation participates on the board in an ex-officio status. Current members with their affiliations are listed on the following website: <http://www.hanford.gov/page.cfm/hab>.

The Hanford Advisory Board assists the broader public in becoming more informed and meaningfully involved in Hanford Site cleanup decisions through its open public meetings. Board members' formal advice on cleanup issues reflects the values of its constituents. Copies of their advice and DOE's responses are on the following website: <http://www.hanford.gov/?page=453>.

Information about the Hanford Advisory Board, including its charter (operating ground rules) is available on the following website: <http://www.hanford.gov/?page=449>.

### **1.6 Hanford Site Regulatory Oversight**

#### *TG Beam*

Several federal, state, and local regulatory agencies are responsible for monitoring and enforcing compliance with applicable environmental regulations at the Hanford Site. These agencies include EPA, Ecology, Washington State Department of Health, and the Benton Clean Air Agency. EPA is the primary federal regulatory agency that develops, promulgates, and enforces environmental regulations and standards as directed in statutes enacted by Congress. In some instances, EPA has delegated authority to the state or authorized the state program to operate in lieu of the federal program when the state's program meets or exceeds EPA requirements. In other activities, the state program is assigned direct environmental oversight of the DOE program, as provided by federal law. Where federal regulatory authority is not delegated or only partially authorized to the state, the EPA Pacific Northwest Regional Office (Region 10) is responsible for

reviewing and enforcing compliance with EPA regulations as they pertain to the Hanford Site. EPA periodically reviews state environmental programs and may directly enforce federal environmental regulations.

### **1.6.1 Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement)**

*TW Noland*

The Tri-Party Agreement (Ecology et al. 1989) is an agreement among the Tri-Party Agencies (DOE, EPA, and Ecology) to achieve environmental regulation compliance on the Hanford Site with CERCLA and RCRA treatment, storage, and disposal (TSD) unit regulations and corrective action provisions. The Tri-Party Agreement is an interagency agreement (also known as a *Federal Facility Agreement and Consent Order*) under CERCLA, Section 120, a corrective action order under RCRA, and a consent order under the Washington State [\*Hazardous Waste Management Act of 1976\*](#) that 1) defines RCRA and CERCLA cleanup commitments, 2) establishes responsibilities, 3) provides a basis for budgeting, and 4) reflects a concerted goal to achieve regulatory compliance and remediation with enforceable milestones. A companion document to the Tri-Party Agreement is the *Hanford Site Tri-Party Agreement Public Involvement Community Relations Plan* ([TPA 89-10, 2002](#)). This plan describes how public information and involvement activities are conducted for Tri-Party Agreement decisions.

The Tri-Party Agreement has evolved as Hanford Site cleanup has progressed. Since its publication in 1989, the Tri-Party Agencies negotiate changes to the agreement to meet the changing conditions and needs of cleanup activities on the Hanford Site. All significant changes undergo a process of public involvement that enhances communication and addresses public concerns prior to final approvals. A new Revision 8 was published in 2011. Revision 8 is current as of July 18, 2011, and incorporates 124 sets of modifications (Change Control Forms) that have been approved since publication of the last revision. Revision 8 is a snapshot in time. As new Change Control Forms are approved through the Tri-Party Agreement change control process, they are incorporated into the Tri-Party Agreement and available on line at:

<http://www.hanford.gov/?page=81>. Printed copies of Revision 8 of the Tri-Party Agreement are publicly available at DOE's Public Reading Room located in the Washington State University Tri-Cities Consolidated Information Center, 2770 University Drive, Richland, Washington, and at public information repositories in Seattle and Spokane, Washington, and Portland, Oregon.

To be placed on the mailing list to obtain Tri-Party Agreement information, call the Hanford Cleanup Line at (800) 321-2008 or send an e-mail to [hanford-info@listserv.wa.gov](mailto:hanford-info@listserv.wa.gov).

#### **1.6.1.1 Tri-Party Agreement Milestone Status**

*TW Noland*

The Tri-Party Agreement commits DOE to comply with the remedial-action provisions of CERCLA as well as with RCRA TSD unit regulations and corrective-action provisions, including Washington State's implementing regulations (WAC 173-303, *Dangerous Waste Regulations*). From 1989 through 2011, a total of 1,143 Tri-Party Agreement milestones were completed and 315 target dates were met. During 2011, 38 specific cleanup milestones were scheduled for completion; 37 were completed ahead of their scheduled date and one was completed on time.

### 1.6.1.2 Tri-Party Agreement Approved Modifications

TW Noland

During 2011, 37 negotiated Change Control Forms to the Tri-Party Agreement were approved; these changes can be viewed at the Tri-Party Agreement website: <http://www.hanford.gov/c.cfm/tpa/>.

### 1.6.2 Washington State Department of Health

TG Beam

The Washington State Department of Health has regulatory authority to enforce federal and state standards applicable to all sources of ionizing radiation in the state. EPA provided delegation of authority to the Washington State Department of Health to implement and enforce the federal standards and requirements in 40 CFR 61, Subpart A (*General Provisions*), and Subpart H (*National Emission Standards for Emissions of Radionuclides other than Radon from Department of Energy Facilities*). Subpart H, is enforced along with the state standards and requirements of *Radiation Protection–Air Emissions* (WAC 246-247), and *Ambient Air Quality Standards and Emission Limits for Radionuclides* (WAC 173-480), issued under the authority of the *Washington Clean Air Act* (70.94 RCW). These regulations include requirements to obtain Washington State Department of Health approval before constructing any new or modified sources of airborne radionuclide emissions. The Washington State Department of Health will then issue and enforce the resulting licenses covering construction and operation. The Washington State Department of Health also inspects emission sources within the state that may emit airborne radioactive material to verify the operations, emissions, and record keeping and reporting are in compliance with all applicable licenses and federal and state regulations. To protect public health with an adequate margin of safety, the state enforces an as low as reasonably achievable environmental approach to minimizing airborne emissions. The Washington State Department of Health maintains an office in Richland, Washington, with staff assigned to oversee Hanford Site operations.

## 1.7 Hanford Site Websites

SA Thompson

Additional information about Hanford Site management and contractors can be accessed at the following websites:

- Advanced Technologies and Laboratories International, Inc.: <http://www.atlintl.com/>
- BNI: <http://www.hanfordvitplant.com/>
- CHPRC: <http://www.plateauremediation.hanford.gov/>
- CSC Hanford Occupational Health Services: <http://www.hanford.gov/amh/>
- ORP: <http://www.hanford.gov/orp/>
- DOE Office of Science: <http://science.energy.gov/>
- RL: <http://www.hanford.gov/rl/>
- DOE Science and Technology: <http://www.energy.gov/sciencetech/>
- Eberline Services Hanford, Inc.: [http://www.eberlineservices.com/page\\_field.htm](http://www.eberlineservices.com/page_field.htm)
- EnergySolutions: <http://www.energysolutions.com/?id=otuy>
- Environmental Restoration Disposal Facility: <http://www.hanford.gov/page.cfm/erdf>
- Hanford Reach National Monument: <http://www.fws.gov/hanfordreach/>

- Hanford Site Tours: <http://www.hanford.gov/page.cfm/hanfordsitetours>
- Jacobs Engineering Group Inc.: <http://www.jacobs.com/>
- Laser Interferometer Gravitational-Wave Observatory: <http://www.ligo.caltech.edu/>
- Lockheed Martin Corporation: <http://www.lockheedmartin.com/>
- MSA: <http://msa.hanford.gov/msa/>
- URS Corporation: <http://www.urscorp.com/>
- HAMMER Facility: <http://www.hammertraining.com/>
- Wackenhut Services, Inc.: <http://www.wsihq.com/>
- WCH: <http://www.washingtonclosure.com/>
- WRPS: <http://www.wrpstoc.com/>

Information about the PNNL Site can be access at the following website:

- Battelle Memorial Institute: <http://www.battelle.org/>
- Environmental Molecular Sciences Laboratory: <http://www.emsl.pnl.gov/emslweb/>
- PNNL: <http://www.pnl.gov/>
- DOE Office of Science, Pacific Northwest Site Office: <http://pnso.oro.doe.gov/>

Additional information about the local area and region can be accessed at the following websites:

- City of Kennewick: <http://www.go2kennewick.com/>
- City of Pasco: <http://www.pasco-wa.gov/>
- City of Richland: <http://www.ci.richland.wa.us/>
- City of West Richland: <http://www.westrichland.org/>
- Columbia River Basin: <http://yosemite.epa.gov/r10/ecocomm.nsf/columbia/columbia>
- Geology of Washington – Columbia Basin:  
<http://www.dnr.wa.gov/researchscience/topics/geologyofwashington/pages/columbia.aspx>
- Port of Benton: <http://www.portofbenton.com/>
- Tri-Cities Visitor & Convention Bureau: <http://www.visittri-cities.com/>
- U.S. Fish and Wildlife Service: <http://www.fws.gov/>
- Washington Department of Fish and Wildlife: <http://wdfw.wa.gov/>

Additional information about other companies in the area can be accessed at the following websites:

- AREVA NP Inc.: <http://www.areva.com/en/operations-925/areva-inc--richland-nuclear-fuel-production.html>
- Energy Northwest, Columbia Generating Station: <http://www.energy-northwest.com/generation/cgs/index.php>
- Perma-Fix Northwest, Inc.: [http://www.perma-fix.com/facilities/pf\\_nuclear\\_richland/](http://www.perma-fix.com/facilities/pf_nuclear_richland/)
- US Ecology, Inc.: <http://www.americanecology.com/richland.htm>

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## 2.0 Compliance Summary

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SA Thompson

DOE policy mandates that all activities at the Hanford Site are performed in compliance with applicable federal, state, and local environmental laws and regulations; DOE orders and executive orders; Secretary of Energy Notices; DOE Headquarters (HQ) and site operations office directives, policies, and guidance. This includes specific requirements, actions, plans, and schedules identified in the Tri-Party Agreement and other compliance or consent agreements. RL and ORP recognize the importance of maintaining a proactive program of self-assessment and regulatory reporting to ensure environmental compliance is achieved and maintained at the Hanford Site. This report also includes the requirements for reporting annual compliance status with environmental standards provided in *Environment, Safety and Health Reporting* (DOE O 231.1A, Chg 1).

This section summarizes the various laws and regulations that affect Hanford Site activities with regard to federal environmental protection statutes and associated state and local environmental regulations. Permits required under specific environmental protection regulations are discussed, as well as notices of violations and notices of noncompliance issued by EPA or Ecology. Notices of violation are the regulatory means of informing organizations that their work activities are not meeting requirements. Notices of noncompliance are informal notifications of regulatory violations.

### 2.1 Hazardous Materials and Waste Management

This section provides compliance information regarding federal environmental statutes and regulations related to hazardous materials and waste management at the Hanford Site.

#### 2.1.1 Comprehensive Environmental Response, Compensation, and Liability Act of 1980

JW Cammann

CERCLA ([42 USC §9601 et seq.](#)) was promulgated to address response, compensation, and liability for past releases or potential releases of hazardous substances, pollutants, and contaminants to the environment. CERCLA was amended by the *Superfund Amendments and Reauthorization Act of 1986* (see [Section 2.1.1.2](#)), which made several important changes and additions, including clarification that federal facilities are subject to the same provisions of CERCLA as any non-governmental entity. The EPA maintains the *National Priorities List for Uncontrolled Hazardous Waste Sites* ([59 FR 43314](#)) of uncontrolled hazardous substance releases for long-term evaluation and response actions. Federal facilities identified on the National Priorities List (NPL) ([59 FR 43314](#)) must enter into an interagency agreement (Tri-Party Agreement) with EPA to remediate the sites. Under CERCLA, two types of response actions are authorized: 1) short-term removal actions to address releases or threatened releases requiring prompt response; and 2) long-term remedial actions that permanently and significantly reduce the dangers associated with releases or threats of releases of hazardous substances that are serious, but not life threatening. EPA is responsible for oversight of DOE's implementation of CERCLA regulations.

The Hanford Site was established in 1943 to produce nuclear materials for national defense. Many production activities resulted in the disposal of wastes containing hazardous constituents and/or radioactive materials. As a result, in July 1989, the EPA placed four sites (100, 200, 300, and 1100 Areas) on the NPL pursuant to CERCLA.

In anticipation of the NPL listing, the Tri-Party Agencies entered into the Tri-Party Agreement in May 1989. This agreement established a procedural framework and schedule for developing, implementing, and monitoring CERCLA response actions on the Hanford Site. The agreement also addresses RCRA (42 USC 6901) compliance and permitting. The Tri-Party Agreement is a legally binding agreement between DOE, EPA, and Ecology that establishes the guidelines and framework for achieving cleanup of the Hanford Site. Since the Hanford Site was placed on the NPL, DOE and its contractors have made considerable progress in the cleanup mission. This cleanup has led to the removal of portions of the 100 Areas from the EPA's NPL ([59 FR 43314](#)) including the Wahluke Slope north of the Columbia River and the entire 1100 Area.

There can be significant overlap between the CERCLA response action program and the RCRA corrective action program (see [Section 2.1.4](#)). Many waste management units on the Hanford Site could be subject to cleanup under both programs. The CERCLA response action program is implemented through the *National Oil and Hazardous Substances Pollution Contingency Plan* (40 CFR 300), which establishes procedures for characterization, evaluation, and remediation of waste sites. The Tri-Party Agreement addresses implementation of both CERCLA response actions and RCRA corrective actions through administrative application of either program while meeting the technical requirements of both.

Executive Order 12580, *Superfund Implementation* (52 FR 2923) directs that DOE, as the lead agency, must conduct CERCLA response actions (removal and remedial actions). The CERCLA regulatory framework for both removal and remedial actions consists of the following five general activities: 1) investigation, 2) evaluation, 3) decision, 4) implementation, and 5) closeout.

During the remedial action investigation phase, a preliminary assessment and site inspection is conducted following the discovery of a release or the threat of release to the environment. Upon determination that the site of the release meets the criteria for inclusion on the EPA's NPL ([59 FR 43314](#)), a more detailed site characterization is performed in accordance with the data quality objectives process, which includes an RI/FS work plan, sampling and analysis plan, field work plan, and quality assurance plan. The evaluation phase includes developing alternatives to eliminate the release or threat of release. DOE then considers the results of site characterization as documented in remedial investigation reports used to support feasibility studies of candidate remedial technologies.

During the decision phase, the preferred alternative is implemented and regulatory approval is obtained. Public involvement is encouraged by issuing a proposed plan and a record of decision (ROD) that defines the action(s) that will be taken to mitigate the threat to human health and the environment caused by the release of hazardous substances. During the implementation phase, the preferred alternative is implemented including preparing a remedial design and remedial action work plan, remedial design report, air monitoring plan, waste management plan, mitigation action plan, and operations and maintenance plan. Finally, during the closeout phase, a remedial site verification package is issued that documents remedial action goals, objectives, and applicable or relevant and appropriate requirements (ARARs) are achieved in accordance with the ROD.

Section 121(d) of CERCLA requires that remedial actions attain or waive federal environmental ARARs, or more stringent state environmental ARARs, upon completion of the remedial action. The *National Oil and Hazardous Substances Pollution Contingency Plan* (40 CFR 300) also requires compliance with ARARs during remedial and removal actions to the extent practicable. The ARARs are identified on a site-by-site basis for all onsite response actions where CERCLA authority is the basis for cleanup.

There are three types of removal actions under CERCLA: 1) emergency, 2) time-critical, and 3) non-time-critical. Emergency removals must be initiated within hours or days in response to acute problems that may

involve fires, explosions, imminent contamination of water supplies, or the release or imminent release of hazardous substances. Time-critical removals are conducted in response to releases requiring onsite action within 6 months (e.g., removal of drums or small volumes of contaminated soil). Non-time-critical removals are conducted in response to releases where a planning period of at least 6 months is available before onsite activities must begin and the need is less immediate. The majority of removal actions on the Hanford Site are conducted as non-time-critical.

Non-time-critical removal actions generally remove or reduce the threat caused by a release of a hazardous substance such that no further action is necessary to be protective of human health and the environment. When a removal action is unsuccessful in reaching a protective situation, it may be followed by a remedial action to complete the site response. Non-time-critical removal actions can provide substantial risk reduction by addressing specific problems without requiring the more time consuming RI/FS process associated with CERCLA remedial actions.

As with remedial actions, non-time-critical removal actions include activities involving investigation, evaluation, decision, implementation, and closeout. Upon completion of an initial evaluation to develop an understanding of the threat posed by a release, the lead agency initiates an engineering evaluation and cost analysis process. This process involves preparing an engineering evaluation and cost analysis of removal action alternatives, conducting community relations activities, and documenting the removal action decision in an action memorandum. The engineering evaluation and cost analysis process is comparable to the RI/FS process; however, it is less comprehensive. The action memorandum is comparable to a ROD; however, it is less elaborate. A removal action work plan is prepared to implement the decisions in the action memorandum. Closeout of the non-time-critical removal process ensures that all removal action objectives have been met and that threats to human health and the environment have been mitigated. If the removal action location is within the boundaries of a CERCLA operable unit on the NPL ([59 FR 43314](#)), then the remedy selected for the removal action must be consistent with the final remedy for the entire operable unit.

For waste sites where hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure, CERCLA requires a review every 5 years to evaluate the implementation and performance of a remedy to determine if the remedy is or will be protective of human health and the environment. The 5-year review requirement applies to all remedial actions selected under CERCLA §121. The methods, findings, and conclusions of the 5-year reviews are documented in a CERCLA Five Year Review Report. The *USDOE Hanford Site First Five-Year Review Report* ([EPA 2001](#)) documented the results of the first 5-year review completed by EPA Region 10 in September 2000. This report covered all portions of the Hanford Site with a CERCLA decision document and included areas that contain hazardous substances, pollutants, or contaminants, which are to be remediated under CERCLA.

The *Second CERCLA Five-Year Review Report for the Hanford Site* ([DOE/RL-2006-20](#)) documented the results of the second 5-year review completed by DOE in November 2006. The report evaluated the performance of the CERCLA remedies selected in interim RODs, including existing institutional controls to prevent exposure to the public and the environment.

The *Third CERCLA Five-Year Review Report* ([DOE/RL-2011-56](#), Rev. 1) documented the results completed by DOE, which was transmitted to EPA on November 4, 2011. The report presented the 5-year review of CERCLA response actions initiated, in progress, or completed at the Hanford Site where the action resulted in hazardous substances, pollutants, or contaminants remaining onsite above levels that allow for unlimited use and unrestricted exposure. The report concluded that the completed interim remedies are protective of human health and the environment except for certain groundwater constituents in the 100 Areas (strontium-90 and

chromium) where amendments to RODs were issued to modify the selected remedies. Final remedies are expected to be protective of human health and the environment upon completion and, in the interim, ensure exposure pathways that could result in unacceptable risks are being controlled. The remedies comply with the decision documents and are functioning as intended.

### **2.1.1.1 Institutional Controls Plan**

*DR Ranade*

The *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions*, ([DOE/RL-2001-41](#)), describes the institutional controls for the Hanford Site and how they are implemented and maintained in accordance with CERCLA decision documents. The CERCLA decision documents present the selected remedial actions chosen in accordance with CERCLA, as amended by the *Superfund Amendments and Reauthorization Act of 1986* and implemented under 40 CFR 300. CERCLA decision documents are developed as part of the cleanup mission at the Hanford Site, which began in 1989 following the end of the national defense mission. The selected remedies chosen may include institutional controls and the CERCLA decision documents identify specific requirements for these controls.

Institutional controls are primarily administrative in nature and typically are used to augment the engineered components of a selected remedy to minimize the potential for human exposure to contaminants. Active institutional controls, such as controlling access to the Hanford Site or activities that may affect remedial action, generally are employed during remediation. After remediation is completed, passive institutional controls are employed such as permanent markers, retaining public records and archives, or sustaining regulations regarding land or resource use. Some active institutional controls, such as monitoring and controlling access to the area, also may be employed after remediation is completed.

Initially, the Hanford Site institutional controls assessments were conducted on an annual basis. However, based on the results of the annual institutional controls assessments and the ongoing [DOE/RL-2001-41](#) review of institutional controls by individual projects, it has been determined that a review of institutional controls is most appropriately conducted in conjunction with the Hanford Site CERCLA 5-year review. DOE will continue to conduct institutional controls assessments as required by the CERCLA decision documents. The ongoing review of the institutional controls by individual projects also will continue. The site-wide institutional controls assessment, in conjunction with the CERCLA 5-year review, will be a 'roll up' of these reviews and will serve as a means to evaluate effectiveness of the institutional controls. Based on the ongoing review, contractors will provide an annual update on the effectiveness of the institutional controls to EPA and Ecology at the Area Unit Managers Meetings conducted every September. Minutes from the unit manager's meeting are available in the Tri-Party Agreement Administrative Record and can be accessed at the following website: <http://www5.hanford.gov/arpir>.

The River Corridor Project, managed by WCH, has a number of institutional controls in both interim action and final ROD documents. Access controls were in place and active for WCH managed projects and no public trespass events were reported during 2011. In addition, approved excavation permits were in place for all active remediation activities. Warning signs were in place at roadway entrances to waste sites within the 300 Area main industrial complex and 618-10 Burial Ground. Temporary signage is used at the 100-IU-2 Operable Unit and 100-IU-6 Operable Unit waste sites; however, more permanent signs will be installed at the main roadways. Shoreline signage checked during September 2011 indicated that signs at the 100-K Area had been removed; these signs were replaced in October 2011.

The Central Plateau Project, managed by CHPRC, also has a number of institutional controls in both interim and final ROD documents. Assessment of institutional controls at 200-UP-1 Operable Unit, 221-U Facility, and 200-ZP-1 Operable Unit did not identify deficiencies with land-use management, entry restrictions, groundwater management, or warning signs.

### **2.1.1.2 CERCLA and Washington State Dangerous Waste Substance Reportable Releases to the Environment**

*TH Pysto*

Federal regulations establish reporting requirements for certain environmental releases; these releases are reported to the National Response Center, the federal central point of contact for reporting hazardous substances and oil spills. Reportable releases include spills or discharges of hazardous substances to the environment, other than releases permitted under state or federal law. CERCLA, Section 103 requires that releases of hazardous substances that equal or exceed specified reportable quantities, including releases that are continuous and stable in quantity and rate but exceed specified limits, must be reported. Washington State regulations (WAC 173-303-145) also require that spills or non-permitted discharges of dangerous waste or hazardous substances to the environment be reported. The requirement applies to spills or discharges onto the ground, into groundwater or surface water (Columbia River), or in the air such that human health or the environment are threatened, regardless of the quantity of dangerous waste or hazardous substance. In April 2011, a report was made to the National Response Center regarding four containers of lead-contaminated soil (Land Disposal Restriction) were inadvertently disposed of in the Environmental Restoration Disposal Facility.

During CY2011, hazardous substance releases were conservatively assessed under WAC 173-303-145, and notifications were provided to Ecology for various minor spills. These spills were cleaned up, and materials were disposed of in accordance with applicable requirements.

### **2.1.1.3 Superfund Amendments and Reauthorization Act of 1986**

*JW Cammann*

Congress passed RCRA in 1976 to govern how hazardous wastes were to be treated, stored, and disposed of to minimize the present and future threat to human health and the environment. Although RCRA provided a 'cradle to grave' approach to managing present and future hazardous waste, it did not address prior activities or abandoned waste sites; therefore, federal, state, and local authorities did not have guidelines for addressing or cleaning up properties contaminated by hazardous substances from past practices.

Congress enacted CERCLA on December 11, 1980, to provide the means to identify responsible parties, fund the cleanup of impacted sites under the *polluter pays principle*, and address the dangers of past-practice hazardous waste sites that create significant risk to human health and the environment. The *Superfund Amendments and Reauthorization Act of 1986* was enacted on October 17, 1986, which amended and reauthorized CERCLA. The *Superfund Amendments and Reauthorization Act of 1986* reflected EPA's experience in administering the complex Superfund Program during its first 6 years and made several important changes and additions to the program. Changes and additions under the *Superfund Amendments and Reauthorization Act of 1986* included the following:

- Stressed the importance of permanent remedies and innovative treatment technologies in cleaning up hazardous waste sites

- Required Superfund actions to consider and generally comply with the standards and requirements found in other state and federal environmental laws and regulations
- Provided new enforcement authorities and settlement tools
- Increased state involvement in every phase of the Superfund Program
- Increased the focus on human health problems posed by hazardous waste sites
- Encouraged greater citizen participation in decisions on how sites should be cleaned up
- Increased the size of the cleanup trust fund to \$8.5 billion.

The *Superfund Amendments and Reauthorization Act of 1986* also required EPA to revise its hazard ranking system to ensure it accurately assessed the relative degree of risk to human health and the environment posed by uncontrolled hazardous waste sites that may be placed on the EPA's NPL ([59 FR 43314](#)).

The *Superfund Amendments and Reauthorization Act of 1986* attempted to accelerate the cleanup of hazardous waste sites and resolve questions of jurisdiction. Section 120 of the *Superfund Amendments and Reauthorization Act of 1986* establishes a timetable and requires participation in the planning and cleanup selection process by state and local officials and the public. In cases where a federal government agency and EPA disagree on the proposed remedy at a site, EPA is to make the selection. Although subsection (g) of Section 120 prohibits the transfer of EPA's authorities to any other agency or person, Executive Order 12580, *Superfund Implementation*, signed by President Reagan on January 23, 1987 (52 FR 2923), gives the Office of Management and Budget the final authority in cases where the EPA and another federal government agency disagree on the remedy selection.

In May and June 1988, EPA concurred with the U.S. Department of Defense and DOE on model language to be included in all federal facility cleanup agreements at Superfund sites owned by the two departments.

The model language provides for and recognizes the following: 1) EPA's authority to assess penalties in the case of noncompliance with the agreement; 2) Departments' commitment to study and perform EPA-approved cleanup activities at the facilities; 3) EPA's commitment to review and comment on the departments' studies and plans; 4) Mechanism for resolving disputes, with final authority resting with the EPA Administrator when staff of the agency and the departments cannot reach agreement on selecting the final remedy; and 5) Enforceability of the agreements by states and citizens. The *Superfund Amendments and Reauthorization Act of 1986* places restrictions on federal government property to ensure that any hazardous waste sites will be cleaned up prior to sale of the property.

A number of new statutory authorities, such as the *Emergency Planning and Community Right-To-Know Act of 1986* ([Section 2.6.1](#)) also were established by the *Superfund Amendments and Reauthorization Act of 1986*.

The *Emergency Planning and Community Right-To-Know Act of 1986*, also known as *Superfund Amendments and Reauthorization Act of 1986 Title III*, establishes emergency planning and reporting requirements for industry and government; and gives communities the necessary tools for planning and responding to the potential release of hazardous waste. In 1994, President Clinton's administration proposed a new Superfund reform bill that was seen as an improvement to existing legislation by some environmentalists and industry lobbyists; however, the effort was unable to gain bipartisan support. Until the mid-1990s, most of the Superfund Program funding came from a tax on the petroleum and chemical industries, reflecting the *polluter pays principle*.

Approximately 70 percent of Superfund Program cleanup activities historically have been funded by potentially responsible parties who may eventually be held liable under CERCLA for the contamination or misuse of a particular property or resource. The only time cleanup costs are not borne by a potentially



responsible party is when that party cannot be found or is unable to pay for cleanup activities, creating an 'orphan' site. For orphan sites, the Superfund Program originally paid for hazardous waste cleanups through the tax on petroleum and chemical industries. The tax went to a trust fund for cleaning up abandoned or uncontrolled hazardous waste sites. However, the last year in which the U.S. Department of the Treasury collected the tax was FY1995. This fund was exhausted by the end of FY2003. Since then, funding for the cleanup of orphan sites has been appropriated by Congress out of general revenues.

Beginning in FY2010, EPA initiated a 3-year strategy called the Integrated Cleanup Initiative and issued the initiative on May 9, 2011. The Integrated Cleanup Initiative identifies and implements opportunities to integrate and leverage EPA's land cleanup authorities to accelerate cleanup activities, address a greater number of contaminated sites, and put these sites back into productive use while protecting human health and the environment. The Integrated Cleanup Initiative examines opportunities for improvements of all EPA's land cleanup programs including Superfund Programs, the Brownfields Program, Federal Facilities Restoration and Reuse Office Programs, RCRA Programs, and the Underground Storage Tank Programs. The Integrated Cleanup Initiative includes a focus on enforcement activities that are critical to ensuring that potentially responsible parties are compelled to clean up contaminated sites, thereby preserving Superfund Program funds to be used to clean up other sites where potentially responsible parties do not exist.

EPA's Office of Solid Waste and Emergency Response in partnership with the Office of Enforcement and Compliance Assurance launched a 3-year strategy to identify and implement improvements to EPA's land cleanup programs. Consistent with EPA's annual 2011 performance measure, remedial action project completions, a strong project management focus and managing projects to completion are overarching principles for the Integrated Cleanup Initiative. With an enhanced project focus, EPA expects to further demonstrate progress at various stages of the cleanup and further optimize the work within the cleanup pipeline.

EPA also developed an implementation plan to further describe the goals and objectives of the Integrated Cleanup Initiative and to identify ongoing or new actions the EPA will advance with their partners during the next 3 years. EPA will use the three stages of the cleanup process common to all land cleanup programs; i.e., starting cleanups, advancing cleanups, and completing cleanups.

The 'starting cleanups' stage focuses on site identification and assessment activities in the early part of the cleanup continuum. The 'advancing cleanups' stage emphasizes coordination during cleanup activities, including enforcement strategies. The 'completing cleanup' stage focuses on pilot projects aimed at accelerating cleanup, reporting to the public, and leveraging revitalization efforts as cleanups are completed. Throughout the continuum, there are opportunities for improved performance metrics, communication, and coordination among EPA's programs and partners.

### **2.1.2 Resource Conservation and Recovery Act of 1976**

*JK Perry*

RCRA was enacted in 1976 with the objective of protecting human health and the environment. In 1984, the *Hazardous and Solid Waste Amendments of 1984* reauthorized RCRA, imposing new requirements on hazardous waste management. The central principle of RCRA is its establishment of cradle-to-grave management to track hazardous waste from its generation to treatment, storage, and disposal. Ecology has the authority to enforce RCRA requirements in the state under the *Dangerous Waste Regulations* (WAC 173-303).

### 2.1.2.1 Hanford Facility Dangerous Waste Permit

*JK Perry*

Ecology issued the *Hanford Facility Dangerous Waste Permit* (WA7890008967) on September 27, 1994 ([WA7890008967, 1994](#)). The Tri-Party Agencies recognized that not all of the Hanford Site treatment, storage, and disposal units could be issued dangerous waste permits simultaneously; therefore, a schedule (Tri-Party Agreement M-20 Milestones) was established to submit unit-specific permit applications and closure plans to Ecology; however, the dangerous waste permit expired on September 27, 2004. DOE continues to operate under the expired permit until a new permit is in effect. Ecology is preparing to reissue the draft *Hanford Facility Dangerous Waste Permit* ([WA7890008967, Revision 9](#)), incorporating the remaining treatment, storage, and disposal units for public comment in May 2012 and continue through September 2012.

Currently there are 14 treatment, storage, and disposal units incorporated into the permit ([WA7890008967, Revision 8C](#)) through the end of CY2011. The permit is issued to seven Permittees: RL and ORP as the owners/operators; and six of their contractors: BNI; CHPRC; MSA; PNNL; WCH; and WRPS, as co-operators.

Permit conditions for the following treatment, storage, and disposal units were modified in 2011 pursuant to following WAC 173-303-830 provisions:

- Liquid Effluent Retention Facility and 200 Area Effluent Treatment Facility (Operating Unit 3)
- 325 Hazardous Waste Treatment Units (Operating Unit 5)
- Waste Treatment and Immobilization Plant (Operating Unit 10)
- 331-C Storage Unit (Operating Unit 15).

### 2.1.2.2 RCRA Inspections

*DL Hagel*

Ecology performed 17 RCRA inspections on the Hanford Site in 2011 to assess compliance with applicable requirements. The Hanford Site received no notices of violation or warning letters of noncompliance that were based on those inspections.

### 2.1.2.3 RCRA Groundwater Monitoring

*MJ Hartman*

RCRA groundwater monitoring is conducted under the Soil and Groundwater Remediation Project ([Section 8](#)). Fourteen RCRA treatment, storage, and disposal units were monitored to determine if contaminated groundwater with dangerous constituents was present. Seven sites were monitored to assess the extent of known contaminants and two sites are monitored under corrective action programs.

The Liquid Effluent Retention Facility is currently operating under the *Hanford Facility Dangerous Waste Permit* ([WA7890008967, Revision 8C](#)) and as cited in [Section 2.1.2.1](#), Ecology is preparing to reissue the permit for public comment in May 2012.

The Integrated Disposal Facility has been operating under the *Hanford Facility Dangerous Waste Permit* ([WA7890008967, Revision 8C](#)), since June 2006 and is under a unit-specific groundwater monitoring plan.

Because the unit has not yet received waste, monitoring is performed under a Pre-Active Life Program (standby mode).

Other sites monitored under RCRA are scheduled for closure under the *Hanford Facility Dangerous Waste Permit* ([WA7890008967, Revision 8C](#)). A summary of groundwater monitoring activities for these sites during 2011 is provided in Section 7 and the detailed groundwater monitoring information for CY2011 will be available in September 2012 with the release of *Hanford Site Groundwater Monitoring Report for 2011*.

#### **2.1.2.4 Washington Administrative Code Groundwater Monitoring**

*MJ Hartman*

Groundwater monitoring was required for three regulated, non-RCRA waste facilities in 2011. The 200 Area Treated Effluent Disposal Facility and the State-Approved Land Disposal Site are monitored under state waste discharge permits (WAC 173-216). The Solid Waste Landfill is monitored for compliance with requirements in WAC 173-350, *Solid Waste Handling Standards*. Wells near these facilities were monitored in 2011 for waste constituents specified in the facility permits.

Section 7 summarizes groundwater monitoring activities for these sites during 2011; detailed information for 2011 is available in the *Hanford Site Groundwater Monitoring for 2011* ([DOE/RL-2011-118](#)).

#### **2.1.3 Federal Facility Compliance Act of 1992**

*JK Perry*

The *Federal Facility Compliance Act of 1992*, enacted by Congress on October 6, 1992, amends Section 6001 of RCRA to specify that the United States waives sovereign immunity from civil and administrative fines and penalties for RCRA violations. In addition, RCRA requires EPA to conduct annual inspections of all federal facilities. Authorized states also are given authority to conduct inspections of federal facilities to enforce compliance with state hazardous waste programs.

The *Federal Facility Compliance Act of 1992* was effective upon enactment on October 6, 1992, with the exception that departments, agencies, and instrumentalities of the executive branch of the federal government would not be subject to the sovereign immunity waiver with respect to civil, criminal, and administrative penalties and fines (as added by the amendments made by subsection [a]) until 3 years after enactment for violations of RCRA Section 3004(j) involving storage of mixed waste that is not subject to an existing agreement, permit, or administrative or judicial order, so long as such waste is managed in compliance with all other applicable requirements. This section forbids the storage of hazardous waste prohibited from land disposal unless the storage is for accumulating such quantities as necessary to facilitate proper recovery, treatment, or disposal.

After October 6, 1995, the provisions added to RCRA's existing waiver of sovereign immunity by the *Federal Facility Compliance Act of 1992* with respect to *civil, criminal, and administrative penalties and fines* shall still not apply to DOE as long as DOE is in compliance with a plan that has been submitted and approved and an order requiring compliance with such a plan. The required plan calls for developing treatment capacities and technologies to treat all mixed wastes at each DOE facility.

The *Federal Facility Compliance Act of 1992* further amends RCRA by imposing several new reporting requirements on DOE related to mixed waste. The Secretary of Energy must submit reports containing a national inventory of mixed wastes on a state-by-state basis, and a national inventory of mixed waste treatment capacities and technologies to the EPA Administrator and the governors of states in which DOE stores or

generates mixed wastes. The mixed waste inventory must describe each mixed waste type, list the amount currently stored, and estimate the amount of each type of mixed waste expected to be generated in the next 5 years at each DOE facility; however, waste not characterized by sampling and analysis also requires description. The inventory of treatment capacities and technologies is required to contain an estimate of available treatment capacity for each waste category described in the waste inventory.

DOE submitted its initial draft mixed waste inventory report to EPA and affected states for comment in April 1993 and published a notice of its availability on April 23, 1993 (58 FR 25822). Also, the Secretary of Energy was directed to prepare and submit plans for developing treatment capacities and technologies for all facilities generating or storing mixed waste that are not subject to any permit, agreement, or order. These plans would include schedules for developing treatment capacity where treatment technologies exist and schedules for identifying and developing treatment technologies where none are currently available. These plans would be reviewed and approved by EPA or the states, depending on whether the state is authorized to regulate mixed waste. In 2011, these reporting requirements were met by the *Calendar Year 2010 Hanford Site Mixed Waste Land Disposal Restrictions Summary Report* ([DOE/RL-2011-31](#)).

#### **2.1.4 National Environmental Policy Act of 1969**

*JW Cammann*

The *National Environmental Policy Act of 1969* (NEPA) requires that an environmental impact statement (EIS) be prepared for major federal agency actions that have the potential to significantly affect human health or the environment. A ROD documents decisions concerning a proposed action for which an EIS has been prepared. Once the final EIS is distributed, DOE waits a minimum of 30 days before issuing a ROD, which is published in the *Federal Register*. The ROD notifies the public of the decision made on the proposed action and the reasons for the decision. In addition to potential environmental impacts, the ROD may include consideration of other decision factors such as technical feasibility, DOE statutory mission and national objectives, and cost. The NEPA process does not dictate that an agency select the most environmentally beneficial alternative. The purpose of the NEPA process is to ensure that accurate environmental analyses are performed; that there is public involvement; and that public officials, like those at DOE, make decisions based on an understanding of the environmental consequences of proposed actions.

An environmental assessment is prepared when it is uncertain if a proposed action would require the preparation of an EIS. A *finding of no significant impact* may be issued to present the reasons why an action will not have a significant effect on human health or the environment and, therefore, will not require preparation of an EIS. Mitigated findings of no significant impact can result when a federal agency concludes its NEPA review with an environmental assessment that is based on a commitment to mitigate potential environmental impacts to keep them below a threshold of significance, so that a more detailed EIS is not required. However, federal agencies must ensure that appropriate levels of funding are available to mitigate potentially significant environmental impacts and monitor the effectiveness of the mitigation measures.

A mitigation action plan is prepared in accordance with NEPA regulations (10 CFR 1021.331) that describes the approach for implementing commitments made in an EIS and its associated ROD, or an environmental assessment and its mitigated finding of no significant impact, to mitigate potentially adverse environmental impacts associated with a proposed action.

A supplement analysis is prepared in accordance with NEPA regulations (10 CFR 1021.314(c)) when it is unclear whether a supplemental EIS or a new EIS is needed (40 CFR 1502.9(c)). A supplement analysis is

prepared to consider new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts if significant.

A notice of intent is a formal announcement of intent to prepare an EIS, which is published in the *Federal Register* in accordance with DOE NEPA regulations (10 CFR 1021.311). The notice of intent describes the proposed action and alternatives DOE is considering; provides information on issues and potential impacts that will be analyzed in the EIS; and invites comments, questions, and suggestions (both written and oral) on the scope of the EIS. These scoping comments aid DOE in determining the alternatives, issues, and environmental impacts to be analyzed in the EIS. The EPA notice of availability is the official public notification published in the *Federal Register* to announce the issuance and public availability of a draft or final EIS.

Certain proposed actions may be categorized into classes that have been analyzed and determined to either individually or cumulatively have no significant environmental impact (10 CFR 1021, Subpart D, Appendices A and B). Known as categorical exclusions, these actions are exempt from NEPA environmental assessment or EIS requirements if certain eligibility criteria found at 10 CFR 1021.410 are met (i.e., proposed action fits classes of actions, proposed action has no extraordinary circumstances, and proposed action is not connected to other actions with potentially significant impacts). Some categorical exclusions are applicable to general DOE actions and do not require written documentation for application. These categorical exclusions are administrative in nature and are listed in 10 CFR 1021, Subpart D, Appendix A. Other categorical exclusions are applicable to specific DOE actions and must be documented in writing when applied. These categorical exclusions are listed in 10 CFR 1021, Subpart D, Appendix B.

Action-specific categorical exclusions listed in 10 CFR 1021, Subpart D, Appendix B must be reviewed and approved by the DOE NEPA Compliance Officer prior to their citation in meeting NEPA requirements. Some action-specific categorical exclusions at the Hanford Site have been pre-approved by the DOE NEPA Compliance Officer as 'one time annual' categorical exclusions because they are routinely conducted actions that not only satisfy the criteria in 10 CFR 1021.410, but also meet conditions that are 'integral elements' (e.g., do not threaten a violation of statutory, regulatory, or permit requirements; do not require siting, construction, or expansion of waste treatment, storage, or disposal facilities; do not disturb hazardous substances, pollutants, contaminants, or CERCLA-excluded petroleum or natural gas products; and do not adversely affect natural, cultural, or ecological resources). The one-time annual categorical exclusions must be reapproved by the NEPA Compliance Officer each year and may be applied to proposed actions by individuals trained in NEPA determinations without further review and approval by the DOE NEPA Compliance Officer.

Hanford Site NEPA documents are prepared and approved in accordance with NEPA policies, regulations, and implementing procedures (i.e., 40 CFR 1500-1508; 10 CFR 1021). DOE activities conducted under CERCLA authority rely on the CERCLA process for review of proposed actions. Under the DOE's NEPA and CERCLA Policy, DOE incorporates NEPA values including analysis of cumulative, offsite, ecological, cultural, and socioeconomic impacts to the extent practicable in work planning documents in lieu of preparing separate NEPA documentation. The basis for the DOE's NEPA and CERCLA policies is a determination by the Department of Justice that there is a statutory conflict between NEPA and CERCLA, and that NEPA, as a matter of law, does not apply to CERCLA response actions.

DOE's approach to NEPA review for RCRA corrective actions is project-specific, allowing DOE to consider the circumstances associated with specific RCRA corrective actions and streamline the environmental review process accordingly. Based on DOE's experience to date, some RCRA corrective actions fall within the scope of a categorical exclusion (10 CFR 1021, Subpart D, Appendix B, categorical exclusion B6.1 for small-scale,

short-term cleanup actions under RCRA, the *Atomic Energy Act*, or other authorities) and are subject to the categorical exclusion process previously discussed.

To further transparency and openness in DOE's implementation of the NEPA process, a new policy was established in November 2009 with regard to the online posting of categorical exclusion determinations made by DOE NEPA Compliance Officers. Under the new policy, each program and field office is required to document and post online all categorical exclusion determinations involving classes of actions listed in 10 CFR 1021, Subpart D, Appendix B of DOE's NEPA implementing procedures that do not disclose classified, confidential, or other information that DOE would not disclose pursuant to the *Freedom of Information Act*. DOE O 451.1B, *National Environmental Policy Act Compliance Program*, has been revised to be consistent with this new policy. NEPA documentation for the Hanford Site is available at the following website: <http://www.hanford.gov/page.cfm/OfficialDocuments>.

The following subsections provide summary information regarding the status of NEPA documentation planned or underway at the Hanford Site (i.e., EISs, supplement analyses, environmental assessments, categorical exclusions, etc.).

#### **2.1.4.1 Hanford Site Environmental Impact Statements**

##### **2.1.4.1.1 *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (DOE/EIS-0391)***

A January 9, 2006, legal settlement required DOE to prepare the *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (DOE/EIS-0391)*. This EIS analyzes the following three key areas:

- Retrieval, treatment, and disposal of waste from 149 single-shell tanks and 28 double-shell tanks and closure of the single-shell tank system
- Final decontamination and decommissioning of FFTF
- Disposal of Hanford Site and other DOE site low-level waste and mixed low-level waste.

A notice of availability for the *Draft Tank Closure and Waste Management Environmental Impact Statement (DOE/EIS-0391)* was issued in the *Federal Register* on October 30, 2009 ([74 FR 56194](#)), initiating a 140-day public comment period. DOE extended the public comment period in March 2010 ([75 FR 13268](#)) for an additional 45 days for a total comment period of 185 days (longer than the required minimum of 45 days) from October 30, 2009 to May 3, 2010. Eight public hearings on the draft EIS were held between January 26 and March 8, 2010, in Washington, Oregon, and Idaho. Since the draft EIS was published, EPA Region 10, and Ecology became co-operating agencies for the EIS.

Efforts during CY2011 focused on addressing public comments and clarifying the draft EIS. This included preparing a supplement analysis ([DOE/EIS-0391D-SA-01](#)) to the draft EIS. When preparing to issue the final EIS, including responses to public comments, DOE identified updates or modifications to the technical data analyzed in the draft EIS and expanded specific discussion areas based on comments received. This information did not change the proposed actions analyzed in the draft EIS; however, DOE found in some cases it was unclear as to whether the updated, modified, or additional information that became available since the draft EIS was issued could warrant a supplemental draft EIS. Accordingly, DOE prepared a supplement analysis to determine if a supplemental or new draft EIS was required.



Based on the analyses in the supplement analysis, DOE concluded that the updated, modified, or additional information developed subsequent to the publication of the draft EIS does not constitute significant new circumstances or information relevant to environmental concerns and bearing on the proposed actions in the draft EIS or their impacts. Also, DOE determined that substantial changes were not made in the proposed actions that are relevant to environmental concerns. Therefore, in accordance with Council on Environmental Quality regulations (40 CFR 1502.9(c)) and DOE regulations (10 CFR 1021.314(c)), DOE determined that a supplemental or new draft EIS is not required. The supplement analysis ([DOE/EIS 0391D SA-01](#)) was issued in February 2012. The final EIS is planned for completion by April 2012 and the schedule for the ROD is to be determined.

#### **2.1.4.1.2 *Environmental Impact Statement for a Natural Gas Pipeline to the Waste Treatment Plant and 242-A Evaporator, Richland, Washington (DOE/EIS-0467)***

DOE determined in 2010 that an EIS was needed to evaluate a proposed action to construct a natural gas pipeline to the WTP and 242-A Evaporator located on the Central Plateau of the Hanford Site. Steam is used for many operations on the Central Plateau. The 242-A Evaporator currently uses diesel-fueled boilers and the WTP is designed to use diesel-fueled boilers when it becomes operational.

DOE proposes to extend an existing natural gas pipeline that runs parallel to State Highway 395 on the east side of the Columbia River. The extension would run under the Columbia River, crossing near the 300 Area of the Hanford Site. The pipeline would run north along Route 4 South to the Central Plateau. Two lift stations (compressor stations), measuring approximately 10,000 square feet (930 square meters) each, may be required to condition the natural gas. One lift station would be located near the 300 Area and the other along Route 4 South either on or near the Central Plateau.

Conversion from diesel fuel to natural gas boilers is expected to have several benefits including:

- Reduce lifecycle operating costs by over \$800 million
- Reduce lifecycle greenhouse gas emissions by approximately 1 million tons (907,000 metric tons)
- Eliminate approximately six diesel tanker trucks per day
- Increase operational reliability by having dual-fired boilers (natural gas and diesel).

Cascade Natural Gas has been retained by DOE to support preparation of the EIS and to begin the permitting process. Cascade Natural Gas would own, construct, operate, and maintain the pipeline using easements provided by DOE on property they own. An engineering feasibility study is underway to evaluate pipeline diameters, alternative pipeline routings, and contacting potentially affected landowners.

A notice of intent to prepare an EIS was published in the *Federal Register* on January 23, 2012 ([77 FR 3255](#)). A public scoping meeting for the EIS was held in Pasco, Washington, on February 9, 2012. The draft EIS is planned for the spring of 2013 with the final EIS planned in the fall of 2013. The ROD would be issued no less than 30 days after issuance of the final EIS.

#### **2.1.4.1.3 *Supplement Analysis to the Environmental Impact Statement for Management of Spent Nuclear Fuel from the K-Basins at the Hanford Site (DOE/EIS-0245)***

DOE published a notice of intent in the *Federal Register* ([60 FR 15905](#)) on March 28, 1995, to prepare an EIS on management of spent nuclear fuel from the K-Basins. The *Draft Environmental Impact Statement for Management of Spent Nuclear Fuel from the K-Basins at the Hanford Site* (DOE/EIS-0245) was issued in October 1995. The purpose of the draft EIS was to provide environmental information to assist DOE in the

selection of an alternative for the management and storage of spent nuclear fuel located in the K-Basins. Management and storage/disposal of sludge, debris, and water in the K-Basins also was included. Alternatives considered are as follows: 1) no action, 2) enhanced K-Basin storage, 3) new wet storage, 4) drying/conditioning with dry storage (the preferred alternative), 5) calcination with dry storage, 6) onsite processing, and 7) foreign processing.

The final EIS was issued in January 1996 and a notice of availability was published in the *Federal Register* on February 2, 1996 ([61 FR 3932](#)). The ROD was published in the *Federal Register* on March 15, 1996 ([61 FR 10736](#)). DOE decided to implement the preferred alternative, which consisted of removing the spent nuclear fuel from the basins; and vacuum drying, conditioning, and sealing the fuel in inert gas filled canisters for dry vault storage in a new facility to be built at the Hanford Site (i.e., Canister Storage Building in 200 East Area). K-Basins would continue to be operated during the period over which the preferred alternative is implemented. The preferred alternative also included transfer of the basin sludge to the double-shell tanks for management, disposal of non-basin debris in a low-level burial ground, disposition of the basin water, and deactivation of the basins pending decommissioning.

A supplement analysis was prepared and issued in August 1998 (DOE/EIS-0245/SA1). In the ensuing 2 years since the ROD, additional process design analyses were completed and characterization data was obtained that better described the chemical and physical properties of the fuel and sludge in the K-Basins. This additional information led to the conclusion that the hot conditioning step would not provide a benefit commensurate with the risk associated with heating the fuel to a high temperature so this step was deleted from the preferred alternative selected in the ROD. Based on the information presented in the supplement analysis, DOE determined that the proposed action did not constitute a substantial change in actions previously analyzed in the K-Basins EIS, and there were no significant circumstances or new information relevant to environmental concerns associated with the proposed action; therefore, no additional NEPA review was required.

A second supplement analysis was prepared and issued in August 2001 ([DOE/EIS-0245-FS/SA2](#)). One of the alternatives in the K-Basins EIS (but not selected in the ROD) involved consolidating the spent nuclear fuel in the K West Basin for long-term wet storage. One component of this alternative was to transfer containerized fuel from K East Basin to K West Basin. Since the ROD was issued, the K West Basin fuel removal system was constructed and operated, successfully transferring containerized fuel from K West Basin to the Cold Vacuum Drying Facility and Canister Storage Building. Ongoing evaluations aimed at reducing personnel exposure, cost, and schedule prompted DOE to reconsider spent nuclear fuel consolidation at K West Basin. Based on the information presented in the supplement analysis, DOE determined that the proposed action did not constitute a substantial change in actions previously analyzed in the K-Basins EIS, and there were no significant circumstances or new information relevant to environmental concerns associated with the proposed action; therefore, no additional NEPA review was required.

A third supplement analysis was prepared and issued in August 2011 ([DOE/EIS-0245F-SA-03](#)). This supplement analysis was prepared to support a determination by DOE regarding whether further NEPA review was needed as DOE continued to manage spent nuclear fuel, including knockout pot product material, in multi-canister overpacks at the Canister Storage Building. Based on the information presented in the supplement analysis, DOE determined that the proposed action did not constitute a substantial change in actions previously analyzed in the K-Basins EIS, and there were no significant circumstances or new information relevant to environmental concerns associated with the proposed action; therefore, no additional NEPA review was required.

### 2.1.4.2 Hanford Site Environmental Assessments

#### 2.1.4.2.1 Draft Environmental Assessment for Closure of the Solid Waste Landfill and the Nonradioactive Dangerous Waste Landfill ([DOE/EA-1707](#))

DOE proposes to close the Solid Waste Landfill (SWL) and the Nonradioactive Dangerous Waste Landfill (NRDWL) located southeast of the Central Plateau off Army Loop Road. The two adjoining non-operating landfills are centrally located in the 600 Area of the Hanford Site. The NRDWL, which covers approximately 10 acres (4.05 hectares), received containerized nonradioactive, dangerous waste chemicals and asbestos-containing waste material until it ceased operation in 1988. The SWL covers approximately 68 acres (27.5 hectares) and received asbestos-containing material, as well as non-dangerous and nonradioactive solid waste until 1996 when operations ceased. After operations ended, both landfills were covered with an interim cover made up of local native soils that ranged in thickness from 2 to 10 feet (.61 to 3.05 meters) and were revegetated with bunchgrasses.

The NRDWL, a RCRA facility, would be closed according to the requirements of WAC 173-303, *Dangerous Waste Regulations*. The SWL, a non-RCRA facility, would be closed according to the requirements of *Solid Waste Handling Standards* (WAC 173-350).

The proposed action is to close NRDWL and SWL by installing a final, permanent engineered surface barrier that would meet the state's regulations in WAC 173-303. Final grade of the cover would be completed to blend in with the existing surroundings to the extent practical. The site would be re-vegetated with native plants consistent with the *Hanford Biological Resource Management Plan* ([DOE/RL-96-32](#)). DOE would monitor the performance of both landfills long term. The close proximity of NRDWL to SWL would allow both facilities be closed simultaneously, taking advantage of cost and work efficiencies.

DOE issued the draft environmental assessment on May 13, 2010, for a 30-day public comment period. The comment period was extended an additional 30 days to July 15, 2010. Based on public comments received, DOE decided to revise and reissue the draft environmental assessment. Ecology became a cooperating agency on the reissue draft environmental assessment.

In February 2011, [PNNL-20162](#), *Cultural Resources Review for Closure of the Nonradioactive Dangerous Waste Landfill and Solid Waste Landfill in the 600 Area* (HCRC #2010-600-018R) was issued. The National Register of Historic Places evaluation of Army Loop Road determined that the road is not eligible for listing on the National Register of Historic Places; therefore, proposed actions would result in no effect to historic properties. National Register-eligible archaeological sites (i.e., anti-aircraft artillery sites) would not be adversely affected by proposed actions because they would be avoided. Borrow Area C, the proposed borrow pit for barrier construction materials, is located within the National Register of Historic Places-eligible traditional cultural property of *Laliik*.

The revised draft environmental assessment was completed in August 2011 after consideration of public comments. The six recurring themes identified in the public comments included waste inventory, groundwater contamination, closure alternatives, barrier effectiveness, barrier design, and the use of Borrow Area C. A 45-day public comment period ran from August 29, 2011 through October 13, 2011. A final environmental assessment determination (i.e., finding of no significant impact or need to prepare an EIS) is expected during the spring or summer of 2012.

During Tribal consultations, the Native American Tribes expressed opposition to the use of Borrow Area C, due to concerns regarding adverse impacts to the traditional cultural property. The Native American Tribes

requested that DOE consider other borrow sources. In recognition of the Native American Tribe concerns; DOE proposes to analyze potential impacts of extracting mineral resources from Borrow Area C and other borrow sources on the Hanford Site in a separate NEPA document (refer to borrow pit environmental assessment below).

**2.1.4.2.2 *Draft Environmental Assessment for Integrated Vegetation Management on the Hanford Site, Richland, Washington (DOE/EA-1728D)***

For decades, vegetation management on the Hanford Site has been implemented using NEPA categorical exclusions in an individual, localized, and project-specific manner; however, DOE now believes it is appropriate to evaluate the overall scope of vegetation management activities conducted on the Hanford Site assessing both individual and cumulative impacts. DOE is evaluating an integrated vegetation management approach using physical, chemical, biological, prescribed burning, and revegetation methods for the purposes of eradicating noxious weeds and invasive plants; minimizing biological uptake and transport of contaminants; promoting worker health and safety; eliminating wildfire hazards; preserving and restoring desirable plant species and wildlife habitat; and protecting natural, cultural, and ecological resources. The scope of the environmental assessment includes all land on the Hanford Site managed by DOE and excludes land managed by others under DOE permit (e.g., Hanford Reach National Monument managed by the U.S. Fish and Wildlife Service [USFWS]).

The draft environmental assessment was issued for a 30-day public review on August 18, 2011 through September 19, 2011. The remainder of CY2011 focused on considering comments received during the public review period and clarifying the environmental assessment. The final environmental assessment and DOE determination (i.e., finding of no significant impact or need to prepare and EIS) is expected in March 2012.

**2.1.4.2.3 *Draft Environmental Assessment on Disposal of Decommissioned, Defueled Naval Reactor Plants from the USS Enterprise (CNV 65)***

The U.S. Department of the Navy prepared and issued a Draft Environmental Assessment on the Disposal of Decommissioned, Defueled Naval Reactor Plants from the USS Enterprise in September 2011. A public comment period for the draft environmental assessment ran from October 30, 2011 through November 30, 2011.

The world's first nuclear-powered naval aircraft carrier, USS Enterprise, is scheduled for decommissioning in 2013, following 51 consecutive years of service. Because the preferred alternative is to dispose of the USS Enterprise reactor plants at the Hanford Site, DOE is a cooperating agency for the environmental assessment.

The preferred alternative is to dispose of the USS Enterprise reactor plants via the existing program at Puget Sound Naval Shipyard and Intermediate Maintenance Facility in Bremerton, Washington. This includes removing defueled reactor compartments from inactivated nuclear powered ships, transporting these reactor compartments to the Hanford Site at Trench 94, and recycling the remainder of the ships. The eight defueled reactor compartments from the USS Enterprise would be similar to those evaluated in the *Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled Cruiser, Ohio Class, and Los Angeles Class Naval Reactor Plants* ([DOE/EIS-0259](#)) April 1996 ([EIS-0259-FEIS-01-1996](#)). Placing the eight defueled reactor compartments from the USS Enterprise at Trench 94 would not exceed the total number of reactor compartments considered at Trench 94 under the final EIS.

**2.1.4.2.4 Draft Environmental Assessment for Hanford Land Transfer**

On January 7, 2011, Congress passed the *Ike Skelton National Defense Authorization Act for Fiscal Year 2011* ([Public Law 111-383](#)). Section 3124 specifically states the Secretary of Energy may establish a program to permit the establishment of energy parks on former defense nuclear facilities ([50 U.S.C. 2814](#)). DOE established a task force on February 17, 2011, on the Asset Revitalization Initiative. The Asset Revitalization Initiative is a DOE complex-wide effort to advance the beneficial reuse of its unique and diverse mix of assets; including land, facilities, infrastructure, equipment, technologies, natural resources, and a highly skilled workforce. In addition to other things, one of the purposes of the Asset Revitalization Initiative is to facilitate discussions among DOE, local communities, nonprofit organizations, tribal communities, private sector entities, and other stakeholders to identify reuse approaches as environmental cleanup efforts reach completion.

The Tri-City Development Council (TRIDEC) along with the city of Richland, Port of Benton, and Benton County formally requested on May 31, 2011, a transfer of DOE land to the community. The site requested is approximately 1,341 acres (543 hectares) (i.e., Tract 1) located along the southern boundary of the Hanford Site directly west of Stevens Drive and north of Horn Rapids Road. TRIDEC and its partners propose dividing Tract 1 into a 900 acre (364.5 hectares) parcel and three smaller 100 to 200 acre (40.5 to 81 hectares) parcels. Tract 1 is the first of three land transfers TRIDEC plans to request over the next 5 years.

TRIDEC is identified as the recognized DOE Community Reuse Organization pursuant to 10 CFR 770, *Transfer of Real Property at Defense Nuclear Facilities for Economic Development*. The land transfer proposal recommends use of TRIDEC's wholly owned subsidiary, the Tri-Cities Asset Reinvestment Company (TARC), as the transfer entity. The TARC was set up to receive personal and real property from DOE.

The *Final Hanford Comprehensive Land Use Plan Environmental Impact Statement* (CLUP-EIS, [DOE/EIS-0222-F](#)), which establishes land use designations, calls for most land in the 586-square-miles (1,524-square-kilometers) comprising the Hanford Site to be used for preservation or conservation/mining as environmental cleanup is completed. However, approximately 10 percent of the land, including the parcel requested by TRIDEC, is designated for industrial use. As such, the land is identified for economic growth and development using existing infrastructure including transportation corridors, utilities, and buildings. DOE plans to prepare an environmental assessment in CY2012 to analyze the proposed land transfer action.

**2.1.4.2.5 Draft Environmental Assessment for Hanford Borrow Pits**

The *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (CLUP-EIS, [DOE/EIS-0222-F](#)), which became final after the ROD was signed by RL in November 1999 ([64 FR 61615](#)), required a mineral resources management plan be prepared as part of implementing the CLUP-EIS. The *Draft Industrial Mineral Resources Management Plan* ([DOE/RL-2000-61](#)) was transmitted to RL in June 2001. This plan provided a framework for the operation of existing borrow pits, recommended closure of others that are not being used or may be incompatible with the current Hanford Site mission, provided direction for borrow pits and quarries that might be developed in the near future, and supported the NEPA requirements with respect to borrow pits and quarries.

In October 2001, the *Environmental Assessment for Use of Existing Borrow Areas on the Hanford Site* ([DOE/EA-1403](#)) was issued. DOE proposed to obtain borrow materials from existing active borrow pits and quarries on the Hanford Site. The total volume of materials to be recovered over a 10-year period was estimated to be approximately 10,000,000 cubic yards (7,600,000 cubic meters). For analysis, it was assumed



that of the total disturbed surface area for active borrow sites (i.e., 1.2 square miles [3 square kilometers]); expansion could result in an additional surface area disturbance of 10 percent (approximately 0.12 square miles [0.3 square kilometer]).

In March 2003, the *Environmental Assessment for Reactivation and Use of Three Former Borrow Sites in the 100-F, 100-H, and 100-N Areas* ([DOE/EA-1454](#)) was issued. The DOE proposed to obtain borrow materials from formerly used borrow pits in the 100-F, 100-H, and 100-N Areas on the Hanford Site that were not included in the *Draft Industrial Mineral Resources Management Plan* ([DOE-RL-2000-61](#)) or in the *Environmental Assessment for Use of Existing Borrow Areas on the Hanford Site* ([DOE/EA-1403](#)). Under the proposed action in [DOE/EA-1454](#) and associated Finding of No Significant Impact (FONSI), the DOE reopened and reactivated the three former borrow sites in the 100-F, 100-H, and 100-N Areas.

An addendum to [DOE/EA-1454](#) was proposed during CY2011 to clarify ambiguity regarding application of the 10 percent expansion allowance and impose a limitation on the depth to which the borrow pits could be excavated. The existing environmental assessment lacked sufficient data to adequately determine the surface area of the borrow pits at the time the environmental assessment was prepared; therefore, it was difficult to ascertain just how much each pit could be expanded. Furthermore, there was a need to define the high groundwater level and add some distance above that level to ensure groundwater would not seep into the borrow pits. The addendum was proposed to develop some level of analysis to further explain or justify the broader interpretation of expansion. The addendum was placed on hold pending the resolution of potentially broader borrow pit considerations at the Hanford Site.

For the 100-F, 100-H, and 100-N Areas' borrow pits, it was decided that because the borrow pits were to be reopened and reactivated pursuant to [DOE/EA-1454](#) and associated FONSI, a survey would be conducted to establish the existing boundaries as a basis for the 10 percent expansion allowed. Best management practices and other protective measures (i.e., review of groundwater monitoring and level data from nearby wells) would be applied to ensure that excavation activities would not reach the groundwater.

DOE is considering a reassessment of the use of all borrow sources on the Hanford Site in light of concerns the Native American Tribes have expressed over the use of Borrow Area C and the anticipated need for mineral resources in support of site remediation and closure. Borrow Area C is a primary source of Warden Silt Loam that is important to proper design, construction, and functioning of evapotranspiration barriers proposed for use at the Hanford Site; however, Borrow Area C is located on a traditional cultural property of significance to Native American Tribes. DOE is considering preparing a new environmental assessment to analyze mineral resource needs and sources on the Hanford Site.

#### **2.1.4.3 Hanford Site Categorical Exclusions**

Categorical exclusions encompass classes of actions that do not individually or cumulatively have a significant effect on human health or the environment, and for which neither an environmental assessment nor an EIS is required. To find that a proposed action is categorically excluded, the DOE NEPA Compliance Officer must determine the following: 1) The proposed action fits within the class of actions listed in 10 CFR 1021, Subpart D, Appendix B; 2) there are no extraordinary circumstances related to the proposal that may affect the significance of the environmental effects of the proposal; 3) the proposal is not connected to other actions with potentially significant impacts, is not related to actions with cumulatively significant impacts, and is not precluded by 40 CFR 1506.1 or 10 CFR 1021.211; and 4) the proposed action meets the conditions that are integral elements of the classes of actions in 10 CFR 1021, Subpart D, Appendix B. To meet the conditions that are integral elements, a proposed action must be one that 1) does not threaten a violation of applicable



statutory, regulatory, or permit requirements; 2) does not require siting and construction or major expansion of waste storage, disposal, recovery, or treatment facilities; 3) does not disturb hazardous substances, pollutants, contaminants, or CERCLA-excluded petroleum and natural gas products that preexist such that an uncontrolled or unpermitted release would occur; and 4) does not adversely affect environmentally sensitive resources.

Copies of categorical exclusions approved in 2011 are posted on the DOE NEPA web page found at: <http://www.hanford.gov/page.cfm/CategoricalExclusions>.

### 2.1.5 Toxic Substances Control Act

*JK Perry*

*Toxic Substances Control Act* requirements that apply to the Hanford Site primarily involve regulation of polychlorinated biphenyls (PCBs). Federal regulations for PCB use, storage, and disposal are provided in 40 CFR 761, *Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions*. Background information regarding Hanford Site PCB management activities are as follows:

- PCB wastes on the Hanford Site are stored and/or disposed in accordance with 40 CFR 761
- Some radioactive PCB waste remains in extended storage onsite pending the development of adequate treatment and disposal technologies and capacities
- Electrical equipment that might contain PCBs is maintained and serviced in accordance with 40 CFR 761
- The *Framework Agreement for Management of Polychlorinated Biphenyls (PBCs) in Hanford Tank Waste* ([EPA et al. 2000](#)), signed on August 31, 2000, resulted in EPA, Ecology, and DOE and its Hanford Site contractors working together to resolve the regulatory issues associated with managing PCB waste at 1) the WTP (currently under construction); 2) the waste tank farms; and 3) affected waste management units adjacent to the waste tank farms.

RL submitted the *2010 Hanford Site Polychlorinated Biphenyl Annual Document Log* ([DOE/RL-2011-70](#), Rev. 0) and the *2010 Hanford Site Polychlorinated Biphenyl Annual Report* ([DOE/RL-2011-69](#), Rev. 0) to EPA in 2011 as required by 40 CFR 761.180. These documents describe the PCB waste management and disposal activities occurring on the Hanford Site.

Risk-based disposal approvals were implemented on the Hanford Site in 2011, including but not limited to continued management of K Basins sludge and single-shell tank waste retrieval activities in accordance with EPA Phase I and II risk-based disposal approvals for the use of double-shell tank PCB remediation waste in accordance with 40 CFR 761.61(c). **Note:** Phase I identifies general conditions that apply to the overall strategy and retrieval process and Phase II identifies tank-specific conditions.

### 2.1.6 Federal Insecticide, Fungicide, and Rodenticide Act

*JM Rodriguez*

The *Federal Insecticide, Fungicide, and Rodenticide Act* (FIFRA) is administered by EPA. The standards administered by the Washington State Department of Agriculture to regulate implementation of the Act in the state include the *Washington Pesticide Control Act* (RCW 15.58), the *Washington Pesticide Application Act* (RCW 17.21), and rules relating to general pesticide use codified in WAC 16-228, *General Pesticide Rules*. Commercial pesticides are applied on the Hanford Site by commercial pesticide operators that are listed on one of two commercial pesticide applicator licenses, and by a licensed private commercial applicator.

## 2.2 Radiation Protection Statutes

*JW DeMers*

The Hanford Site is subject to radiation protection statutes and regulations designed to protect the health and safety of the public, workforce, and the environment.

### 2.2.1 Atomic Energy Act of 1954

*JW DeMers*

The *Atomic Energy Act of 1954* was promulgated to ensure the proper management of radioactive materials. The Act and its amendments include provisions to delegate the roles and responsibilities for the control of radioactive materials and nuclear energy primarily to DOE, the U.S. Nuclear Regulatory Commission, and EPA. Through the Act, DOE regulates the control of radioactive materials under its authority, including the treatment, storage, and disposal of low-level radioactive waste from its operations. Sections of the Act authorize DOE to establish radiation protection standards for itself and its contractors. Accordingly, DOE promulgated a series of regulations (e.g., 10 CFR 820, 10 CFR 830, and 10 CFR 835) and directives (e.g., DOE O 435.1, Chg 1 [Section 5.2.3] and DOE O 5400.5, Chg 2 [Section 5.2.2]) to protect public health and the environment from potential risks associated with radioactive materials. Hanford Site operations are subject to the requirements in these regulations and directives. In 2011, the following DOE regulations or directives that potentially impact the management and control of radioactive materials were issued or underwent significant revision:

- DOE G 441.1-1C, Chg 1, Radiation Protection Programs Guide for Use with 10 CFR 835
- DOE O 458.1, *Radiation Protection of the Public and the Environment*.

DOE Directives may be accessed via the Departmental Directives Program website at:

<https://www.directives.doe.gov/>.

DOE Standards may be accessed via the DOE Office of Health, Safety, and Security website at:

<http://www.hss.doe.gov/nuclearsafety/ns/techstds/>.

### 2.2.2 DOE O 5400.5, Radiation Protection of the Public and the Environment

*JW DeMers*

*Radiation Protection of the Public and the Environment* (DOE O 5400.5) was initially issued in February 1990, and underwent minor revisions in June 1990 (Chg 1) and January 1993 (Chg 2). The purpose of this order is to establish standards and requirements for conduct of DOE and DOE contractor operations with respect to radiological protection of the public and the environment. This order was developed and issued consistent with DOE's policy to implement legally applicable radiation protection requirements; to consider and adopt, as appropriate, recommendations by authoritative organizations (e.g., the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection); and to adopt and implement standards generally consistent with those of the U.S. Nuclear Regulatory Commission for DOE facilities and activities not subject to U.S. Nuclear Regulatory Commission authority. Specifically, relative to guidance, standards, and regulatory requirements existing at the time of its issuance, this order adopted applicable standards issued by the International Commission on Radiological Protection and the National Council on Radiation Protection and Measurements, incorporated regulatory requirements applicable to DOE operations, and consolidated and upgraded DOE guidance for contaminated property.

DOE O 5400.5, Chg 2, applies to all DOE elements and contractors performing work for DOE, as provided by law and/or contract, and as implemented by the appropriate contracting officer. This order was developed and issued under the authority of the *Atomic Energy Act of 1954*, as amended, which authorizes DOE to provide for the radiological health and safety of the public for operations conducted under DOE direction.

Relative to the radiological health and safety of the public, the objectives of DOE O 5400.5, Chg 2, are to ensure that DOE operations achieve the following:

- Radiation exposures to the public are maintained within established limits
- Radioactive contamination is controlled through the management of real and personal property
- Potential exposures to the public are as far below established limits as is reasonably achievable
- DOE facilities have the capabilities, consistent with the types of operations conducted, to monitor routine and non-routine releases and to assess doses to the public.

In addition to providing radiological protection to the public, the objective of DOE O 5400.5 is to provide radiological protection of the environment to the extent practical.

DOE O 5400.5, Chg 2 also provides derived concentration guide values as reference values for conducting radiological environmental protection programs at operational DOE facilities and sites. Table 2.1 provides the radiation standards (dose limits) for protection of the public from all routine DOE Concentrations. These DOE-derived concentration guide values are based on a committed dose standard of 100 millirem (1 millisievert) due to ingestion, inhalation, or direct exposure during a given year, and are provided for three exposure pathways; ingestion of water, inhalation of air, and immersion in a gaseous cloud. This order also provides radiological protection requirements and guidelines for cleanup of residual radioactive material, management of the resulting wastes and residues, and clearance of property. These requirements and guidelines are applicable at the time the property is released.

In CY2011, DOE issued a comprehensive revision and update to DOE O 5400.5, Chg 2; this effort resulted in a significant changes to this order (re-numbered DOE O 458.1). Following contractual action and contractor implementation, DOE O 458.1 is scheduled for full implementation in CY2012.

### **2.2.3 DOE O 435.1, Radioactive Waste Management**

*MS Collins*

The purpose of DOE O 435.1, *Radioactive Waste Management*, is to establish requirements to ensure DOE radioactive waste is managed in a manner that is protective of worker and public health and safety, and the environment. The order takes a “cradle-to-grave” approach to managing waste and includes requirements for waste generation, storage, treatment, disposal, and post-closure monitoring of facilities.

Radioactive waste shall be managed such that the requirements of other DOE orders, standards, and regulations are met, including the following:

- [10 CFR 835](#), *Occupational Radiation Protection*
- [DOE O 440.1A](#), *Worker Protection Management for DOE Federal and Contractor Employees*
- [DOE O 450.1A](#), *Environmental Protection Program*
- [DOE O 5400.5](#), Chg. 2, *Radiation Protection of the Public and the Environment*.

DOE O 435.1 establishes requirements for the management of high-level waste, transuranic waste, and low-level waste. It also covers mixed waste (i.e., high-level waste, transuranic waste, and low-level waste containing chemically hazardous constituents). DOE O 435.1, Chg 1, approved in 2001, includes minor revisions to the original order.

**Table 2.1 Radiation Standards (Dose Limits<sup>[a]</sup>) for Protection of the Public from all Routine DOE Concentrations**

<b>All Pathways (DOE O 5400.5, Chg 2)</b>		
Effective dose equivalent for any member of the public from all routine DOE operations <sup>(b)</sup> shall not exceed the values below.		
	<b>Effective Dose Equivalent<sup>(c)</sup></b>	
	<b>mrem/yr</b>	<b>mSv/yr</b>
Routine public dose	100	1
Potential authorized temporary public dose(d)	500	5
<b>Dose to Native Aquatic Animal Organisms from Liquid Discharges (DOE O 5400.5, Chg 2)</b>		
Radioactive material in liquid waste discharged to natural waterways shall not cause an absorbed dose <sup>(e)</sup> to native aquatic animal organisms that exceed 1 rad (10 mGy) per day.		
<b>Drinking Water Pathway Only (40 CFR Parts 9, 141, and 142 (65 FR 76707); WAC 246-290; and DOE O 5400.5, Chg 2)</b>		
Radionuclide concentrations in DOE-operated public drinking water supplies shall not cause persons consuming the water to receive an effective dose equivalent greater than 4 mrem (0.04 mSv) per year. DOE operations shall not cause private or public drinking water systems downstream of the facility discharge to exceed the radiological drinking water limits in <a href="#">40 CFR</a> Parts 9, 141, and 142.		
<b>Air Pathways Only (40 CFR 61)</b>		
	<b>Effective Dose Equivalent<sup>(c)</sup></b>	
	<b>mrem/yr</b>	<b>mSv/yr</b>
Public dose limit at location of maximum annual air concentration as a consequence of routine DOE operations <sup>(b)</sup>	10	0.1
<p>(a) Radiation doses received from natural background, residual weapons testing and nuclear accident fallout, medical exposure, and consumer products are excluded from the implementation of these dose limits.</p> <p>(b) Routine DOE operations imply normal, planned activities and do not include actual or potential accidental or unplanned releases.</p> <p>(c) Effective dose equivalent is expressed in rem (or millirem) and sievert (or millisievert).</p> <p>(d) Authorized temporary annual dose limits may be greater than 100 mrem (1 mSv) per year (but cannot exceed 500 mrem [5 mSv]) per year if unusual circumstances exist that make avoidance of doses greater than 100 mrem (1 mSv) per year to the public impracticable. The DOE Richland Operations Office is required to request and receive specific authorization from DOE HQ for an increase from the routine public dose limit to a temporary annual dose limit.</p> <p>(e) Absorbed dose is expressed in rad (or millirad) with the corresponding value in gray (or milligray) in parentheses.</p>		

## 2.3 Air Quality

### TG Beam

This section provides information on federal, state, and local statutes applicable to the Hanford Site air quality program.

### 2.3.1 Air Quality Regulatory Authority

The federal *Clean Air Act* was enacted to protect and enhance air quality and is the legal basis for federal, state, and local air quality regulations. The law, originally passed in 1967, has been revised extensively on numerous occasions. The *Clean Air Act Amendments of 1990* is the most recent revision and is the framework for a significant portion of current federal air quality regulations. The *Washington Clean Air Act*, which

parallels and supplements federal law, has been revised periodically to keep pace with changes at the federal level. Table 2.2 provides the selected DOE-derived concentration guides.

**Table 2.2 Selected DOE-Derived Concentration Guides<sup>(a,b,c)</sup>**

Radionuclide	Consumed Water		Inhaled Air	
	pCi/L	Bq/L	pCi/m <sup>3</sup>	Bq/m <sup>3</sup>
Tritium	2,000,000	74,000	100,000	3,700
Carbon-14	70,000	2,590	500,000	18,500
Chromium-51	1,000,000	37,000	60,000	2,220
Cobalt-60	5,000	185	80	2.96
Strontium-90	1,000	37	9	0.333
Technetium-99	100,000	3,700	2,000	74
Ruthenium-103	50,000	1,850	2,000	74
Ruthenium-106	6,000	222	30	1.11
Iodine-129	500	18.5	70	2.59
Iodine-131	3,000	111	400	14.8
Cesium-137	3,000	111	400	14.8
Uranium-234	500	18.5	0.09	0.00333
Uranium-235	600	22.2	0.1	0.0037
Uranium-238	600	22.2	0.1	0.0037
Plutonium-238	40	1.48	0.03	0.00111
Plutonium-239	30	1.11	0.02	0.00074
Plutonium-240	30	1.11	0.02	0.00074
Americium-241	30	1.11	0.02	0.00074

- (a) Concentration of a specific radionuclide in water or air that could be continuously consumed or inhaled at average annual rates and not exceed an effective dose equivalent of 100 mrem (1 mSv) per year.
- (b) Values in this table represent the lowest, most-conservative, derived concentration guides considered potentially applicable to Hanford Site operations and may be adjusted upward (larger) if accurate solubility information is available.
- (c) From DOE O 5400.5, Chg. 2.

EPA provides high-level programmatic oversight of the air quality program on the Hanford Site but has delegated authority for implementing applicable *Clean Air Act* regulations to designated state and local regulatory agencies.

The Washington State Department of Health regulates radioactive air emissions on the Hanford Site by enforcing applicable federal requirements in 40 CFR 61, Subparts A and H, as well as the state requirements in WAC 173-480 and WAC 246-247. The federal regulations contained in 40 CFR 61, Subpart H, which is part of the Federal *National Emission Standards for Hazardous Air Pollutants* (NESHAP), are collectively referred to at the Hanford Site as "Rad NESHAP" because they provide regulations for radioactive air emissions.

Ecology regulates criteria and toxic air pollutant emissions at the Hanford Site by enforcing applicable federal requirements in 40 CFR 52, 40 CFR 60, 40 CFR 61, 40 CFR 63, 40 CFR 68, and 40 CFR 82 as well as the state requirements in WAC 173-400, WAC 173-460, WAC 173-480, and WAC 173-491. Criteria and toxic air pollutant emissions are often referred to as 'nonradioactive' air emissions at the Hanford Site. Criteria pollutants are particulate matter, nitrogen oxides, sulfur oxides, carbon monoxide, lead, and volatile organic compounds. Toxic pollutants are other chemical contaminants as regulated by Washington State.

The Benton Clean Air Agency regulates demolition and asbestos renovation activities at the Hanford Site in accordance with federal requirements in 40 CFR 61, Subpart M. The Benton Clean Air Agency also regulates outdoor burning activities at the Hanford Site in accordance with state requirements in WAC 173-425.

### 2.3.2 Air Permits

Hanford Site contractors evaluate each proposed new or modified emission unit using the new source review requirements of radioactive air emissions (WAC 246-247), and criteria and toxic air pollutants (WAC 173-400-110, WAC 173-460-040) to determine whether a notice of construction application must be submitted to the Washington State Department of Health and/or Ecology (as applicable) for approval before construction or operation of the proposed source.

Hanford Site radioactive air emission sources are operated in accordance with the *Radioactive Air Emissions License for the Department of Energy Richland Operations Office Hanford Site, License Number FF-01* ([DOH 2012](#)) issued by the Washington State Department of Health in February 2012. The FF-01 license is a compilation of all applicable radioactive air emission requirements and is renewed every 5 years. For each emission unit, the FF-01 license includes either 1) an approval to modify/construct, or 2) an operating license. Overall, Hanford Site radioactive air emissions are controlled to sufficiently low levels to ensure the resultant exposure to any offsite individual remains well below the 10 millirem (100 microsievert) per year standard specified in 40 CFR 61.92. Hanford Site radioactive air emissions data are published annually in the radionuclide air emissions report for the Hanford Site (DOE/RL-2012-19).

As a major source of air pollutants, the Hanford Site is subject to the air operating permit requirements in 40 CFR 70 and WAC 173-401. In coordination with the Washington State Department of Health and the Benton Clean Air Agency, Ecology issued Renewal 1 of the Air Operating Permit for a period of 5 years, effective January 1, 2007. The [Air Operating Permit](#) is a compilation of applicable *Clean Air Act* requirements for both radioactive and criteria/toxic air pollutant emissions, including the radioactive air emissions license FF-01 ([DOH 2012](#)) issued by the Washington State Department of Health and notice of construction approval orders issued by Ecology. The Air Operating Permit requires the submittal of semiannual reports to the regulatory agencies documenting the status of required monitoring and permit deviations. In addition, an annual report documenting the compliance status of Hanford Site emission sources against applicable *Clean Air Act* requirements, and an annual report that documents total emissions of criteria and toxic pollutants is also required. The Air Operating Permit was not revised in 2011 to incorporate new Washington State Department of Health and Ecology air emission licenses, approval orders, and updated regulatory requirements. However, because Renewal 1 of the Air Operating Permit was scheduled to expire on December 31, 2011, the Hanford Site submitted a renewal application to ensure the permit would continue in effect until Ecology issues Renewal 2 of the Air Operating Permit scheduled for the fall of 2012.

### 2.3.3 Inspections

The Washington State Department of Health, Ecology, and the Benton Clean Air Agency conduct regular inspections of Hanford Site emission sources to verify compliance with applicable *Clean Air Act* requirements. Hanford Site contractors and DOE actively work to resolve any potential compliance issues identified during these inspections. During 2011, the regulatory agencies conducted over 25 *Clean Air Act* inspections at the Hanford Site; those inspections did not result in any violations being issued by regulatory agencies.



## 2.4 Water Quality

*CJ Clement*

This section provides information on federal, state, and local requirements, including permits, related to protection of water quality.

### 2.4.1 Federal Permit – Discharges to Columbia River

The *Clean Water Act of 1977*, as amended, applies to discharges to surface waters in the United States. At the Hanford Site, regulations are applied through the *EPA Administered Permit Programs: The National Pollutant Discharge Elimination System* (40 CFR 122) permit that governs effluent discharges to the Columbia River. The National Pollutant Discharge Elimination System (NPDES) Permit ([WA-002591-7](#)), is issued to the CHPRC by the EPA. WA-002591-7 governs the effluent discharges from the 100 Area facilities (two outfalls in the 100-K Area) to the Columbia River.

### 2.4.2 State Waste Discharge Permits – Discharges to the Soil Column/Groundwater

Ecology has a State Wastewater Discharge Permit Program that regulates discharges to waters of the state, including groundwater. Five individual Ecology state waste discharge permits were in effect during 2011 ([ST-4500](#), [ST-4501](#), [ST-4502](#), [ST-4507](#), and [ST-4511](#)). DOE is the holder of all the state waste discharge permits. Ecology cancelled ST-4501 on September 1, 2011, and provided temporary permit coverage for State Waste Discharge Permit ST-4511. The discharges associated ST-4501 are covered under the ST-4511 Temporary Permit.

Two general Ecology permits were in effect during 2011, [WAG-50-5180](#) and [WAG-50-5181](#). These are Washington State Sand and Gravel General Permits that were issued to BNI.

Most onsite sewage systems (e.g., septic systems operate under permits issued by the Washington State Department of Health. The Washington State Department of Health issues annual permits to DOE for the operation of Hanford Site onsite sewage systems, which include some holding-tank sewage systems.

### 2.4.3 Local Discharge Permit – Discharges to the City of Richland Sewer

The city of Richland regulates industrial wastewater discharges to its sewer collection system in accordance with city of Richland Code, Richland Pretreatment Act – Chapter 17.30. DOE is the holder of Permit No. CR-IU010, which allow discharges from the 300 Area facilities.

### 2.4.4 Safe Drinking Water Act of 1974

*LM Kelly*

The *Safe Drinking Water Act of 1974* established a cooperative program among local, state, and federal agencies to institute drinking water regulations applicable to all public water systems in the United States. States were granted primary responsibility—known as primacy—for administering and enforcing the *Safe Drinking Water Act of 1974*. To obtain primacy, states were required to meet certain criteria, including adoption of regulations equal to or more stringent than EPA regulations.

Washington State was awarded primacy in 1978. The State Board of Health and the Washington State Department of Health became partners in developing and enforcing state drinking water regulations. Hanford Site water systems were designated as public water systems in 1986 and became formally registered as public systems under the jurisdiction of the Washington State Department of Health in 1987.

The *Safe Drinking Water Act of 1974* was amended in 1986 and 1996 (*Safe Drinking Water Act Amendments*). While the 1986 amendments included provisions that emphasized treatment to ensure safe drinking water, the 1996 amendments focused on source water protection, funding for water system improvements, operator training, providing public information, and strengthening EPA's scientific work, including the use of risk and cost benefit analysis in establishing drinking water standards. Between 1975 and 2006, these amendments have resulted in the development of 18 new drinking water regulations. Post-1996 regulations have included more complex compliance determinations and more advanced treatment technologies. Based on site-specific conditions, many public water systems are either employing or investigating the use of new treatment technologies to comply with the increasingly complex requirements.

The Microbial and Disinfection Byproduct Rules that include nine drinking water regulations, address acute threats from microbial contamination and chronic threats from disinfectant residuals and disinfection byproducts. These rules limit disinfectant residuals and disinfection byproducts in the distribution systems while improving particle removal in the drinking water treatment plants. In 2011, affected Hanford Site water systems demonstrated compliance with the filtration and disinfection treatment technique requirements and limits for disinfectant residuals and disinfection byproducts.

The Washington State Department of Health conducted sanitary surveys on December 6, 2011, for the 300 Area and 400 Area Group A Hanford Site public water systems. A Group A water system in Washington State is a public water system with 15 or more connections, or serves an average of 25 people per day for 60 or more days within a calendar year (WAC 246-290-020). A sanitary survey evaluates the ability of a water system to reliably produce and distribute safe drinking water. No major issues or deficiencies were noted in the final sanitary survey reports.

To protect the health of workers using public water supplies on the Hanford Site, water systems were monitored during 2011 for microbiological, chemical, physical, and radiological constituents. There were no microbiological detections during the 2011 monitoring cycle, and all chemical concentrations in drinking water were well below the maximum contaminant levels established by EPA. Table 2.3, provides selected drinking water standards; and system-specific information and analytical results for 2011 radiological monitoring are summarized in [Section 7.1.3](#). Table 2.4 provides the selected surface freshwater quality criteria for toxic pollutants and Table 2.5 provides the Washington State water quality criteria for the Hanford Reach of the Columbia River.

#### **2.4.5 Permit Violations**

No permit violations on the Hanford Site were reported in 2011.

**Table 2.3. Selected Drinking Water Standards**

Constituent	Drinking Water Standard <sup>(a)</sup>		Agency <sup>(b)</sup>
Antimony	6 µg/L	0.006 ppm	EPA, DOH
Arsenic	10 µg/L	0.01 ppm	EPA, DOH
Barium	2,000 µg/L	2 ppm	EPA, DOH
Cadmium	5 µg/L	0.005 ppm	EPA
Carbon tetrachloride	5 µg/L	0.005 ppm	EPA, DOH
Chloroform (THM) <sup>(c)</sup>	80 µg/L	0.08 ppm	EPA
Chromium	100 µg/L	0.1 ppm	EPA, DOH
cis-1,2-Dichloroethene	70 µg/L	0.07 ppm	EPA, DOH
Copper	1,300 µg/L	1.3 ppm	EPA
Cyanide	200 µg/L	0.2 ppm	EPA, DOH
Fluoride	4 mg/L	4 ppm	EPA, DOH
Lead	15 µg/L	0.015 ppm	EPA
Mercury (inorganic)	2 µg/L	0.002 ppm	EPA, DOH
Methylene chloride	5 µg/L	0.005 ppm	EPA, DOH
Nitrate, as NO <sub>3</sub> <sup>-</sup>	45 mg/L	45 ppm	EPA, DOH
Nitrite, as NO <sub>2</sub> <sup>-</sup>	3.3 mg/L	3.3 ppm	EPA, DOH
Selenium	50 µg/L	0.05 ppm	EPA, DOH
Tetrachloroethene	5 µg/L	0.005 ppm	EPA, DOH
Thallium	2 µg/L	0.002 ppm	EPA, DOH
Trichloroethene	5 µg/L	0.005 ppm	EPA, DOH
Antimony-125	300 pCi/L <sup>(d)</sup>	11.1 Bq/L	EPA
Beta particle and photon activity	4 mrem/yr <sup>(e)</sup>	40 µSv/yr	EPA, DOH
Carbon-14	2,000 pCi/L <sup>(d)</sup>	74.1 Bq/L	EPA
Cesium-137	200 pCi/L <sup>(d)</sup>	7.4 Bq/L	EPA
Cobalt-60	100 pCi/L <sup>(d)</sup>	3.7 Bq/L	EPA
Iodine-129	1 pCi/L <sup>(d)</sup>	0.037 Bq/L	EPA
Ruthenium-106	30 pCi/L <sup>(d)</sup>	1.11 Bq/L	EPA
Strontium-90	8 pCi/L <sup>(d)</sup>	0.296 Bq/L	EPA, DOH
Technetium-99	900 pCi/L <sup>(d)</sup>	33.3 Bq/L	EPA
Total alpha (excluding uranium)	15 pCi/L <sup>(d)</sup>	0.56 Bq/L	EPA, DOH
Tritium	20,000 pCi/L <sup>(d)</sup>	740 Bq/L	EPA, DOH
Uranium	30 µg/L	0.03 ppm)	EPA, DOH

(a) Maximum contaminant level for drinking water supplies.

(b) DOH = Washington State Department of Health at WAC 246-290.

EPA = U.S. Environmental Protection Agency at 40 CFR 141, 40 CFR 143, and EPA 822-R-96-001.

(c) Standard is for total trihalomethanes (THM).

(d) EPA drinking water standards for radionuclides were derived based on a 4-mrem/yr dose standard using maximum permissible concentrations in water specified in *National Bureau of Standards Handbook 69* (U.S. Department of Commerce, August 1963, as amended).

(e) Beta and gamma radioactivity from anthropogenic radionuclides. Annual average concentration shall not produce an annual dose from anthropogenic radionuclides equivalent to the total body or any internal organ dose >4 mrem/yr. If two or more radionuclides are present, the sum of their annual dose equivalents shall not exceed 4 mrem/yr. Compliance may be assumed if annual average concentrations of total beta, tritium, and strontium-90 are <50, 20,000, and 8 pCi/L, respectively.

**Table 2.4. Selected Surface Freshwater Quality Criteria for Toxic Pollutants**

Compound	Level that Yields Acute Toxicity <sup>(a)</sup>		Level that Yields Chronic Toxicity <sup>(a)</sup>		Protective Level for Human Health Consumption of Water and Organisms <sup>(b)</sup>	
	µg/L	ppm	µg/L	ppm	µg/L	ppm
<b>Dissolved Metals</b>						
Antimony	--	--	--	--	14	0.014
Arsenic	360.0	0.360	190.0	0.19	0.018	0.000018
Cadmium	1.6	0.0016 <sup>(c)</sup>	0.59	0.00059 <sup>(d)</sup>	--	--
Chromium(VI)	15	0.015	10	0.01	--	--
Copper	8.4	0.0084 <sup>(e)</sup>	6.0	0.006 <sup>(f)</sup>	--	--
Lead	28	0.028 <sup>(g)</sup>	1.1	0.0011 <sup>(h)</sup>	--	--
Mercury	2.1	0.0021	--	--	0.14	0.00014
Nickel	750	0.75 <sup>(i)</sup>	83	0.083 <sup>(j)</sup>	610	0.61
Silver	0.94	0.00094 <sup>(k)</sup>	--	--	--	--
Thallium	--	--	--	--	1.7	0.0017
Zinc	60	0.060 <sup>(l)</sup>	55	0.055 <sup>(m)</sup>	--	--
<b>Total Recoverable Metals</b>						
Chromium(III) <sup>(n)</sup>	300	0.30 <sup>(o)</sup>	96	0.096 <sup>(p)</sup>	--	--
Mercury	--	--	0.012	0.000012	--	--
Selenium	20	0.02	5.0	0.005	--	--
<b>Anions</b>						
Cyanide <sup>(q)</sup>	22.0	0.022	5.2	0.0052	700	0.70
Chloride <sup>(r)</sup>	860,000	860	230,000	230	--	--
<b>Organic Compounds</b>						
Benzene	--	--	--	--	1.2	0.0012
Carbon tetrachloride	--	--	--	--	0.25	0.00025
Chloroform	--	--	--	--	5.7	0.0057
1,2-Dichloroethane	--	--	--	--	0.38	0.00038
Methylene chloride	--	--	--	--	4.7	0.0047
Toluene	--	--	--	--	6,800	6.80
Tetrachloroethene	--	--	--	--	0.8	0.0008
1,1,2-Trichloroethane	--	--	--	--	0.60	0.0006
Trichloroethene	--	--	--	--	2.7	0.0027
Vinyl chloride	--	--	--	--	2	0.002
1,4-Dichlorobenzene	--	--	--	--	400	0.40

(a) WAC 173-201A-240. For hardness-dependent criteria, the minimum value of 47 mg CaCO<sub>3</sub>/L for 1992-2010 water samples collected near the Vernita Bridge by the U.S. Geological Survey is used. Parts per million (ppm) values are equivalent to the reported micrograms per liter (µg/L) concentrations shown.

(b) 40 CFR 131.36.

(c)  $(1.1367 - [\ln(\text{hardness})]) 0.04184 \exp(1.128[\ln(\text{hardness})] - 3.828)$ . Hardness expressed as mg CaCO<sub>3</sub>/L.

(d)  $(1.1017 - [\ln(\text{hardness})]) 0.04184 \exp(0.7852[\ln(\text{hardness})] - 3.490)$ .

(e)  $(0.960) \exp(0.9422[\ln(\text{hardness})] - 1.464)$ .

(f)  $(0.960) \exp(0.8545[\ln(\text{hardness})] - 1.465)$ .

(g)  $(1.4620 - [\ln(\text{hardness})]) 0.1457 \exp(1.273[\ln(\text{hardness})] - 1.460)$ .

(h)  $(1.4620 - [\ln(\text{hardness})]) 0.1457 \exp(1.273[\ln(\text{hardness})] - 4.705)$ .

(i)  $(0.998) \exp(0.8460[\ln(\text{hardness})] + 3.3612)$ .

(j)  $(0.997) \exp(0.8460[\ln(\text{hardness})] + 1.1645)$ .

(k)  $(0.85) \exp(1.72[\ln(\text{hardness})] - 6.52)$ .

(l)  $(0.978) \exp(0.8473[\ln(\text{hardness})] + 0.8604)$ .

(m)  $(0.986) \exp(0.8473[\ln(\text{hardness})] + 0.7614)$ .

(n) Where methods to measure trivalent chromium are unavailable, these criteria are to be represented by total recoverable chromium.

(o)  $(0.316) \exp(0.8190[\ln(\text{hardness})] + 3.688)$ .

(p)  $(0.860) \exp(0.8190[\ln(\text{hardness})] + 1.561)$ .

(q) Criteria based on weak and dissociable method.

(r) Dissolved in association with sodium.

**Table 2.5. Washington State Water Quality Criteria for the Hanford Reach of the Columbia River<sup>(a)</sup>**

Parameter	Permissible Levels
Fecal coliform	(1) Geometric mean value less than or equal to 100 colonies/100 milliliters (0.026 gallon) (2) Not more than or equal to 10 percent of samples may exceed the geometric mean value of 200 colonies/100 milliliters (0.026 gallon)
Dissolved oxygen	Greater than 8 mg/L (8 ppm)
Temperature	(1) Less than or equal to 18°C (64°F) as a result of human activities (2) When natural conditions exceed 18°C (64°F), no temperature increases will be allowed that will raise the temperature of the receiving water by more than 0.3°C (0.54°F) (3) Incremental temperature increases resulting from point sources shall not at any time exceed $t = 28/(T + 7)$ , where t = maximum permissible temperature increase measured at a mixing zone boundary and T = background temperature. Incremental temperature increases resulting from non-point sources shall not exceed 2.8°C (5.04°F).
pH	(1) 6.5 to 8.5 range (2) Less than 0.5-unit induced variation
Turbidity	Turbidity shall be less than or equal to 5 nephelometric turbidity units over background turbidity when the background turbidity is 50 nephelometric units or less, and shall not increase more than 10 percent when the background turbidity is >50 nephelometric units
Aesthetic value	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste
Radioactive substances	Deleterious concentrations of radioactive materials for all classes shall be as determined by the lowest practicable level attainable and in no case shall exceed 1/12.5 of the values listed in WAC 246-221-290 or exceed EPA drinking water regulations for radionuclides, as published in EPA-570/9-76-003 or subsequent revisions thereto (Table 2.1)
Toxic substances	Shall not be introduced above natural background levels in waters of the state that have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic toxicity to the most sensitive biota dependent on those waters, or adversely affect public health, as determined by the department (Table 2.8)

(a) WAC 173-201A

## 2.5 Natural and Cultural Resources

This section provides information on federal statutes and assessments related to ecological and cultural resource compliance at the Hanford Site.

### 2.5.1 Ecological Compliance

*MR Sackschewsky*

DOE policies require that all Hanford Site projects with the potential to adversely affect biological resources have an ecological compliance review conducted before the project starts. Regulators use the review to determine if the project will comply with the *Endangered Species Act of 1973* ([16 USC 1531](#)), the *Migratory Bird Treaty Act*, and the *Bald and Golden Eagle Protection Act*, as well as Executive Orders 11988 ([42 FR 26951](#)) and 11990 ([42 FR 26961](#)). The review also addresses whether other significant resources such as Washington State-listed species of concern, wetlands, and native shrub-steppe habitats are adequately considered during the project planning process. Where adverse effects are identified, mitigation actions are

prescribed. Mitigation actions may include avoidance of significant resources, minimization of effects, and rectification or compensation if resources are affected.

There were 303 reviews performed during 2011, including 122 ecological compliance reviews to support general Hanford Site activities, and 181 reviews for River Corridor environmental restoration activities.

#### **2.5.1.1 Endangered Species Act of 1973**

Several protected species of plants and animals exist on the Hanford Site and along the Hanford Reach of the Columbia River. Upper Columbia River Steelhead trout (*Oncorhynchus mykiss*) and spring-run Chinook salmon (*Oncorhynchus tshawytscha*) are listed under the *Endangered Species Act of 1973* as either threatened or endangered (50 CFR 17, Subpart B) and occur onsite, and Critical Habitat for these species has been designated within the Hanford Reach. The *Threatened and Endangered Species Management Plan: Salmon and Steelhead* ([DOE/RL-2000-27](#)) is in place for these species. The bull trout (*Salvelinus confluentus*) is also listed under the *Endangered Species Act of 1973* and may occasionally occur in the Hanford Reach of the Columbia River; critical habitat for bull trout was designated in the Hanford Reach in 2010 ([USFWS 2010a](#)). Consultation under Section 7 of the Act was initiated in 2010 with the National Marine Fisheries Service and the USFWS regarding potential impacts of the demolition of the 100-K Area and 100-N Area intake structures to Upper Columbia River spring Chinook, steelhead, and bull trout and their critical habitat; these consultations were completed in 2011. Other species on the Hanford Site are listed by the Washington Department of Fish and Wildlife as endangered, threatened, or sensitive (refer to [Section 10.2](#)).

#### **2.5.1.2 Migratory Bird Treaty Act**

The *Migratory Bird Treaty Act* prohibits taking or disturbing listed migratory birds or their feathers, eggs, or nests. Over 100 species of birds that regularly occur on the Hanford Site are protected by the *Migratory Bird Treaty Act*. All Hanford Site projects with a potential to affect federal or state-listed species of concern complied with the requirements of this Act by using the ecological compliance review process as described in the *Hanford Site Biological Resources Management Plan* ([DOE/RL-96-32](#), Rev. 0). When applicable, ecological reviews produce recommendations to minimize adverse impacts to migratory birds, such as performing work outside of the nesting season and minimizing the loss of habitat. MSA maintains a migratory bird permit issued by the USFWS (MB14155A-0) that allows for certain *Migratory Bird Treaty Act*-related actions. A report of all activities conducted under this permit is provided to USFWS annually.

#### **2.5.1.3 Bald and Golden Eagle Protection Act**

The *Bald and Golden Eagle Protection Act* provides for the protection of the bald eagle and the golden eagle by prohibiting, except under certain specified conditions, the taking, possession, or commerce of such birds. A revised *Bald Eagle Site Management Plan for the Hanford Site, South Central Washington* was published in 2009 to direct Hanford Site activities in accordance with current federal and state regulations and guidelines ([DOE/RL-94-150](#), Rev. 1). This management plan outlines seasonal access restrictions around documented nesting and communal roosting sites at the Hanford Site between November 15 and March 15, and establishes guidelines for the protection of perches, roosts, and alternative nest sites. When applicable, ecological reviews have produced recommendations to minimize adverse impacts to bald eagles including performing work outside of the winter season; staying out of established buffer areas; or entering buffer areas at mid-day, minimizing impacts by avoiding eagle roosting periods.



In 2010, a supplement was added to the *Bald Eagle Site Management Plan for the Hanford Site* ([DOE/RL-94-150](#), Rev. 1) to clarify allowable activities at the 100-K Area. Work supporting demolition of the 181-KW River Pump House required CHPRC to acquire a bald eagle take permit from the USFWS to cover potential disturbance to eagles using the 100-K Area night roost. In 2011, the scope of the existing permit was expanded to include operation of the 100-HX pump-and-treat system between 100-H and 100-D Areas.

#### 2.5.1.4 Executive Orders 11988 and 11990

Executive Order 11990, *Protection of Wetlands* (42 FR 26961), and Executive Order 11988, *Floodplain Management* (42 FR 26951), require federal agencies to minimize the loss or degradation of wetlands on federal lands, and account for floodplain management when developing water- and land-use plans, respectively. DOE implements the requirements of these two executive orders through 10 CFR 1022, *Compliance with Floodplain and Wetlands Environmental Review Requirements*. It is DOE policy to 1) restore and preserve natural and beneficial values served by floodplains; 2) minimize the destruction, loss, or degradation of wetlands; and 3) preserve and enhance the natural and beneficial value of wetlands. Compliance with these executive orders, as well as the wetland provisions of the *Clean Water Act of 1977*, are implemented at the Hanford Site through the ecological compliance review process in conjunction with the appropriate site Environmental Compliance Officers. The compliance process includes the identification, protection, and when necessary, mitigation of wetlands and floodplains on the Hanford Site.

### 2.5.2 Cultural Resource Compliance

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DOE's policy is to comply with all cultural resource-related laws and regulations (DOE P 141.1). Cultural resources on the Hanford Site are subject to the provisions of laws, regulations, executive orders, and proclamations. Laws include the *Antiquities Act of 1906*, *Historic Sites Act of 1935*, *National Historic Preservation Act of 1966*, NEPA, *Archaeological and Historic Preservation Act of 1974*, *American Indian Religious Freedom Act of 1978*, *Archaeological Resources Protection Act of 1979*, and *Native American Graves Protection and Repatriation Act of 1990*.

Regulations applicable to cultural resources include the *National Register of Historic Places* (36 CFR 60), *Determinations of Eligibility for Inclusion in the National Register of Historic Places* (36 CFR 63), *National Historic Landmarks Program* (36 CFR 65), *Curation of Federally-Owned and Administered Archaeological Collections* (36 CFR 79), *Protection of Historic Properties* (36 CFR 800), *Protection of Archaeological Resources* (43 CFR 7), and *Native American Graves Protection and Repatriation and Regulations* (43 CFR 10).

Executive orders include Executive Order 11593, *Protection and Enhancement of the Cultural Environment* (36 FR 8921); Executive Order 13007, *Indian Sacred Sites* (61 FR 26771); Executive Order 13175, *Consultation and Coordination with Indian Tribal Governments* (65 FR 67249); Executive Order 13287, *Preserve America* (68 FR 10635); and Presidential Proclamation 7319, *Establishment of the Hanford Reach National Monument* (65 FR 37253). Refer to [Section 11.3](#) for details regarding Hanford Site Cultural Resource Programs.

## 2.6 Other Environmental Statutes

Information regarding these additional statutes is presented in the following sections.

### 2.6.1 Emergency Planning and Community Right-to-Know Act of 1986

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The *Emergency Planning and Community Right-to-Know Act of 1986* requires each state to establish an emergency response commission and local emergency planning committees, and develop a process to distribute information on hazardous chemicals present in local facilities. These committees gather information and develop emergency plans for local planning districts. Facilities that produce, use, release, or store toxic or hazardous substances in quantities above threshold quantities must submit information regarding the chemicals to emergency planning committees to support emergency planning.

The *Emergency Planning and Community Right-to-Know Act of 1986* has four major provisions: emergency planning, emergency release notification, hazardous chemical inventory reporting, and toxic chemical release inventory reporting. Table 2.6 summarizes sections of the Act and their requirements.

Two annual reports are required under the *Emergency Planning and Community Right-to-Know Act of 1986*:

1) Tier Two Emergency and Hazardous Chemical Inventory, which contains information about hazardous chemicals stored at each facility in amounts exceeding minimum threshold levels; and 2) Toxic Chemical Release Inventory, which contains information about total annual releases of certain toxic chemicals and associated waste management activities.

The *2011 Hanford Site Tier Two Emergency and Hazardous Chemical Inventory* report (DOE/RL-2012-05), was submitted to Ecology's Community Right-To-Know Unit; local emergency planning committees for Benton, Franklin, and Grant Counties; and the city of Richland and Hanford Site fire departments on February 27, 2012. Fifty-nine hazardous chemicals exceeded the reporting thresholds for the Hanford Site. One chemical category (lead acid batteries, which contain sulfuric acid, an extremely hazardous substance) exceeded the reporting threshold for offsite locations (700 Area, 1100 Area, and the Federal Building). Table 2.7 lists the average quantities of the 10 hazardous chemicals stored in greatest quantity on the Hanford Site in 2011.

The *2011 Hanford Site Toxic Chemical Release Inventory* report ([DOE/RL-2012-06](#)), was submitted to EPA and Ecology on June 26, 2012. Information concerning six toxic chemicals that exceeded Hanford Site reporting thresholds during CY2011 is described in Table 2.8.

Table 2.9 provides an overview of reporting under the *Emergency Planning and Community Right-to-Know Act of 1986* during 2011 and early 2012.

**Table 2.6. Emergency Planning and Community Right-to-Know Act of 1986 Sections and Requirements Summary**

Section	CFR Section	Reporting Criteria	Due Date	Agencies Receiving Report
302	40 CFR 355: Emergency Planning Notifications	The presence of an extremely hazardous substance in quantity equal to or greater than threshold planning quantity at any one time.	Within 60 days of threshold planning quantity exceedance.	Local Emergency Planning Committee; State Emergency Response Commission
302	40 CFR 355: Emergency Planning Notifications	Change occurring at a facility that is relevant to emergency planning.	Within 30 days after the change has occurred.	Local Emergency Planning Committee
304	40 CFR 355: Emergency Release Notifications	Release of an extremely hazardous substance or a CERCLA hazardous substance in quantity equal to or greater than reportable quantity.	Initial notification: immediate (within 15 minutes of knowledge of reportable release). Written follow-up: within 14 days of the release.	Local Emergency Planning Committee; State Emergency Response Commission
311	40 CFR 370: Material Safety Data Sheet Reporting	The presence at any one time at a facility an Occupational Safety and Health Administration (OSHA) hazardous chemical in quantity equal to or greater than 10,000 pounds (4,500 kilograms), or an extremely hazardous substance in quantity equal to or greater than threshold planning quantity or 500 pounds (230 kilograms), whichever is less.	Revised list of chemicals due within 3 months of a chemical exceeding a threshold.	Local Emergency Planning Committee; State Emergency Response Commission; Local Fire Departments
312	40 CFR 370: Tier Two Report	The presence at any one time at a facility an OSHA hazardous chemical in quantity equal to or greater than 10,000 pounds (4,500 kilograms), or an extremely hazardous substance in quantity equal to or greater than threshold planning quantity or 500 pounds (230 kilograms), whichever is less.	Annually by March 1	Local Emergency Planning Committee; State Emergency Response Commission; Local Fire Departments
313	40 CFR 372: Toxic Release Inventory Report	Manufacture, process, or use at a facility, any listed Toxic Release Inventory chemical in excess of its threshold amount during the course of a calendar year. Thresholds are 25,000 pounds (11,300 kilograms) for manufactured or processed or 10,000 pounds (4,500 kilograms) for otherwise used except for persistent, bio-accumulative, toxic chemicals, which have thresholds of 100 pounds (45 kilograms) or less.	Annually by July 1	EPA; State Emergency Response Commission

**Table 2.7. Average Quantity of the 10 Hazardous Chemicals<sup>(a)</sup> Stored in Greatest Quantities (2011)**

Hazardous Chemical	Average Quantity, lbs	Average Quantity, kg
Mineral oil	2,380,000	1,080,000
Portland Cement	2,320,000	1,050,000
Sodium	2,320,000	1,050,000
Nitrogen	1,900,000	862,000
Motor Oil, Used	836,000	379,000
Diesel Fuel (Grades 1 and 2)	744,000	337,000
Petroleum Distillates	535,000	243,000
Lead Acid Batteries	475,000	215,000
Sulfuric Acid	423,000	192,000
Calcium Chloride	311,000	141,000

(a) Includes chemicals defined as hazardous under 29 CFR 1910.1200(c), Hazard Communication

**Table 2.8. Toxic Chemicals Exceeding Reporting Thresholds (2011)**

Chemical	CAS No.	Main Source	Use Description
Lead	7439-92-1	Ammunition	Discharged during firearms range practice by Hanford Site safeguards and security programs
Naphthalene	91-20-3	Diesel	Vehicle use (exempt); non-vehicle use (non-exempt)
Propylene	115-07-1	Propane gas	Used for construction-related heating purposes
Toluene	108-88-3	Gasoline	Vehicle use (exempt); non-vehicle use (non-exempt)
Xylene	1330-20-7	Gasoline	Vehicle use (exempt); non-vehicle use (non-exempt)

**Table 2.9. Emergency Planning and Community Right-to-Know Compliance Reporting**

Section	Description of Reporting	Status	Notes
302	Emergency planning notifications	Yes	
304	Extremely hazardous substance release notification	Not required	No releases occurred.
311	Material safety data sheet	Yes	
312	Chemical inventory	Yes	
313	Toxic release inventory	Yes	

### 2.6.1.1 Chemical Management Systems

Hanford Site contractors have developed and documented formal systems to manage chemicals. Chemical Management Systems apply to the acquisition, use, storage, transportation, and final disposition of chemicals, including hazardous chemicals as defined in 29 CFR 1910, Subpart Z, *Occupational Safety and Health Standards*. Chemical Management Systems are reviewed periodically and improvements are made as needed. In summer 2010, a site-wide *Emergency Planning and Community Right-to-Know Act of 1986* requirements implementation process was developed and approved by affected contractors. The new site-wide process will improve the efficiency and accuracy of the data submitted for *Emergency Planning and Community Right-to-Know Act of 1986* reports and notifications.

## 2.6.2 Pollution Prevention Program

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The *Pollution Prevention Act of 1990* requires that pollution be prevented or reduced at the source whenever possible, and pollution that cannot be prevented be recycled or treated in an environmentally safe manner.

The Hanford Site Pollution Prevention Program was created to address these requirements.

RL is responsible for the Hanford Site Pollution Prevention Program and provides program implementation guidance to Hanford Site contractors. The Pollution Prevention Program reflects federal and DOE policies to reduce, reuse, and/or recycle wastes, as established by the *Pollution Prevention Act of 1990*.

Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management* (72 FR 3919), Executive Order 13514, *Federal Leadership in Environmental, Energy, and Economic Performance* (74 FR 52117), and DOE O 450.1A, *Environmental Protection Program* establish pollution prevention and environmental stewardship requirements. In accordance with these requirements, pollution prevention and waste minimization activities are documented, tracked, and reported. Table 2.10 summarizes Hanford Site pollution prevention and waste minimization quantities recycled in FY2011.

### 2.6.2.1 Pollution Prevention and Waste Minimization Accomplishments and Awards

The Hanford Site submitted 16 Star of Excellence (E-Stars) award applications to DOE HQ for pollution prevention and waste minimization accomplishments. The Hanford Site was awarded three DOE EM Best In Class awards and eight Honorable Mention Awards.

### 2.6.2.2 Contractor-Specific Accomplishments

The MSA recycle/reuse and waste minimization activities included the following:

- Increasing recycling of regulated and non-regulated materials by 35 percent
- Implementation of the Voice over Internet Protocol (VoIP) Project, which was initiated in 2010, thereby reducing power consumption by approximately 885,000 watts/hour over the next 10 years
- Reuse of approximately 10 tons (9 metric tons) of electronic server equipment
- Reduction in 1,650 tons (1,497 metric tons) of greenhouse gas emissions through acquisition of alternative fuel vehicles, investment in electric transportation, and reduction in the Hanford Site vehicle fleet
- Consolidation of Information Technology data centers assets estimated to conserve approximately 60,000 kilowatt/year
- Reducing 3,000,513 pounds (1,360,777 kilograms) of carbon dioxide emissions, 2,000,000 kilowatts/hour of power, and a cost savings of approximately \$5 million over 4 years through the implementation of the Thin Client and Cloud Computing project.

**Table 2.10. Recycle Quantities**

<b>FY2011 Recycled Material</b>	<b>Quantity (Metric Tons)</b>
<b>Non-Hazardous Material</b>	
Cardboard	54.47
CI Shredded Paper	528.53
Copper Metals	0.51
Electronics	1.79
Ferrous Metals	901.45
Furniture	124.37
Non-Ferrous Metals	20.12
Plastic Bottles	21.56
Tires	14.71
Wood Pallets	77.97
<b>Hazardous Material</b>	
Antifreeze	11.29
Antifreeze - Fleet	13.15
Ballasts	4.62
Batteries	8.60
Fluorescent Bulbs	9.58
Fuel Waste	4.70
Lamps	2.37
Lead Acid Batteries	34.07
Lead Acid Batteries (Fleet)	7.26
Mercury-Containing Equipment	0.24
Shop Towels	0.02
Toner Cartridges	14.59
Used Engine Oils (Fleet)	51.75
Used Oil	22.05

CHPRC recycle/reuse and waste minimization activities included the following:

- Diverting approximately 275,573 tons (250,000 metric tons) of concrete rubble from the landfill and staging it to build the cap on U Canyon in the 200 Area
- Reducing waste generation through the use of drum bags and boxes in the Next Generation Retrieval process
- Conserving approximately 6,000 gallons (22,800 liters) of diesel fuel and reducing greenhouse gas emissions by grouting railcars at the rail site rather than transporting for macroencapsulation
- Excessing of 16 roll-on/roll-off containers to the Department of Justice Bureau of Prisons and U.S. Penitentiary in Lewisburg, PA, in lieu of disposal at the Environmental Restoration Disposal Facility
- Reuse of approximately 58,000 tons (52,606 metric tons) of soil for backfilling remediation excavations in lieu of disposal, saving approximately 10,000 gallons (38,000 liters) of fuel
- Implementing a new ion exchange resin at the DX and HX pump-and-treat facilities that reduced frequency required for changing the resin, resulting in cost and energy savings



- Reclamation of 2,500 pounds (1,135 kilograms) of ozone depleting substance from the Plutonium Finishing Plant facilities and transfer to the U.S. Department of Defense, Defense Logistics Agency Halon Repository

WRPS recycle/reuse and waste minimization activities included the following:

- Recycling approximately 6.6 tons (6 metric tons) of radiologically contaminated lead bricks
- Upgrading the 222-S Laboratory to become more energy efficient, reducing the amount of water and electricity used
- Reducing the generation of waste and overall efficiency by replacing a steam-powered heating system at the 222-S Laboratory with heaters that run on electricity
- Reducing the volume of waste generated through the use of alternative characterization methods for contaminated soil samples
- Reducing the volume of low-level waste disposed through treatment from 28,252 cubic feet (800 cubic meters) to 3,814 cubic feet (108 cubic meters)
- Saving 4,336,000 gallons (16,476,800 liters) of water by using Double-Shell Tank waste supernate for retrieving the solids from C Farm Single-Shell Tanks
- Diverting over 16 tons (14.5 metric tons) of wood pallets from the municipal landfill
- Recycling over 960 pounds (435 kilograms) of lead acid batteries.

WCH recycle/reuse and waste minimization activities included the following:

- Reuse of rubble from building demolition as ground cover for in the 300 Area
- Recycling of 3,000 tons (2,751 metric tons) of non-contaminated scrap metal from the water treatment facilities for C Reactor
- Recycling of approximately 30,000 pounds (13,608 kilograms) of carbon and stainless steel from the Basalt Waste Isolation Project at Gable Mountain
- Coordination with CHPRC to reuse 212,000 tons (192,284 metric tons) of concrete to build the cap at U Canyon
- Reuse of approximately 5,000 tons (4,535 metric tons) of rail
- Using portable solar lights to provide temporary lighting to a remediation site.

CSC Hanford Occupational Health Services recycle/reuse and waste minimization activities included the installation of the Digital X-Ray/PACS System, eliminating the use of Developer and Fixer chemicals and reducing the amount of hazardous waste generated by 800 gallons (3,040 liters) per year.

### **2.6.3 Environmental Orders**

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The Hanford Site must comply with environmental protection orders including three DOE orders and two Presidential Executive Orders.

[Executive Order 13423](#), *Strengthening Federal Environmental, Energy and Transportation Management* (72 FR 3919) established a policy for federal agencies to conduct legally, environmentally, economically, and fiscally sound environmental, transportation, and energy-related activities in an integrated, efficient, continuously improving, and sustainable manner. The order established goals for the following areas: improved energy efficiency; reduced greenhouse gas emissions; use of renewable energy sources; renewable

energy generation; reduced water consumption; acquisition of goods and services; reduced use of toxic and hazardous chemicals and materials; increased waste minimization, prevention and recycling; use of sustainable building practices; reduced use of petroleum products for vehicles; and electronics stewardship. In addition, Executive Order 13423 requires that an Environmental Management System be established as the mechanism for managing environmental goals, as well as other impacts to the environment from Hanford Site operations, and establishing environmental objectives and targets. The order also requires establishing environmental management training, environmental compliance review and auditing, and leadership awards to recognize outstanding environmental, energy, or transportation management performance.

[Executive Order 13514](#), *Federal Leadership in Environmental, Energy and Economic Performance* (74 FR 52117), states that federal agencies shall increase energy efficiency; measure, report, and reduce their greenhouse gas emissions from direct and indirect activities; conserve and protect water resources through efficiency, reuse, and stormwater management; eliminate waste, recycle, and prevent pollution; leverage agency acquisitions to foster markets for sustainable technologies and environmentally preferable materials, products, and services; design, construct, maintain, and operate high performance sustainable buildings in sustainable locations; strengthen the vitality and livability of the communities in which federal facilities are located; and inform federal employees about and involve them in the achievement of these goals. In addition, Executive Order 13514 requires that targets for baseline Scope 1 (generated from site operations and activities) and Scope 2 (associated with the purchase of energy [electricity, heat, or steam] used by site contractors) greenhouse gas emissions, along with 2020 reduction targets, be established.

Similar numbers for Scope 3 (emissions associated with ancillary activities related to Hanford Site operations, including business travel, employee commuting, vendor activities, delivery services, etc.) emissions must be established. Executive Order 13514 also sets goals for improved water use efficiency and management, promotion of pollution prevention and waste elimination, advancement of regional and local integrated planning, implementation of sustainable building lifecycle management practices, advancement of sustainable acquisition, and promotion of electronics stewardship. Executive Order 13514 requires continued implementation of a formal sustainable Environmental Management System.

[DOE O 430.2B](#), *Departmental Energy, Renewable Energy and Transportation Management* provides requirements and responsibilities for managing energy, buildings, and vehicle fleets at all DOE facilities, laboratories, and sites. The order implements the requirements of Executive Order 13423 and Executive Order 13514 including the establishment of an Environmental Management System that includes environmental, energy, and transportation objectives and targets.

[DOE O 450.1A](#), *Environmental Protection Program*, requires implementation of an Environmental Management System that is integrated into the Integrated Safety Management System and reflects the elements and framework found in the International Organization for Standardization (ISO) 14001:2004(E) standard, *Environmental Management Systems – Requirements with Guidance for Use*. DOE O 450.1A states that each Environmental Management System include policies, procedures, and training to identify operations and activities with significant environmental impacts; to manage, control, and mitigate impacts; and to assess performance, implement corrective actions where needed, and to ensure continual environmental improvement. In addition, the Environmental Management System must address sustainable practices for enhancing environmental, energy, and transportation performance required by Executive Order 13423 and DOE O 430.2B to include protecting public health and the environment, wildland fire protection, natural and cultural resource protection and stewardship, monitoring effluent and environmental data, providing quality

analytical data, assessing engineered nanomaterial's hazards, and identifying opportunities to implement sustainable practices.

[DOE O 436.1](#), *Departmental Sustainability* was approved in May 2011. The order requires developing a Site Sustainability Plan that is integrated with the Hanford Site operational plans. In addition, the order requires developing an Environmental Management System that is certified to or conforms with the ISO 14001:2004 standard, submittal of sustainability goal data and reports, as well as *Emergency Planning and Community Right-to-Know Act of 1986* reporting. Implementation of DOE orders and executive orders by Hanford Site contractors is addressed in [Section 3.0](#).

MSA, as the Hanford Site services and infrastructure contractor, updated the sustainability plan for the Hanford Site in 2011 with input from DOE and Hanford Site contractors. The plan describes the energy management program; identifies planned energy efficiency, water conservation, transportation fleet management, and sustainable buildings activities; and includes an Emergency Conservation Plan, as required by DOE O 430.2B and Executive Order 13423. Environmental objectives developed in 2010 were maintained in 2011, as were plans for recycling, ozone-depleting substance management, environmentally preferred procurement management, and electronic asset stewardship (refer to [Section 3.0](#)).

## 2.7 Environmental Occurrences

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Releases of radioactive and regulated materials to the environment are reported to DOE and other federal and state agencies as required by law. The specific agencies notified depend on the type, amount, and location of each release event. This section addresses releases or potential releases to the environment that may not be documented by other reporting mechanisms. All Hanford Site occurrences are reported to the Occurrence Notification Center and subsequently recorded in the Occurrence Reporting and Processing System. This system is a DOE electronic database that tracks occurrence reports across the DOE complex ([DOE M 231.1-2](#)). The following sections summarize 2011 occurrences that may have impacted the Hanford Site environment. The occurrences are arranged according to significance category, which are assigned based on the nature and severity of the occurrence. The categories include Operational Emergency; Recurring; Category 1 (significant impact), Category 2 (moderate impact), Category 3 (minor impact), and Category 4 (some impact).

### 2.7.1 Operational Emergency; Recurring; Category 1

There were no Hanford Site environmental occurrences ranked as Operational Emergency, Recurring, or Category 1 (Significant Impact).

### 2.7.2 Category 2 – Moderate Impact

One Category 2 occurrence with potential moderate environmental impacts occurred in 2011. Ventilation Control Zone 3 of Buildings 234-5Z and 236-Z radiological areas at the Plutonium Finishing Plant were evacuated in August 2011 due to a loss of normal ventilation caused by a failure of Exhaust Fan 1 (EF-1). The failure resulted in the fan belt overheating and catching fire. The fire was extinguished, but the exhaust fan's housing was damaged as a result of the event, which presented the potential for a radiological release. Area and personnel surveys confirmed that there was no reportable release to the environment.

### 2.7.3 Category 3 – Minor Impact

In 2011, four Category 3 occurrences with potential environmental implications were documented: chemical fumes were released, chemical odors released from a 55-gallon (209-liter) drum, a compound gas release and undisclosed radioactive material.

**Chemical fumes.** In November 2011, at the 200W Pump-and-Treat Splitter Box, during preparation to remove corrosion from a 4-inch 10-centimeter) pipe by pickling, subcontract pipefitters transferred about 2 ounces (57 grams) of a "pickling" paste into a quart size metal container. The pickling material (acid based) reacted with the container creating heat and colored smoke. The splitter box is a non-permitted confined space. The workers were sent to an onsite medical provider for evaluation and returned to work with no restrictions.

**Chemical odors.** In April 2011, an employee was decanting an 8-pint (4-liter) plastic container of liquid from Laboratory Analytical (LA) procedure LA-505-410, Acid Digestion of Aqueous and Solid Samples for Total Metals Analysis by ICP-AES, into a 55-gallon (209-liter) drum (6266-11R302375) Satellite Accumulation Area for Radioactive Liquid Waste. The employee noted a strong chemical odor and burning sensation in the nasal cavity/throat. The employee stopped decanting after 2 pints (1 liter), closed the bottle and drums, and left the work area. The employee intended to talk to Industrial Hygiene in the morning. The next morning, the employee reported to work with a sore throat and notified the Operations Specialist of the event. The employee was transported by their manager to CSC, Hanford Occupational Health Service for evaluation. The employee returned to work with no treatment or restrictions.

**Gas Release.** In April 2011, BNI Iron Workers from the Pretreatment Facility reported a Stargon (argon, carbon dioxide, and nitrogen) compound gas cylinder positioned in a hand truck (Saf-T-Cart 750-10) that tipped over and fell. The fall/impact broke off the gas regulator resulting in a low volume of pressurized gas being released until a nearby pipefitter was able to close the bottle valve. There were no injuries and the gas cylinder did not move from its fallen location.

**Undisclosed radioactive material.** In February 2011, two Associated Technologies Incorporated instruments, used for vent and balance testing of radiological systems, contained undisclosed radioactive material and were shipped to the Energy Northwest calibration facility. On January 31, 2011, radiological surveys were performed on the instruments before shipment to prepare for offsite shipment. Some items could not be completely internally surveyed for full release and were bagged and labeled as radiological material. This bag was placed inside the Associated Technologies Incorporated instrument storage container (similar to a suitcase) pending disposition. All remaining radiological surveys were negative, which supported radiological release of the units for shipment to an offsite facility, and all radioactive markings were removed from the container's exteriors.

### 2.7.4 Category 4 – Some Impact

Category 4 occurrences are defined as having some impact on safe facility operations, worker or public safety and health, regulatory compliance, or public and business interests. Summarized below, is one Category 4 occurrence with potential environmental implications that occurred on the Hanford Site in 2010, and the discoveries of legacy contamination.

**Discovery of Legacy Contamination.** Each year on the Hanford Site, legacy contamination is spread as a result of environmental conditions. Some contamination is discovered during routine survey work. Biological vectors also spread contamination; tumbleweeds, rabbits, and mud daubers (wasps) are all common biological

vectors. Tumbleweeds have a deep taproot that can sequester contamination from below the soil surface into the plant body on the surface. Rabbits eat vegetation located in contaminated areas, and then deposit contaminated feces outside of the contaminated area. Mud daubers build nests from mud and occasionally use mud from contaminated areas, resulting in the transfer of contamination to uncontaminated areas. Of these three biological vectors, contaminated tumbleweeds occur most frequently and have the potential to transfer contamination the farthest distance from their original locations. High winds may contribute to the spread of legacy contamination beyond posted areas. Reports of legacy contamination discovered throughout the year are consolidated into quarterly reports. In 2011, there were 31 documented occurrences of legacy contamination.

## 2.8 Standards and Permits

Hanford Site operations must conform to a variety of government standards and permits. The primary environmental quality standards and permits applicable to Hanford Site operations are listed in Table 2.11.

**Table 2.11. Environmental Permits**

Air Permits
<ul style="list-style-type: none"> <li>Hanford Site <a href="#">Air Operating Permit</a> 00-05-006, Renewal 1, covers operations on the Hanford Site having a potential to emit airborne emissions. This permit was effective on January 1, 2007, and expires January 1, 2012. The permit is intended to provide a compilation of applicable <i>Clean Air Act</i> requirements for both radioactive and non-radioactive emissions at the Hanford Site. It will be implemented through federal and state programs.</li> <li><i>Radioactive Air Emissions License for the Department of Energy Richland Operations Office Hanford Site, License Number FF-01</i> (<a href="#">DOH 2012</a>), is issued to RL by the Washington State Department of Health. This permit was effective February 23, 2012, and expires December 31, 2017. The FF-01 license, is a compilation of all applicable radioactive air emission requirements.</li> </ul>
Resource Conservation and Recovery Act Permit (Ecology)
<ul style="list-style-type: none"> <li>Permit <a href="#">WA7890008967, Revision 8C</a>, was issued on September 27, 1994, and has undergone several revisions. The permit expired on September 27, 2004, and Ecology is preparing to reissue the Hanford Facility Dangerous Waste Permit (WA7890008967, Rev. 9), incorporating the remaining units. Ecology is scheduled to issue the draft Permit for public comment in May 2012 and continue through September 2012. The Permit <a href="#">WA7890008967, Revision 8C</a>, remains in effect until a new permit is issued.</li> </ul>
Wildlife Permits
<ul style="list-style-type: none"> <li>Federal Fish and Wildlife Permit No. MB14155A-2, issued by the U.S. Fish and Wildlife Service to Mission Support Alliance; authorizes the collection of migratory birds from transformers and conductors when imminent threat of fire and power outages. This permit expires March 31, 2013.</li> <li>Federal Fish and Wildlife Section 7 Review Reference Number 13260-2009-I-0121, issued to Environmental Assessment Services in July of 2009 for the potential of incidental take of salmonids during fishing activities in the Columbia River. This review has no expiration listed.</li> <li>Federal Fish and Wildlife Section 7 Review Reference Number 13260-2011-I-0080, issued to U.S. Department of Energy in July of 2011 for the potential of incidental take of bull trout during fishing activities in the Columbia River. This review has no expiration listed.</li> <li>Scientific Collection Permit 11-295c, issued by the Washington Department of Fish and Wildlife to Environmental Assessment Services for August 2011 through August 2012; authorizes the collection of food fish, shellfish, game fish, and wildlife for research purposes. This permit is renewed annually.</li> </ul>

**Water Permits**

- NPDES Permit [WA-002591-7](#) is issued to the CHPRC by the EPA. WA-002591-7 governs the effluent discharges from the 100 Area facilities (two outfalls in the 100-K Area) to the Columbia River.
- NPDES Permit CR-IU005 allows wastewater from the Environmental Molecular Sciences Laboratory to be discharged to the city of Richland's wastewater treatment facility.
- NPDES Permit CR-IU011 allows wastewater from the Physical Sciences Facility to be discharged to the city of Richland's wastewater treatment facility.
- Permit [CR-IU010](#), 300 Area combined Sewer Industrial Wastewater Permit, is issued to RL by the city of Richland. Permit CR-IU010 governs the discharges from the 300 Area facilities into the city of Richland sewer collection system.
- Permit [ST 4500](#), *State Waste Discharge Permit* allows treated wastewater from the Effluent Treatment Facility to be discharged to the State-Approved Land Disposal Site. This permit expired August 1, 2005, and has not been reissued. The old permit will remain in effect until the new permit is issued.
- Permit [ST 4501](#), *State Waste Discharge Permit* allows for the discharge of cooling water and other primarily uncontaminated wastewater from 400 Area facilities to two ponds located north-northeast of the 400 Area perimeter fence. This permit was effective October 1, 2003, and expired on October 1, 2008. It will remain in effect until a new permit is issued.
- Permit [ST 4502](#), *State Waste Discharge Permit* allows treated effluent from the 200-East and 200-West Areas to be discharged to the 200 Area Treated Effluent Disposal Facility. This permit expired in May 2005 and has not been reissued. The old permit will remain in effect until the new permit is issued.
- Permit [ST 4507](#), *State Waste Discharge Permit* allows domestic wastewater to be discharged to the 100-N Area sewage lagoon. This permit expired in May 2002. A renewal application has been submitted. The old permit will remain in effect until a new permit is issued.
- Permit [ST 4511](#) is a consolidation of permits: ST 4508, ST 4509, and ST 4510. This Categorical State Waste Discharge Permit authorizes the discharge of wastewater from maintenance, construction, and hydro testing activities and allows for cooling water, condensate, and industrial storm water discharges at the Hanford Site. This permit was issued February 16, 2005, and expires February 16, 2010. A permit renewal application for ST 4511 was filed with the Washington State Department of Ecology in August 2009. The old permit will remain in effect until a new permit is issued.
- NPDES General Permit [50-0000](#), The Sand and Gravel General Permit, is a NPDES and State Waste Discharge General Permit. This permit was effective October 1, 2010, and expires on October 1, 2015.
- Washington State Sand and Gravel General Permit [WAG-50-5180](#), for the Concrete Batch Plant in the 200 East Area. The permit is issued to BHI by Ecology. This permit was effective October 1, 2010, and expires on October 1, 2015.
- Washington State Sand and Gravel General Permit [WAG-50-5181](#), for Gravel Pit 30 Quarry in the 200 East Area. Ecology issued the permit to BNI as the owner and to Ready Mix Concrete as the operator. This permit was effective October 1, 2010, and expires on October 1, 2015. The Pit 30 Quarry supports the construction of the Hanford Tank Waste Treatment and Immobilization Plant. Primary function is making gravel.

**Agency Contact Information**

State of Washington	U.S. Environmental Protection Agency	U.S. Department of Energy
Department of Ecology	Region 10	Richland Operations Office
P.O. Box 47600	1200 Sixth Avenue	825 Jadwin Avenue
Olympia, WA 98504-7600	Seattle, WA 98101	Richland, WA 99352



## 3.0 Environmental Management Systems

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AS Nagel

DOE requires that all Hanford Site contractors develop and operate under an Integrated Safety Management System (ISMS) that includes an Environmental Management System consistent with the ISO standard—*Environmental Management Systems – Requirements with Guidance for Use* ([ISO 14001:2004](#)[E]). Hanford Site contractors have established ISMSs as mandated by their contracts with DOE. These systems are intended to protect workers, the public, and the environment by integrating environmental, safety, and health considerations into the way work is planned, performed, and improved. DOE verified that all Hanford Site entities under the authority of [DOE P 450.4](#), *Safety Management System Policy*, had incorporated the requirement within [DOE O 450.1A](#), *Environmental Protection Program*, to establish an Environmental Management System within their ISMS. The dates in which DOE approved the Hanford Site contractor ISMSs are provided in Table 3.1.

[DOE O 450.1A](#), *Environmental Protection Program*, requires implementation of an Environmental Management System that is integrated into each DOE site ISMS and reflects the elements and framework in the [ISO 14001:2004](#)(E) standard (ISO 14001). Elements of ISO 14001, include a defined environmental policy; planning, including environmental aspects, legal and other environmental requirements, and environmental objectives, targets, and programs; implementation and operations, including resources, roles, responsibility and authority, competence, training and awareness, communication, documentation, document control, operational control, and emergency preparedness and response; checking, including monitoring and measuring, evaluation of compliance, nonconformity, corrective and preventative action, records control, and internal audit; and management review.

[DOE O 450.1A](#) further states that each Environmental Management System must include policies, procedures, and training to identify operations and activities with significant environmental impacts; to manage, control, and mitigate impacts; and to assess performance, implement corrective actions where needed, and to ensure continual environmental improvement. In addition, the Environmental Management System must address sustainable practices for enhancing environmental, energy, and transportation performance required by Executive Order 13423, *Strengthening Federal Environmental, Energy and Transportation Management* (72 FR 3919) and DOE O 430.2B, *Departmental Energy, Renewable Energy and Transportation Management*; protection of public health and the environment; wildland fire protection; natural and cultural resource protection and stewardship; effluent and environmental monitoring; quality of analytical data; assessment of engineered nanomaterial hazards; and identification of opportunities to implement additional sustainable practices.

Implementing an Environmental Management System provides further assurance that contractors are employing sound stewardship practices that are protective of the air, water, land, and other natural and cultural resources potentially impacted by their operations. [Executive Order 13514](#), *Federal Leadership in Environmental, Energy, and Economic Performance* (74 FR 52117), builds upon the requirements of [Executive Order 13423](#) (72 FR 3919), including the requirement to implement an Environmental Management System and includes additional obligations for federal agencies to increase efficiency energy, conserve and protect water resources, reduce greenhouse gas emissions, and implement and maintain other sustainable practices. The dates in which DOE directed Hanford Site contractors to implement [DOE O 450.1A](#), [DOE O 430.2B](#), [Executive Order 13423](#), and [Executive Order 13514](#) are provided in Table 3.1. Dates in which these orders were issued are provided in Table 3.2.

[DOE O 436.1](#), *Departmental Sustainability*, approved in May 2011, requires development of a Site Sustainability Plan that is integrated into operational plans, and development of an Environmental Management System that is certified to, or conforms with the [ISO 14001:2004](#) standard. The order also requires submitting sustainability goal data and reports as well as [Emergency Planning and Community Right-to-Know Act](#) reporting. The dates that DOE directed Hanford Site contractors to implement [DOE O 436.1](#) are provided in Table 3.1, in addition to the dates that Hanford Site contractors became certified to the [ISO 14001:2004](#) standard.

Performance related to Environmental Management Systems must be reported annually to DOE HQ. Each contractor is given an overall ranking of Red, Yellow or Green based on the previous fiscal year's performance. Rankings for Hanford Site contractors are provided in Table 3.0.1 along with rankings for the three Hanford DOE Offices.

MSA—as the services and infrastructure contractor for the Hanford Site—developed a sustainability plan for the Hanford Site in 2010 with input from site contractors. The plan was revised in 2011 and describes the energy management program; identifies planned energy efficiency, water conservation, transportation fleet management, and sustainable buildings activities; and includes an Emergency Conservation Plan, as required by DOE O 430.2B and Executive Order 13423 (72 FR 3919). Environmental objectives, developed in 2010, were maintained, as were plans for recycling, ozone-depleting substance management, environmentally preferred procurement management, and electronic asset stewardship. The *Hanford Site Ozone-Depleting Substance Program Plan* ([DOE/RL-2010-86](#)) describes ozone-depleting substance management and disposal requirements at the Hanford Site as well as requirements for evaluating and considering the use of non-ozone-depleting alternatives before procuring any refrigerant material. Hanford Site officials coordinate with the U.S. Department of Defense (as required by DOE O 450.1A) when disposing ozone-depleting substances that are removed from refrigerant systems being decommissioned or taken out of service.

Several contractors have made their environmental policy and environmental aspects available to the public through company Internet websites (Table 3.3). Benefits of implementing the systematic approach of an Environmental Management System as reported by Hanford Site contractors include enhanced public perception as a 'good neighbor'; reduced operational costs; use of upfront planning to identify waste-disposal pathways and reduce volume; early requirements identification to avoid project delays; high level of integration with existing programs to reduce administrative burden; more efficient systems; cooperation with key stakeholders; fewer environmental violations; improvements in business practices and staff awareness; reduced water use; improvement in groundwater quality; reduction in energy needs through building removal; efficient environmental sampling; increased recycling; and more efficient waste disposal.

### 3.1 Environmental Performance Measures

MSA, in consultation with the DOE and other Hanford Site prime contractors, developed and maintains environmental performance measures for the Hanford Site. Performance measures address the goals of [DOE O 450.1A](#), [DOE O 430.2B](#), [Executive Order 13423](#) (72 FR 3919), and [Executive Order 13514](#) (74 FR 52117). The measures developed in response to these executive orders and DOE orders include regulated waste reduction; toxic and hazardous material reduction; sustainable acquisition; compliance with Electronic Product Environmental Assessment Tool standards; sanitary waste diversion; construction waste diversion; electricity use; facility fuel use; water use; vehicle fuel use; numbers of alternative fuel vehicles; on-time environmental deliverables; environmental inspections; and environmental non-compliances. Baseline data were obtained in accordance with guidance in the orders.

Where no guidance was available, data from 2009 or 2010 were used to establish performance baselines. Performance measurement data are used as a tool to ensure environmental goals within the DOE orders are appropriately managed. Performance related to Environmental Management Systems must be reported annually to DOE HQ.

**Alternative Fuel Vehicles.** Number of alternative fuel vehicles in inventory at the Hanford Site has decreased; however, the percentage of alternative fuel vehicles remained the same (Figure 3.1). Requirements specified in [Executive Order 13514](#) (74 FR 52117) include the acquisition of alternative fuel vehicles, optimizing their numbers within the onsite fleet. Low greenhouse gas-emitting vehicles, including alternative fuel vehicles, are associated with alternative fuel usage.

Table 3.1 DOE Contract Actions and Contractor Implementation

DOE Contract Actions & Contractor Implementation	RL				ORP			DOE-PNSO	
	CSC	CHPRC	MSA	WCH	ATL	BNI	WRPS	PNNL	
Contract Implementation	06/06/04	10/01/08	08/24/09	08/27/05	05/05/05	12/11/00	10/01/08	12/30/94	
Contractor ISMS Established	N/A	11/09	01/11	11/07	03/06	02/03	09/09	06/98	
Direction to Implement DOE EO 13423	N/A	10/08	08/09	06/09	N/A	N/A	10/08	2008	
Direction to Implement DOE O 430.2B	N/A	06/09	08/09	06/09	N/A	N/A	10/08	07/08	
Direction to Implement DOE O 450.1A	06/08	06/09	08/09	06/09	11/09	N/A	10/09	12/08	
Direction to Implement DOE EO 13514	N/A	N/A	05/11	N/A	N/A	N/A	03/11	10/11	
Direction to Implement DOE O 436.1	N/A	N/A	N/A	N/A	N/A	N/A	NA	N/A	
Contractor EMS Established	12/09	11/09	12/09	09/09	N/A	N/A	09/09	10/96	
DOE Declared DOE O 450.1A Conformance	N/A	12/09	12/09	11/09	N/A	N/A	09/09	06/09	
ISO 14001 Certification	N/A	N/A	09/11	N/A	N/A	N/A	NA	10/02	
Contractor EMS Scorecard Rating	Yellow	Green	Green	Green	N/A	Red	Green	Green	
2011 EMS Scorecard	Green				Yellow			Green	
RL: DOE-Richland Operations Office		ORP: DOE-Office of River Protection			PNSO: DOE-Pacific Northwest Site Office				
CSC:	CSC Hanford Occupational Health Services	ATL:	Advanced Technologies and Laboratories, Inc.			PNNL: Pacific Northwest National Laboratory			
CHPRC:	CH2M HILL Plateau Remediation Company	BNI:	Bechtel National, Inc.			operated by Battelle Memorial Institute			
MSA:	Mission Support Alliance, LLC	WRPS:	Washington River Protection Solutions, LLC						
WCH:	Washington Closure Hanford, LLC								

**Table 3.2 DOE Order and Executive Order Issuance**

Order	Approval Date
DOE Order 450.1	January 15, 2003
Executive Order 13423	January 26, 2007
DOE Order 430.2B	February 27, 2008
DOE Order 450.1A	June 4, 2008
Executive Order 13514	October 8, 2009
DOE Order 436.1	May 2, 2011

**Table 3.3 Hanford Site Environmental Management System Internet Links**

Contractor	Website	Category
CHPRC	<a href="http://www.platauremediation.hanford.gov/index.php/page/154/">http://www.platauremediation.hanford.gov/index.php/page/154/</a>	Policy
MSA	<a href="http://msa.hanford.gov/msa/filedisplay.cfm?fileid=1158">http://msa.hanford.gov/msa/filedisplay.cfm?fileid=1158</a>	Policy, Aspects
PNNL	<a href="http://www.pnl.gov/about/environmental.asp">http://www.pnl.gov/about/environmental.asp</a> <a href="http://www.pnl.gov/ems/env_impacts.asp">http://www.pnl.gov/ems/env_impacts.asp</a>	Policy, Aspects
WCH	<a href="http://www.washingtonclosure.com/about_us/environmental_stewardship">http://www.washingtonclosure.com/about_us/environmental_stewardship</a>	Policy, Aspects
WRPS	<a href="http://www.wrpstoc.com/what_we_do/environmental_management">http://www.wrpstoc.com/what_we_do/environmental_management</a>	Policy, Aspects

**Alternative Fuel Use.** The alternative fuel use target was surpassed for FY2011; however, petroleum-based fuel use did not meet its target (Figure 3.2). The requirement specifies the Hanford Site contractors' entire fleet operate alternative fuel vehicles exclusively on alternative fuels to the maximum extent possible to reduce the amount of petroleum-based fuels by 2 percent annually through to FY2020, relative to a FY2005 baseline (Executive Order 13514 [74 FR 52117]).

**Potable and Non-Potable Water.** The target objectives for potable and non-potable water were met in 2011 (Figure 3.3). Water use requirements, as specified by Executive Order 13514 (74 FR 52117), stipulate the reduction of potable water consumption intensity by 2 percent annually through FY2020, or 26 percent by the end of FY2020, relative to a baseline of water consumption in FY2007. Correspondingly, there is a requirement to reduce non-potable water use by 2 percent annually through the end of FY2020, or 20 percent by the end of FY2020, relative to a FY2010 baseline.

**Green Electricity.** The target objective for green electricity was met; however, the target objective for standard electricity was not met in FY2011 (Figure 3.4). Targets and objectives for electricity use designate improvements to increase energy efficiency and energy management. Requirements call for the reduction of standard electricity use by 3 percent annually, or 45 percent through the end of FY2020, relative to the FY2003 baseline, and an increase in renewable energy consumption (green electricity) equivalent to 7.5 percent of the annual electricity and thermal consumption total by FY2010.

**Facility Fuel.** The target objectives for facility fuel use were met in 2011 (Figure 3.5). Objectives were established to demonstrate improvements in energy efficiency and effective management of energy use while increasing the use of clean energy sources. The target requirements include reducing energy use by 3 percent annually (or 45 percent through the end of FY2020) relative to the FY2003 baseline.

**Electronic Product Environmental Assessment Tool.** The target objectives for Electronic Product Environmental Assessment Tool were exceeded, with 99 percent of the purchases meeting the requirements (Figure 3.6). [Executive Order 13514](#) (74 FR 52117) specifies 95 percent of procured electronic assets (notebooks, computers and monitors) must comply with the Electronic Product Environmental Assessment Tool standard in an effort to reduce or eliminate the environmental impacts of electronic assets by incorporating electronic stewardship practices.

**Chlorine and Herbicide Reduction.** The target objectives for chlorine and herbicide reduction (Figure 3.7) were met. A 5 percent annual reduction target was established for herbicides and chlorine, using FY2007 values as baselines. [Executive Order 13514](#) (74 FR 52117) stipulates the elimination or minimization of the acquisition, use, and associated release of toxic and hazardous chemicals and materials, including hazardous substances, ozone-depleting substances, and other pollutants.

**Sanitary Waste Reduction.** The target objective was met for sanitary waste reduction. Reduction of regulated sanitary wastes requires the diversion of post-consumer materials suitable for reuse and recycling from landfills by 10 percent per year, based on a FY2010 baseline (Figure 3.8). More Hanford Site sanitary waste was recycled than was sent to landfills in FY2011.

**Regulated Waste Reduction.** The target objective for regulated waste reduction was met (Figure 3.9). Objectives for regulated waste reduction on the Hanford Site include eliminating or minimizing waste generation 5 percent annually (based on FY2009 generation) through source reduction including segregation, substitution, and reuse that would otherwise require storage, treatment, and long-term monitoring and surveillance. Regulated waste includes waste such as hazardous, universal, special, state-regulated industrial and radioactive waste not suitable for disposal in sanitary or construction and demolition landfills. Regulated waste from the Environmental Restoration Disposal Facility is not included in Figure 3.9. Waste to this facility increased considerably in 2011 because of Hanford Site remediation activities (Figure 3.10).

In addition to these metrics, each contractor has established company-specific performance measures within their Environmental Management Systems.

## **3.2 Awards and Recognition**

*AS Nagel and JF Ollero*

### **3.2.1 Hanford Site**

The Hanford Site received an EPA Federal Electronic Challenge Gold Award for its FY2011 efforts in successfully managing the lifecycle of electronic equipment in a sustainable manner, and the Bronze Green Buy award from DOE for FY2011 efforts in purchasing sustainable products. Acquisition and procurement, operations and maintenance, and end of life management of electronic equipment are all considered when awarding at the bronze, silver, gold, and platinum levels. In addition, the Hanford Site was awarded three DOE EM Best In Class awards and eight Honorable Mention Awards.

### **3.2.2 Advanced Technologies and Laboratories**

Advanced Technologies and Laboratories receive notification from DOE in February 2011 that it successfully maintained its Voluntary Protection Program Star Status.



The Hanford Site did not receive any other DOE, federal agency, state agency, or industry-sponsored environmental awards or recognition in 2011. As part of their Environmental Management System, several Hanford Site contractors developed internal environmental awards programs to recognize leadership in environmental, energy, and transportation stewardship.

### **3.2.3 CH2M Hill Plateau Remediation Company**

In July 2011, CHPRC received the Voluntary Protection Program Merit Status. CHPRC was awarded four DOE Environmental Management (EM) Environmental Star Awards in 2012 for activities performed in FY2011, including two EM Best-in-Class awards and two Honorable Mention awards. The projects awarded the EM Best-in-Class, *Preparation of the U-Canyon for Demolition and Barrier Construction*, a co-project with WCH, and *Next Generation Retrieval*, focused on pollution prevention measures to divert waste from being disposed of in landfills. The projects awarded Honorable Mentions included *Stockpiled Material Used as Backfill and Rail Cars Preserved for Public Display*. CHPRC also was awarded the ORP Manager's Award for Exemplary Service for developing a method to remove radioactive sodium metal from the scrap metal of a sodium-cooled nuclear reactor.

### **3.2.4 Mission Support Alliance, LLC**

MSA achieved certification in September 2011 to the ISO 14001:2004[E] standard. Also in September 2011, DOE awarded the HAMMER training facility, operated by MSA, the Voluntary Protection Program Star Status. DOE awarded MSA with Voluntary Protection Program Star Status in January 2011 for its Mission Support Services and Merit Status for its Safeguards and Security group. Star status is DOE's highest level of excellence in employee safety and health. MSA also was awarded several DOE EM Environmental Star Awards in 2012 for activities performed in FY2011, including one EM Best-in-Class award and four Honorable Mention awards. The project awarded Best-in-Class, *Data Center and Infrastructure Consolidation*, focused on operational efficiencies within datacenters that allowed consolidation of 13 datacenters into two and yielded a 50 percent power and 18 percent energy load reduction. Activities awarded an Honorable Mention included *Voice over Internet Protocol (VoIP)*, *Sustainable Fleet Management*, *Thin Client*, and a co-project with WCH *Solar Powered Lighting at the 618-11 Burial Ground Remediation Site*.

### **3.2.5 Washington Closure Hanford, LLC**

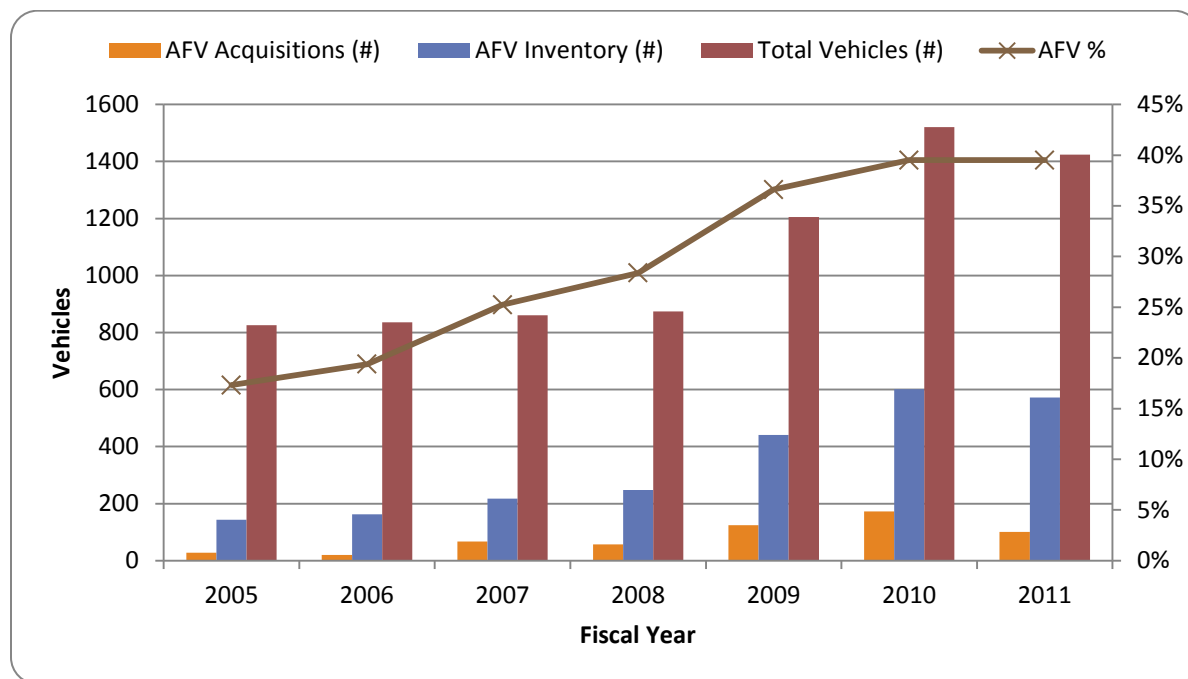
WCH was awarded three DOE EM Environmental Star Awards in 2012 for activities performed in FY2011, which included one DOE EM Best-in-Class award and two Honorable Mention awards. The project awarded Best-in-Class, *Preparation of the U-Canyon for Demolition and Barrier Construction*, a co-project with CHPRC, focused on pollution prevention measures to divert waste from being disposed of in landfills. The Honorable Mention awards included *Removal and Reuse of 30 Miles of Rail Line* and a co-project with MSA *Solar Powered Lighting at the 618-11 Burial Ground Remediation Site*.

### **3.2.6 Pacific Northwest National Laboratory**

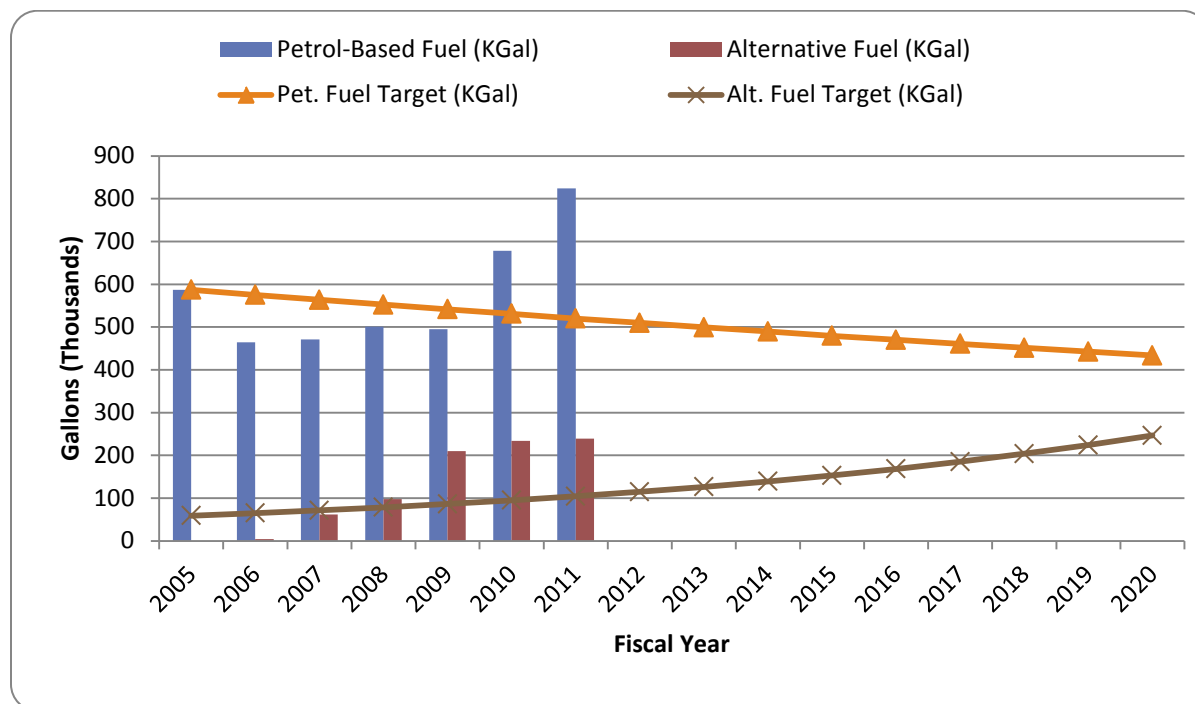
PNNL received recognition and several awards for environmental stewardship in 2011, including the *Office of Science Best in Class Award, Greenhouse Gas Management Category* for identifying greenhouse gas abatement strategies to help reach a goal of climate neutrality; i.e. no net greenhouse gas emissions (GHG), for the PNNL campus. PNNL is working toward implementing the most feasible of the GHG greenhouse gas abatement strategies. PNNL also received the DOE Environmental Star Award for integrating sustainability

programs into an effective and efficient operational model. The model includes a collaborative steering committee comprised of research organizations, facilities, human resources, and environmental staff. A third award received was the *Association of Washington Business, Environmental Excellence Award, Sustainable Communities and Green Building Category* for sustainable design of PNNL's new Biological Sciences, Computational Sciences, and Physical Sciences facilities including efforts to identify climate neutrality strategies. PNNL also achieved recertification to the ISO standard—*Environmental management systems – Requirements with guidance for use* (ISO 14001:2004[E]) in 2011. Organizations certified to the standard have developed and implemented an Environmental Management System based on ISO 14001:2004 requirements, must pass annual external audits from an accredited registrar on a 3-year cycle, and have committed to continually improving their environmental performance.

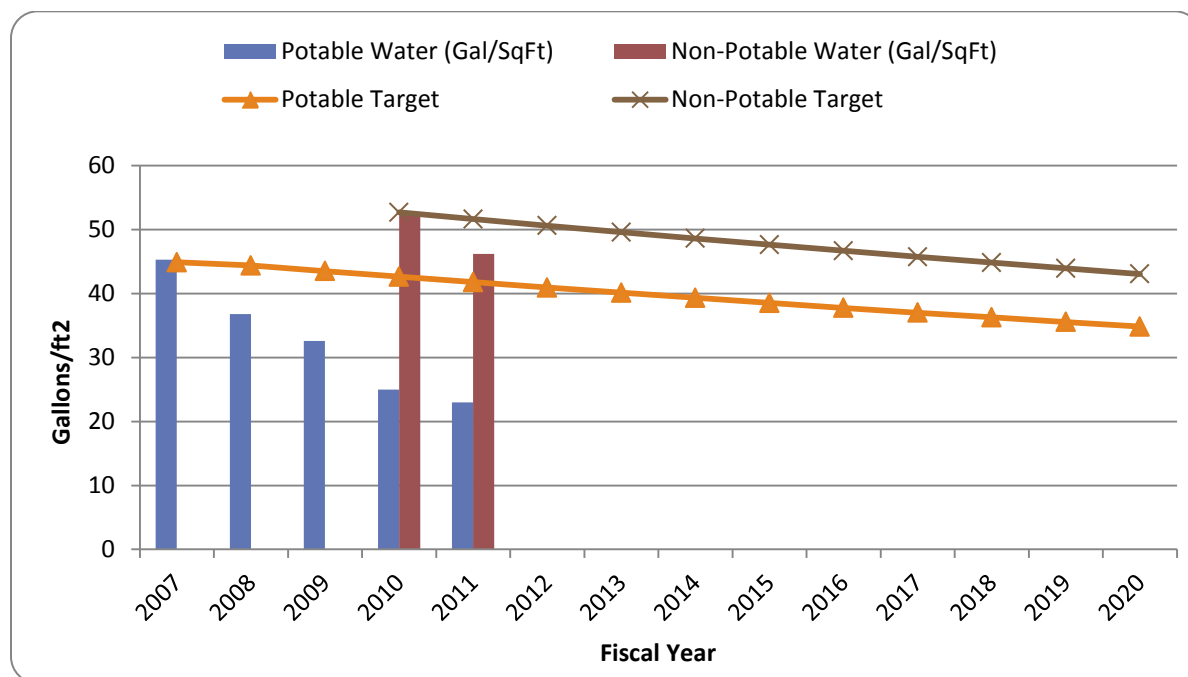
**Figure 3.1. Vehicle Classifications**  
(FY2005 through FY2011)  
AFV = alternative fuel vehicles



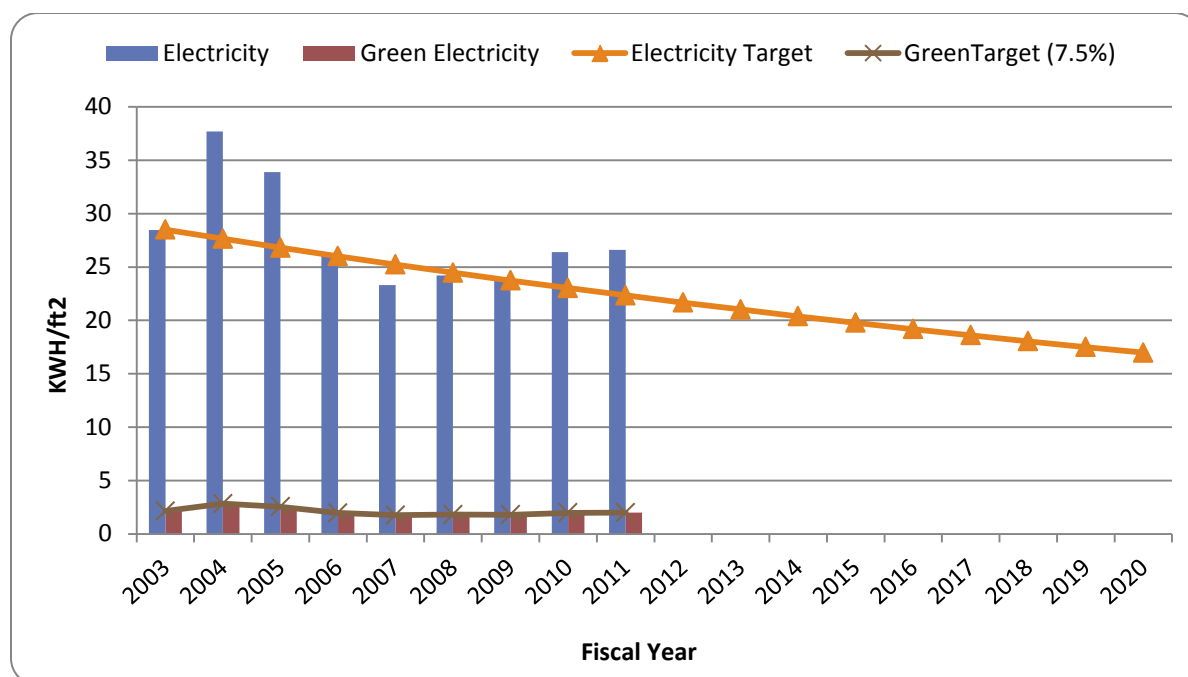
**Figure 3.2. Vehicle Fuel Use**  
(FY2005 through FY2011, Target Objectives through 2020)



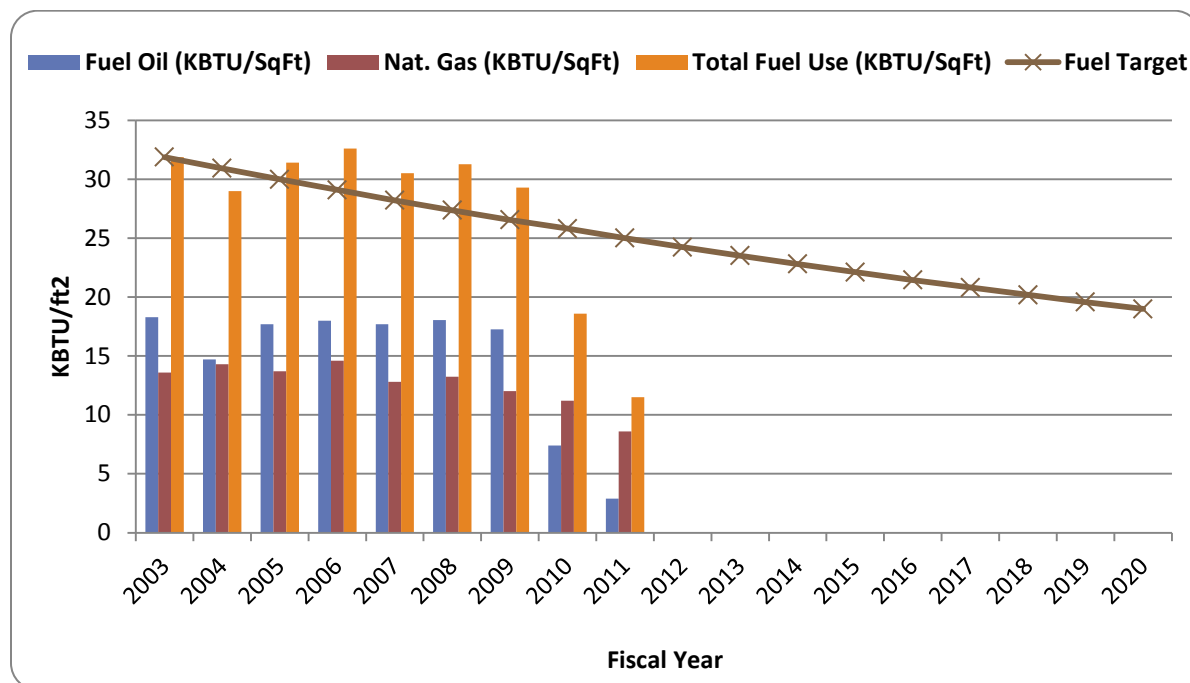
**Figure 3.3. Water Use**  
(FY2007 through FY2011, Target Objectives through 2020)



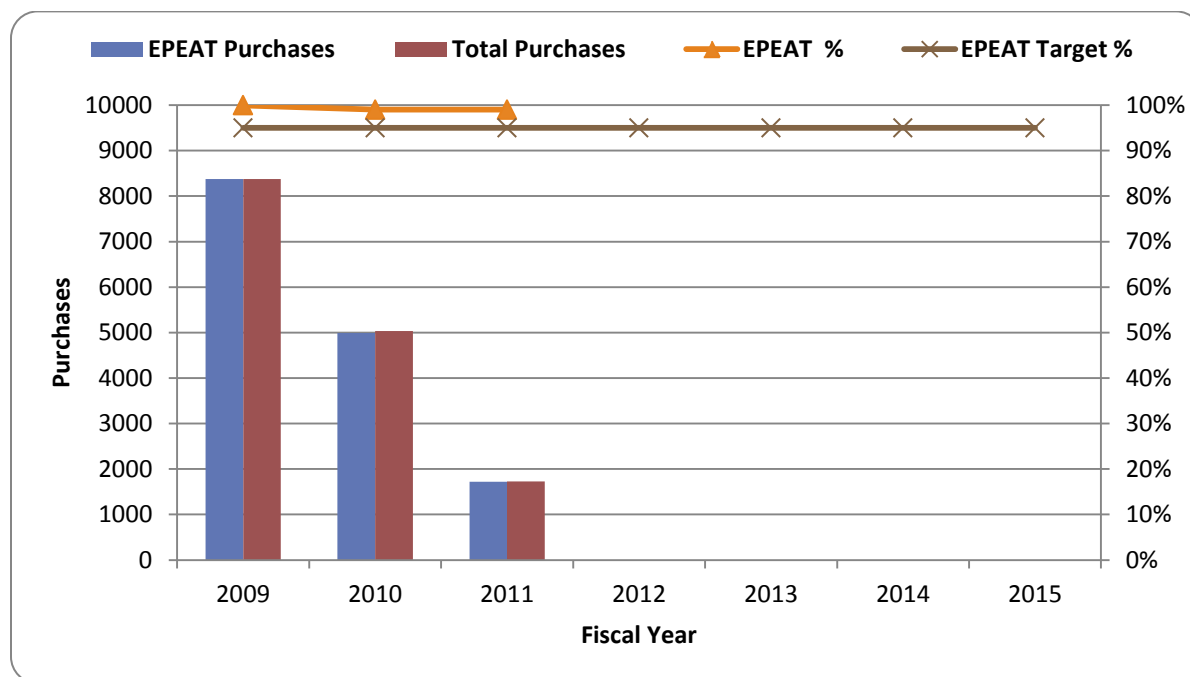
**Figure 3.4. Electricity Use**  
(FY2003 through FY2011, Target Objectives through 2020)



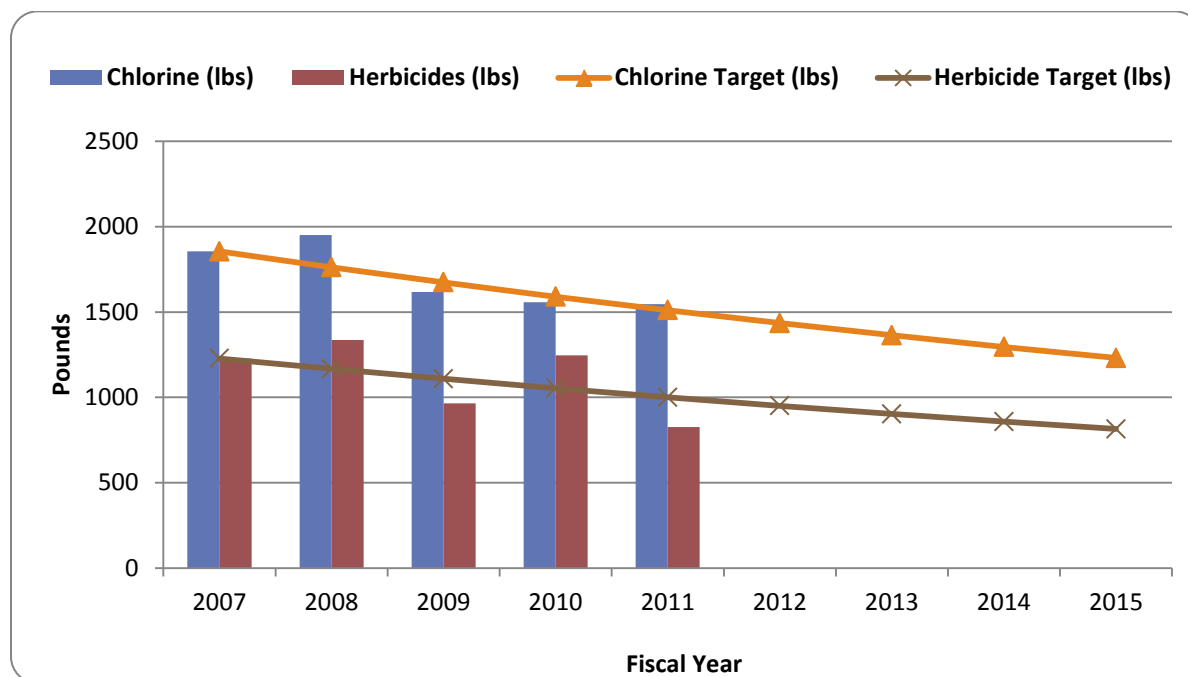
**Figure 3.5. Fuel Use**  
(FY2003 through FY2011, Target Objectives through 2020)  
KBTU = one thousand British thermal units



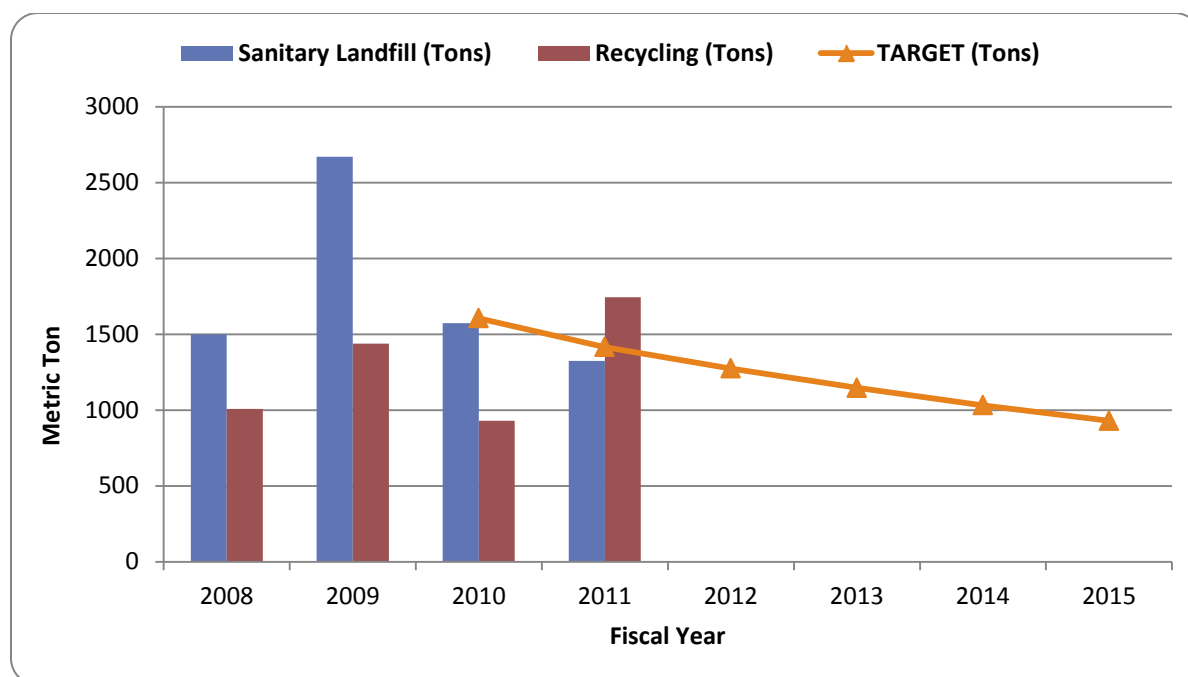
**Figure 3.6. Electronic Product Environmental Assessment Tool Standards Compliance**  
(FY2009 through FY2011, with Target Objectives through 2015)



**Figure 3.7. Toxic and Hazardous Waste Reduction**  
(FY2007 through FY2011, Target Objectives through 2015)

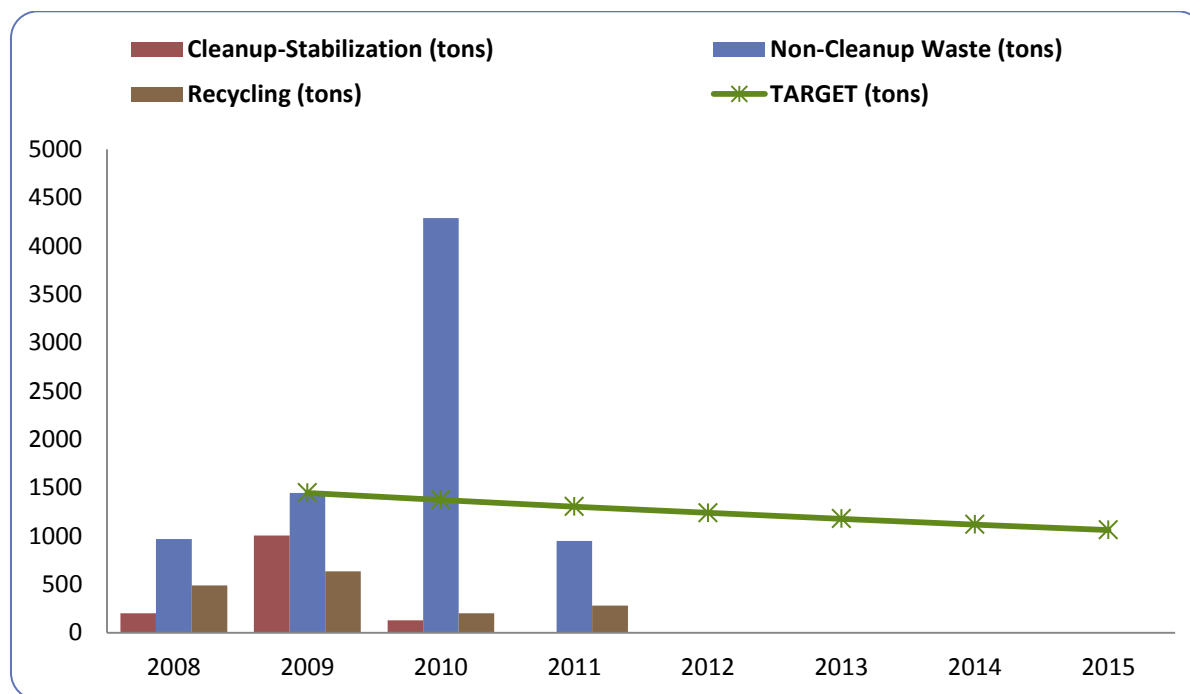


**Figure 3.8. Sanitary Waste Reduction**  
(FY2008 through FY2011, Target Objectives through 2015)

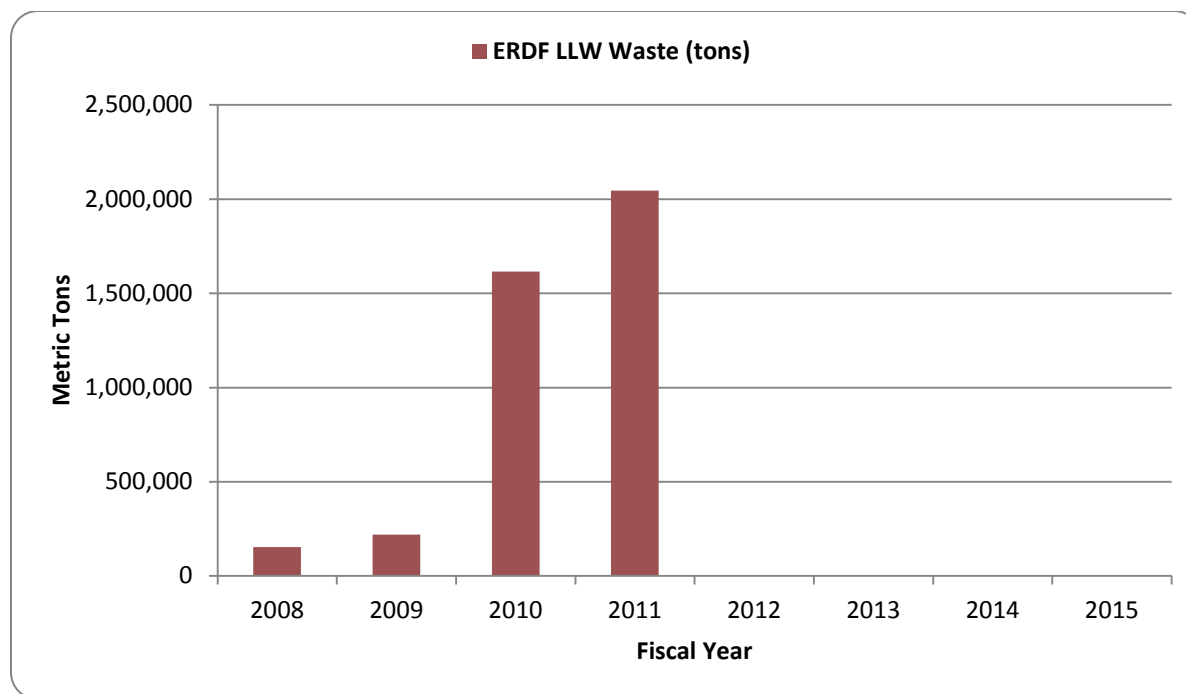




**Figure 3.9. Waste Reduction**  
(FY2008 through FY2011, Target Objectives through 2015)



**Figure 3.10. Waste Disposed**  
(FY2008 to FY2011, at the Environmental Restoration Disposal Facility)



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## 4.0 Radiological Protection Program and Doses

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This section provides information on Hanford Site radiological program and doses, and cleanup activities as DOE progresses toward site closure and the likely transfer of property to other entities.

### 4.1 External Radiation Monitoring

*CJ Perkins*

External radiation is defined as radiation originating from a source external to the human body. External radiation was monitored in 2011 at the Hanford Site in relative proximity to known or potential radiation sources. Sources of external radiation at the Hanford Site include waste materials associated with the historical production of plutonium for defense; residual nuclear inventories in former production and processing facilities; radioactive waste handling, storage, and disposal activities; waste cleanup and remediation activities; atmospheric fallout from historical nuclear weapons testing; and natural sources such as cosmic radiation. During any given year, external radiation levels can vary from 15 percent to 25 percent at any location because of changes in soil moisture and snow cover (National Council on Radiation Protection and Measurements 1975).

The Harshaw<sup>TM(1)</sup> thermoluminescent dosimeter (TLD) system is used to measure external radiation on the Hanford Site. This system includes the Harshaw 8800-series dosimeter and the Harshaw 8800 reader. The Harshaw 8800-series environmental dosimeter consists of two TLD-700 chips and two TLD-200 chips and provides both shallow- and deep-dose measurement capabilities using filters in the dosimeter. Data obtained from the two TLD-700 chips were used during 2011 to determine the average total environmental dose at each location. The two TLD-200 chips were included to determine doses in the event of a radiological emergency and were not used in calculating average total environmental dose. The average daily dose rate was determined by dividing the average total environmental dose by the number of days the dosimeter was exposed. Daily dose equivalent rates (millirem per day) at each location were converted to annual dose equivalent rates (millirem per year) by averaging the daily dose rates and multiplying by 365 days per year. The TLDs were positioned approximately 3.3 feet (1 meter) aboveground and were collected and read quarterly.

Radiation surveys with portable instruments are conducted to monitor and detect contamination and to provide a coarse screening for external radiation fields. The types of areas surveyed in 2011 included underground radioactive material areas, contamination areas, soil contamination areas, high-contamination areas, roads, and fence lines.

External radiation fields were monitored with TLDs in 2011 at 119 locations near Hanford Site facilities and operations. The TLD results were used individually or averaged to determine dose rates in a given area for a specific sampling period. Table 4.1 compares 2010 and 2011 results for TLDs located near waste-handling facilities at the Hanford Site. Individual TLD results and detailed maps of monitoring locations are available upon request (refer to Preface for contact information).

Additional information on radiation, dose rates, and dose terminology can be found in Appendix A, Helpful Information; and Appendix B, Glossary.

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(1) Harshaw is a trademark of Thermo Fisher Scientific, Inc., Waltham, Massachusetts.

#### **4.1.1 External Radiation Measurements**

**100-K Area.** Cleanup activities for the K Basins Closure Project during 2011 resulted in continued decreases in the average dose rates at most TLD locations in the 100-K Area compared to 2010 (Figure 4.1). Dose-rate levels measured in 2010 at monitoring stations in the K-East Area and at the Cold Vacuum Drying Facility were, respectively, 20 percent and 1 percent lower than 2010 levels. Dose-rate levels measured in 2011 at monitoring stations in the K-West Area were, overall, 20 percent higher than in 2010. This was primarily due to second and third quarter increases measured at the monitoring station located near the 105-K West facility where radioactively contaminated waste containers were temporarily staged prior to transport to ERDF. Dose rate levels at this location returned to typical levels during the 4th-quarter of the year.

**100-N Area.** Average dose-rate levels observed in the 100-N Area during 2011 showed an overall increase (approximately 20 percent) compared to 2010 levels. This was primarily due to second and third quarter increases measured at the monitoring station located along/near the transportation route for disposal of radioactive waste. Dose rate levels at this location returned to typical levels during the fourth quarter of the year.

**100-N Area Shoreline (N Springs).** Dose rates were measured along the Columbia River shoreline in the 100-N Area (N Springs) to determine potential external radiation doses to onsite workers and to the public accessing the river. Cleanup activities at the retired 116-N-1 and 116-N-3 Trenches (located near the Columbia River) have decreased dose rates notably over the past few years (Figure 4.1). The 2011 average dose rate was unchanged compared to 2010, and was less than 100 millirem (1 millisievert) per year.

**200-East and 200-West Areas.** Dose rate levels measured during 2011 in the 200-East and 200-West Areas were slightly decreased compared to 2010 (Figure 4.1).

Average dose rates measured in 2011 at ERDF (located near the 200 West Area) were comparable to 2010 levels.

**200-North Area.** One TLD monitoring site, located in the 200-North Area at the contaminated 212-R Railroad Car Disposition Area, showed a significant annual average dose rate decrease of 80 percent in 2011 compared to 2010 levels. This TLD location was established in 2000 to monitor expected high radiation levels emitted from contaminated railroad cars. During the fourth quarter of 2010, dose rate levels began to fall as the radiologically contaminated railroad cars were dispositioned.

**300 and 400 Areas.** The average dose rates in 2011 in the 300 and 400 Areas and at the 300 Area Treated Effluent Disposal Facility were comparable to 2010 levels (Figure 4.1).

**618-10 Burial Ground.** TLD monitoring was initiated during late-February 2010 at four locations at this project. The average dose rates in 2011 were comparable to 2010 levels.

**Integrate Disposal Facility.** The average dose rates in 2011 were unchanged from 2010 levels.

**Table 4.1. Thermoluminescent Dosimeter Results (2010 and 2011)**(mrem/year)<sup>(a)</sup>

Location	No. of Dosimeters	2010		2011		Percentage Change <sup>(e)</sup>
		Maximum <sup>(b)</sup>	Average <sup>(c,d)</sup>	Maximum <sup>(b)</sup>	Average <sup>(c,d)</sup>	
100-K	14	187 ± 131	109 ± 68	207 ± 203	102 ± 74	-6
100-N	5	152 ± 201	94 ± 65	203 ± 185	116 ± 115	23
200-East	42	480 ± 187	107 ± 127	385 ± 407	100 ± 98	-6
200-West	24	219 ± 49	98 ± 62	178 ± 63	96 ± 52	-1
200-North (212-R) <sup>(f)</sup>	1	1,508 ± 226	1,329 ± 397	570 ± 86	251 ± 456	-80
300 Area	8	113 ± 22	87 ± 28	114 ± 12	86 ± 29	-1
300 TEDF	6	83 ± 3	81 ± 4	81 ± 6	79 ± 4	-1
400 Area	7	88 ± 6	79 ± 8	89 ± 8	79 ± 9	<1
618-10	4	77 ± 20	76 ± 2	75 ± 34	74 ± 4	-2
CVDF	4	80 ± 10	73 ± 9	78 ± 13	74 ± 5	1
ERDF	3	80 ± 10	78 ± 2	89 ± 5	81 ± 13	3
IDF <sup>(f)</sup>	1	88 ± 13	84 ± 8	88 ± 13	83 ± 7	<1

(a) To convert to international metric system units, multiply mrem/year by 0.01 to obtain mSv/year

(b) Maximum values are ± analytical uncertainty

(c) ± 2 standard deviations

(d) Each dosimeter is collected and read quarterly

(e) Numbers indicate a decrease (-) or increase from the 2009 mean

(f) Maximum value represents highest quarterly value ± analytical uncertainty.

CVDF = Cold Vacuum Drying Facility (100 K Area)

ERDF = Environmental Restoration Disposal Facility (200 West Area)

IDF = Integrated Disposal Facility (200 East Area)

TEDF = 300 Area Treated Effluent Disposal Facility

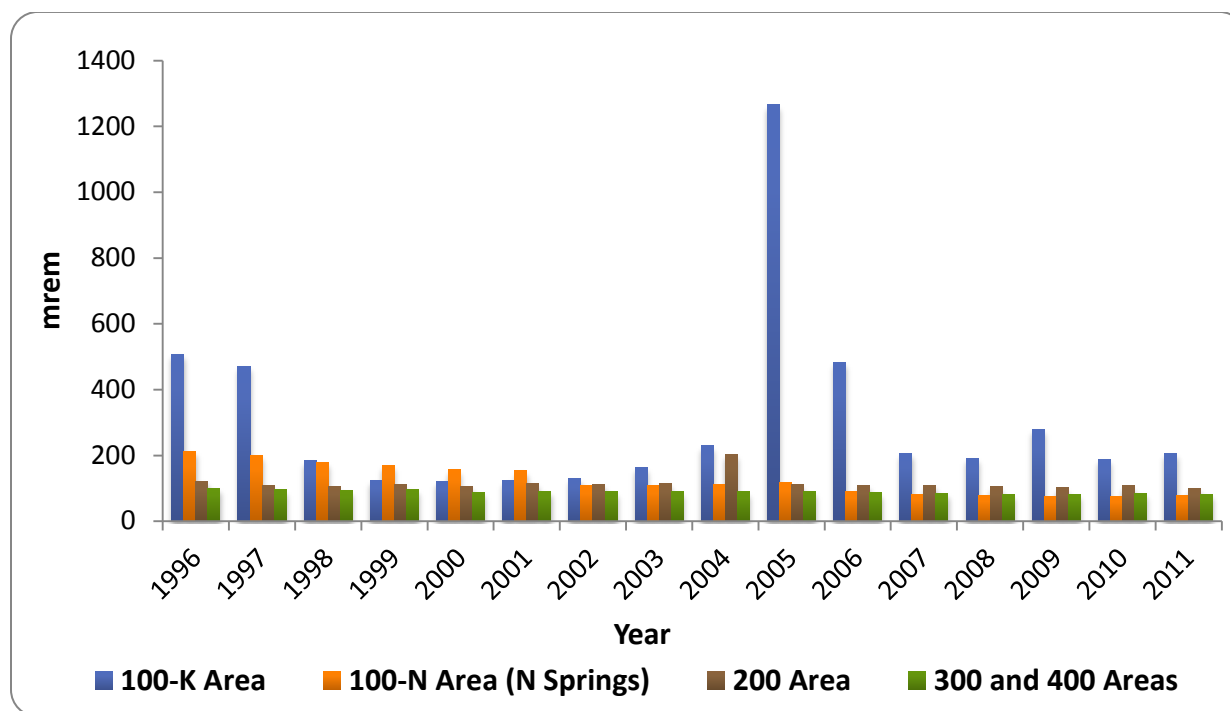
#### 4.1.2 Waste Disposal Sites Radiological Surveys

MC Dorsey

During 2011, a total of 8,022 environmental radiological surveys were conducted at active and inactive waste disposal sites and the surrounding terrain to detect and characterize radioactive surface contamination.

Vehicles equipped with radiation detection devices and global positioning systems were used to accurately measure the extent of contamination. Area measurements were entered into the Hanford Geographical Information System, a computer database maintained by MSA. Routine radiological survey locations included former waste disposal cribs and trenches, retention basin perimeters, ditch banks, solid waste disposal sites (e.g., burial grounds), unplanned release sites, tank farm perimeters, stabilized waste disposal sites, roads, and firebreaks in and around the Hanford Site operational areas. These sites were posted as underground radioactive material areas, contamination areas, and soil contamination areas. The external dose rate at 80 percent of the outdoor contamination areas was estimated to be less than 1 millirem (0.01 millisievert) per hour, although direct dose-rate readings from isolated radioactive specks could have been higher.

Underground radioactive material areas are regions where radioactive materials occur below the soil surface. These areas are typically stabilized cribs, burial grounds, covered ponds, trenches, and ditches. Barriers have been placed over the contamination sources to inhibit radionuclide transport to the surface. These areas are surveyed at least annually to assess the effectiveness of the barriers.

**Figure 4.1. Selected Average Thermoluminescent Dosimeter Results (1996 through 2011)**

Contamination areas and soil contamination areas may or may not be associated with an underground structure containing radioactive material. A breach in the surface barrier of a contaminated underground area may result in the growth of contaminated vegetation. Insects or animals may burrow into the soil and bring contamination to the surface. Vent pipes or risers from an underground structure may be sources of speck contamination (particles with a diameter less than 0.25 inch [0.6 centimeter]). Areas of contamination not related to subsurface structures can include sites contaminated with fallout from effluent stacks or with materials from unplanned releases (e.g., contaminated tumbleweeds and animal feces).

All contaminated areas may be susceptible to contaminant migration and are surveyed at least annually to assess their current radiological status. In addition, onsite paved roadways are surveyed annually, and the intersections along ERDF haul routes are surveyed quarterly.

The Hanford Site had approximately 8,850 acres (3,580 hectares) of outdoor contaminated areas of all types during 2011 and approximately 1,364 acres (552 hectares) that contained underground radioactive materials, not including active facilities. Table 4.2 lists the contamination areas, underground radioactive material areas, and interim-closed areas as well as their status and general locations. No new areas of significant size were discovered during 2011. Waste sites are 'interim-closed' and released from radiation posting when the remedial actions meet the ROD cleanup requirements for the operable unit. Approximately 26 acres (11 hectares) of previously posted contamination and/or underground radioactive material areas underwent remediation in 2011 and were interim closed. Table 4.2 summarizes the change in status of outdoor contamination areas during 2011.



**Table 4.2. Outdoor Contamination Areas, Underground Radioactive Material Areas, and Interim-Closed Areas (2011)**

Area	Contamination Areas(a)		Underground Radioactive Material Areas(b)		Interim Closed Areas	
	acres	ha	acres	ha	acres	ha
100-B/C	0	0	37	15	77	31
100-D/DR	0	0	44	18	25	10
100-F	0	0	7	3	47	19
100-H	0	0	12	5	22	9
100-K	12	5	111	45	49	20
100-N	1	0	40	16	67	27
200-East <sup>(c)</sup>	175	71	348	141	0	0
200-West <sup>(c)</sup>	67	27	554	224	2	1
300	0	0	101	41	57	23
400	0	0	0	0	0	0
600 <sup>(d)</sup>	8,594	3,478	109	44	27	11
<b>Totals</b>	<b>8,849</b>	<b>3,581</b>	<b>1,364</b>	<b>552</b>	<b>372</b>	<b>151</b>

(a) Includes areas posted as contamination/soil contamination or as radiologically controlled and areas that had both underground radioactive material and contamination/soil contamination.

(b) Includes areas with only underground contamination.

(c) Includes tank farms.

(d) Includes BC Controlled Area, Environmental Restoration Disposal Facility, and waste-disposal facilities outside the 200-East and 200-West Areas boundaries

**Table 4.3. Outdoor Contamination Area Status (2011)**

Areas	Change in Status of Outdoor Contamination Areas	Area	
		acres	ha
100 Area	Contamination/soil contamination area/underground radioactive material area to interim closed <sup>(a)</sup>	11.3	4.6
200-East Area	Contamination/soil contamination area/underground radioactive material area to interim closed <sup>(a)</sup>	0.1	0.0
200-North Area	Contamination/soil contamination area/underground radioactive material area to interim closed <sup>(a)</sup>	12.9	5.2
200-West Area		1.6	0.7
300 Area	Contamination/soil contamination area/underground radioactive material area to interim closed <sup>(a)</sup>	0.0	0.0
400 Area	None to report	0.0	0.0
600 Area	Contamination/soil contamination area/underground radioactive material area to interim closed <sup>(a)</sup>	0.0	0.0
<b>Totals</b>		<b>25.9</b>	<b>10.5</b>

(a) Change due to remediation activities.

## 4.2 Potential Radiological Doses

*R Perona, RT Ryti*

Potential radiological doses to the public and biota from Hanford Site operations in 2011 were evaluated to determine compliance with pertinent regulations and limits. Potential sources of radionuclide contamination included gaseous emissions from stacks and ventilation exhausts, liquid effluent from operating wastewater treatment facilities, contaminated groundwater seeping into the Columbia River, and fugitive emissions from areas of contaminated soil and operating facilities. A summary of the methods and results of the public and biota dose assessments is provided here. Details of the methods used to calculate radiological doses are provided in Appendix D.

The radiological impacts of 2011 Hanford Site operations were assessed in terms of the following:

- Dose to a hypothetical, maximally exposed individual at an offsite location, evaluated by using a multimedia pathway assessment ([DOE O 458.1](#), Chg 2; [Section 4.1.1](#))
- Collective dose to the population residing within 50 miles (80 kilometers) of Hanford Site operation areas ([Section 4.2.2](#))
- Doses for air pathways calculated using regulation-specified EPA methods, for comparison to the *Clean Air Act* standards in 40 CFR 61, Subpart H, *National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities* ([Section 4.2.3](#))
- Doses from recreational activities including hunting and fishing ([Section 4.2.4.1](#))
- Dose to a worker consuming drinking water on the Hanford Site ([Section 4.2.4.2](#))
- Doses from non-DOE industrial sources on and near the Hanford Site ([Section 4.2.5](#))
- Absorbed dose received by biota exposed to radionuclide releases to the Columbia River and to radionuclides in onsite surface water bodies ([Section 4.2.6](#)).

Radiological dose assessments related to environmental releases are ideally based on direct measurements of radionuclide concentrations in specific exposure media; however, amounts of many radioactive materials released in 2011 from Hanford Site sources were too small to be measured directly after they were dispersed in the offsite environment. For many of the radionuclides present in measurable amounts, it is difficult to separate Hanford Site source contributions from contributions caused by fallout from historical nuclear weapons testing and naturally-occurring radionuclides such as uranium and its decay products; therefore, computer models are employed to calculate offsite radionuclide concentrations based on measured and estimated releases.

Calculations of radiation dose require the use of biological and radiological models of the behavior of radioactive material in the human body. Scientific understanding of these processes has improved over time. In the 1960s, the annual environmental reporting at the Hanford Site used the recommendations and methodologies of the International Commission on Radiological Protection (ICRP) Report 2 ([ICRP 1959](#)). In the 1970s the annual reports began to follow the newer recommendations in ICRP Reports 26 and 30 ([ICRP 1977](#), [1979](#)), incorporated in the dose factors from the EPA in Federal Guidance Reports 11 and 12 ([EPA 520/1-88-020](#); [EPA 402-R-93-081](#)). The GENII Version 1 computer code, used at the Hanford Site beginning in 1988, used ICRP 26/30 methods ([ICRP 1977](#), [1979](#)) and EPA dose factors.

Offsite dose for a maximally exposed individual ([Section 4.2.1](#)) and collective dose for the population residing within 50 miles (80 kilometers) of Hanford Site operation areas ([Section 4.2.2](#)) are calculated separately for

liquid releases to the Columbia River and stack air emissions. Radiological doses from the water pathways are calculated based on measured discharges to the Columbia River from the 100 Areas and from differences in radionuclide concentrations between upstream and downstream sampling points on the Columbia River. Although the downstream minus upstream radionuclide concentrations include contributions from other operating areas, they have been assigned to the 200 Area for tabulation of radiological dose. No direct discharge of radioactive materials from the 300 Area to the Columbia River was reported during 2011. Radiological doses from the air pathways are calculated based on stack emissions measurements from approximately 60 emission points in Hanford Site operation areas.

Columbia River shoreline spring water containing radionuclides is known to enter the river along the portion of the Hanford Site shoreline extending from the 100-BC Area downstream to the 300 Area. Cesium-137, tritium, and uranium isotopes were found in the Columbia River downstream of the Hanford Site in 2011 at concentrations elevated relative to upstream levels (Appendix C). In addition, strontium-90 and plutonium-239/240 entered the Columbia River from direct discharges in the 100-K Area (Figure 7.8). Radioactive air emissions in 2011 are discussed in [Section 6.1](#) and summarized in Table 6.1. For the GENII Version 2.10 ([PNNL-14583, Rev 3a](#)) dose calculations, ingrowth of radioactive progeny during environmental transport was calculated to develop a complete set of radionuclide release estimates for the model. Details on the development of air pathway and water pathway radioactive release estimates for input to the GENII Version 2.10 computer code ([PNNL-14583, Rev 3a](#)) is provided in Appendix D.

#### **4.2.1 Maximally Exposed Individual Dose (Offsite Resident)**

The maximally exposed individual is a hypothetical person whose location and lifestyle is such that it is unlikely any actual member of the public would have received a higher radiological dose from Hanford Site releases during 2011. This individual's exposure pathways were chosen to maximize the combined doses from all reasonable environmental routes of exposure to radionuclides in Hanford Site liquid effluents and air emissions using a multimedia pathway assessment (DOE O 458.1, Chg 2; Section 4.e). In reality, such a combination of maximized exposures to radioactive materials is highly unlikely to apply to any single individual. The individual pathway dose calculations themselves also incorporate conservative assumptions intended to ensure that modeled concentrations of radionuclides in exposure media and resulting doses are protective. For these reasons, the dose assessment results for the maximally exposed individual represent a reasonable upper bound of potential individual dose rather than an anticipated dose to an actual individual.

The location of the hypothetical, maximally exposed individual varies, depending on the relative contributions of radioactive air emissions and liquid effluent releases from Hanford Site operational areas. Three offsite locations are evaluated annually to determine the location of the maximally exposed individual (Figure 4.2). The Ringold and Sagemoor locations receive maximal air pathway impacts from 200 and 300 Areas, respectively. A small population of West Pasco residents obtains their drinking water from the Riverview location via a community water system, and the domestic drinking water pathway is applied to that location. Riverview is also a location where Columbia River water is withdrawn for irrigation of small gardens and farms.

Dose calculations for 2011 releases indicate that the maximally exposed individual is located across the Columbia River (east of the Hanford Site) at Sagemoor. For the Sagemoor receptor dose calculations, the following exposure routes were evaluated:

- Inhalation and external radiation exposure related to airborne radionuclides
- External radiation exposure and inadvertent soil ingestion for radionuclides deposited on the ground

- Ingestion of locally grown food products irrigated with Columbia River water and/or containing radionuclides deposited from the air
- External radiation exposure to radionuclides in Columbia River water and sediments near the Hanford Site during recreational activities, and inadvertent ingestion of water while swimming
- Consumption of locally caught Columbia River fish.

A graphical depiction of the conceptual site model showing all potentially complete exposure pathways for the Sagemoor maximally exposed individual evaluated using GENII Version 2.10 ([PNNL-14583, Rev 3a](#)) is provided in Figure 4.3. Additional information related to the selection of the maximally exposed individual location for 2011 releases is provided in Appendix D. Exposure variable input values related to residency and recreational exposure times, intake rates for foods and other media, and agricultural pathway assumptions for the maximally exposed individual are provided in Appendix D.

The total dose to the maximally exposed individual at Sagemoor was calculated in 2011 to be 0.09 millirem (0.9 microsievert) per year (Table 4.4; Figure 4.4). This dose is 0.09 percent of the 100-millirem (1,000-microsievert) per year public dose limit specified in DOE O 458.1, Chg 2 and 0.36 percent of the 25-millirem (250-microsievert) per year threshold where a supplemental assessment of dose to the lens of the eye, skin, and extremities is required. Air pathway contributions from 300 Area emissions and water pathway contributions assigned to the 200 Areas contributed equally to the total dose of 0.09 mrem/year.

The primary radionuclides and exposure pathways contributing to the maximally exposed individual dose are as follows:

- Air Releases: Consumption of food products grown downwind from the Hanford Site contributed approximately 90 percent of the of the total air pathways dose of 0.046 mrem/year. The remaining air pathways dose is related to inhalation. Virtually all of these food and inhalation doses are due to airborne releases of tritium from the 300 Area.
- Water Releases: Consumption of fish from the Columbia River contributed approximately 70 percent of the total water pathways dose of 0.045 mrem/year. Consumption of food grown using Columbia River water withdrawn downstream from the Hanford Site contributed approximately another 30 percent of the 0.045 mrem/year total. Uranium isotopes were the primary contributors to both the irrigation and fish consumption exposure pathways.
- Details related to the contribution of individual radionuclides and exposure pathways for air and water releases from Hanford Site operational areas are provided in Appendix D. Compared to 2010 dose calculations ([PNNL-20548](#)), the total annual dose in 2011 is approximately 50 percent lower. The primary cause of the difference between 2010 and 2011 dose estimates is the curtailing of radon-220 air emissions from the 300 Area in 2011.

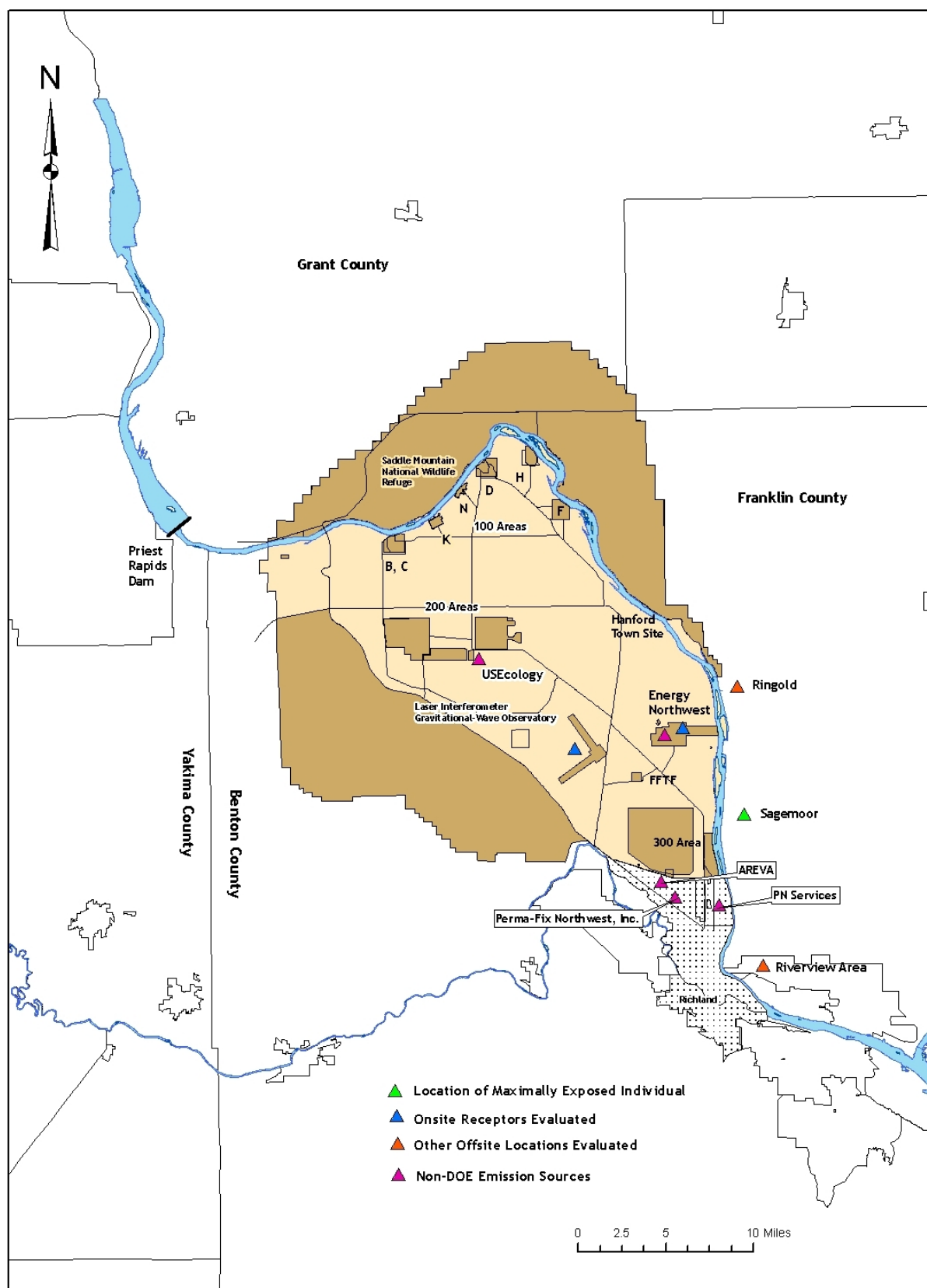
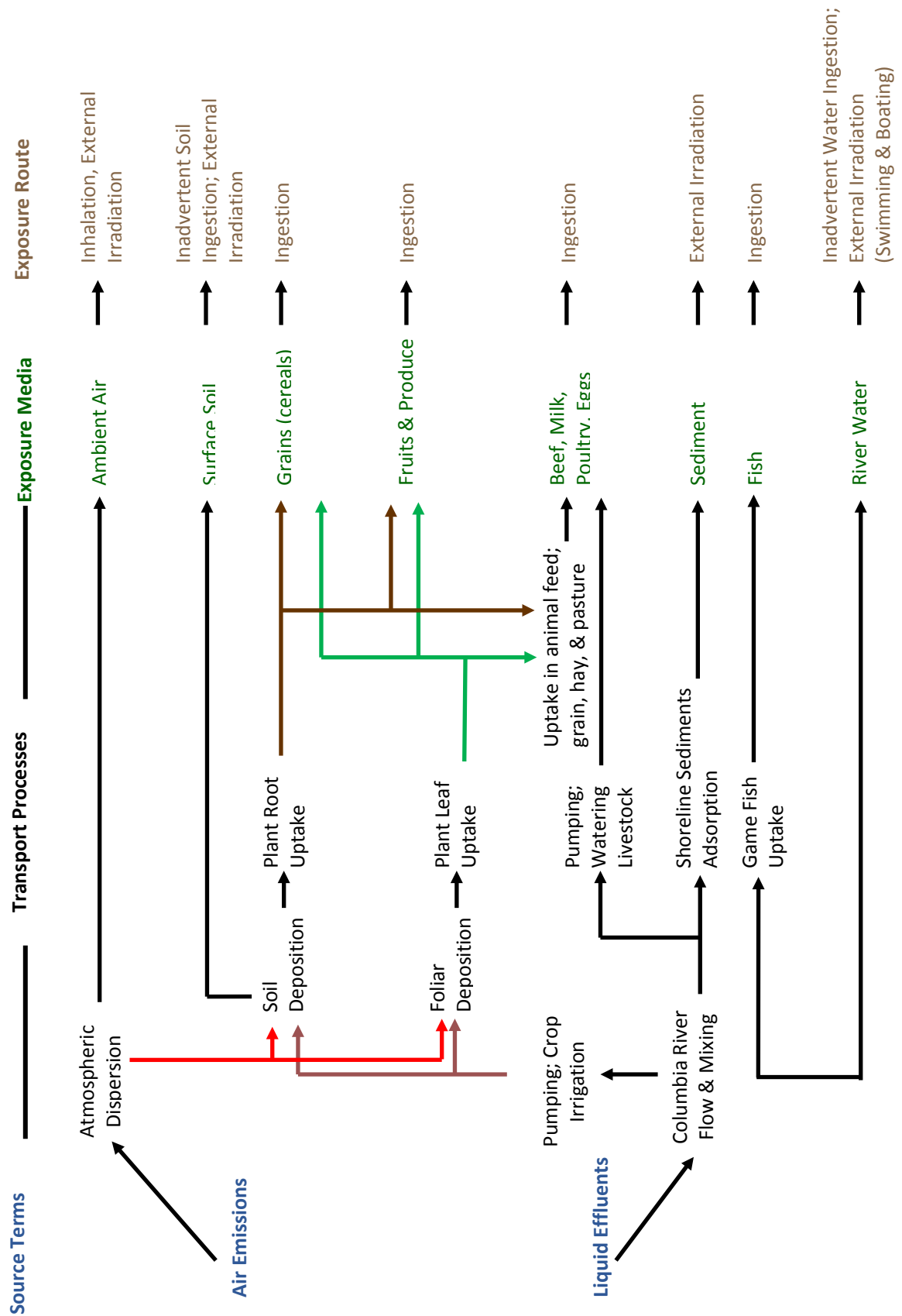
**Figure 4.2. Locations Important to Hanford Site Dose Calculations (2011)**

Figure 4.3 Conceptual Site Model of Exposure Pathways Evaluated in Dose Calculations (Sage Moor MEI)



**Table 4.4. Pathway Doses for the Hypothetical, Maximally Exposed Individual Residing at Sagemoor (2011)**

Release Type / Exposure Pathway	Dose Contributions from Operational Areas, mrem <sup>(a)</sup>				
	100 Areas <sup>(b)</sup>	200 Areas	300 Area	400 Area	Pathway Total
<b>Air</b>					
Food Ingestion	7.5E-07	8.5E-05	4.2E-02	6.3E-08	4.2E-02
Inhalation	6.5E-06	1.5E-05	3.9E-03	2.2E-07	3.9E-03
External, Soil Ingestion	3.4E-09	1.0E-07	5.7E-05	1.2E-09	5.7E-05
<b>Subtotal Air</b>	<b>7.3E-06</b>	<b>1.0E-04</b>	<b>4.6E-02</b>	<b>2.8E-07</b>	<b>4.6E-02</b>
<b>Water</b>					
Irrigation (food and soil ingestion; external)	8.5E-08	1.4E-02	NA	NA	1.4E-02
Recreation (river water and sediments; external and ingestion)	1.5E-09	1.7E-04	NA	NA	1.7E-04
Fish Ingestion	1.7E-07	3.1E-02	NA	NA	3.1E-02
<b>Subtotal Water</b>	<b>2.6E-07</b>	<b>4.5E-02</b>	<b>NA</b>	<b>NA</b>	<b>4.5E-02</b>
<b>Air + Water Total</b>	<b>7.5E-06</b>	<b>4.5E-02</b>	<b>4.6E-02</b>	<b>2.8E-07</b>	<b>9.1E-02</b>

(a) To convert millirem (mrem) to International System dose units (microsievert;  $\mu\text{Sv}$ ) multiply by 10.

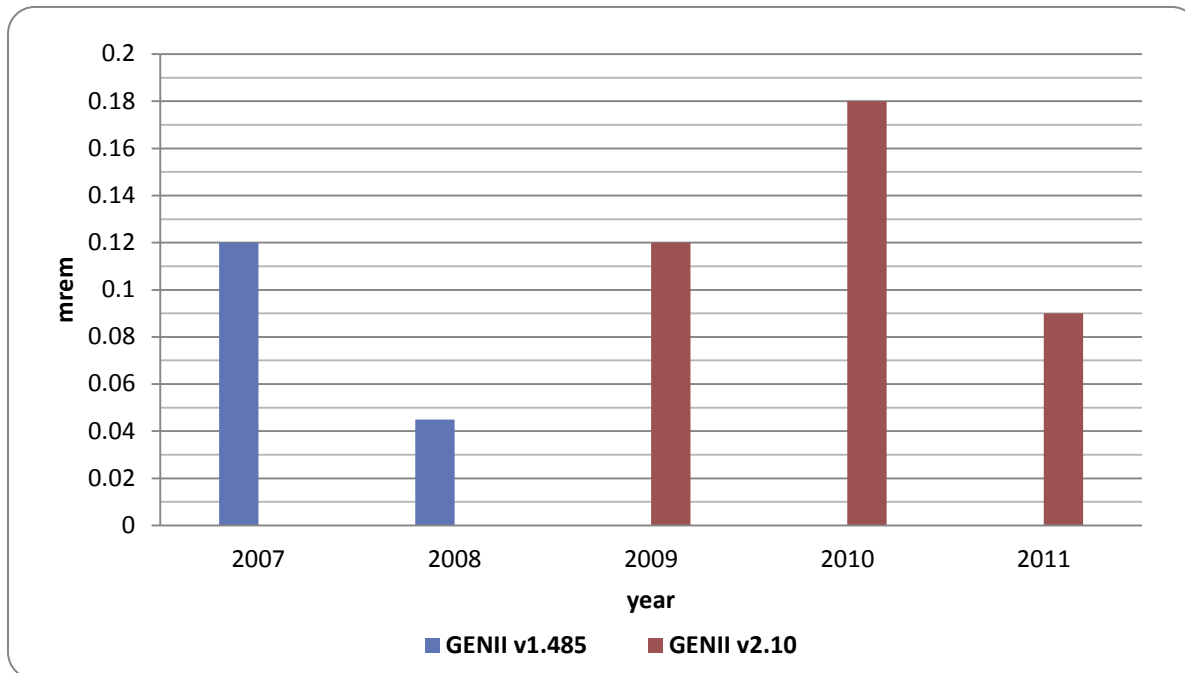
(b) 100 Areas water-related doses are based on measured discharges from the 1908-K Outfall, which ceased releases in March 2011.

NA: Not applicable. All liquid discharges reflected in the difference between upstream and downstream radionuclide concentrations are assigned to the 200 Area.

Although the calculated annual dose for the maximally exposed individual is only a very small fraction of the 100-millirem (1,000-microsievert) per year public dose limit, this dose estimate incorporates a number of conservative assumptions to ensure that pathway doses are protective. In the air pathways calculations, measurements of gross alpha and gross beta radiation in stack emissions were protectively added to the measured emissions of plutonium-239/240 and strontium-90, respectively. Although gross alpha and gross beta levels in stack emissions are similar to ambient air background, this was done to ensure that contributions from any unmeasured operations-related radionuclides are incorporated in the estimated doses.

In the irrigation pathways calculations, all produce eaten by the maximally exposed individual at Sagemoor was assumed to originate from areas irrigated with Columbia River water even though the Sagemoor area receives irrigation water from upstream of the Hanford Site. Food ingestion pathways therefore maximize the potential contribution from both air and irrigation pathways by simultaneously assuming crops are at the Sagemoor location with respect to air deposition and at another location (such as Riverview) with respect to irrigation. For the fish consumption pathway, near-shore water samples were protectively used to represent Columbia River water generally and it was assumed that all fish consumed by the maximally exposed individual are resident species rather than salmon or steelhead returning to spawn. Because returning species have not been living and feeding in the Hanford Reach of the Columbia River they would not be expected to harbor contaminants associated with this area.



**Figure 4.4 Total Dose for the Hypothetical, Maximally Exposed Individual (2007 through 2011)**

#### 4.2.2 Collective Dose

Collective dose is defined as the sum of doses to all individual members of the public within a defined distance of a specific release location. The regional collective dose from 2011 Hanford Site operations was estimated by calculating the radiological dose to the population residing within a 50-mile (80-kilometer) radius of onsite operating areas ([DOE O 458.1](#), Chg 2; Section 4.e(d)). Collective doses reported for 2011 are based on regional population data from the 2010 census, as described in Appendix D.

The conceptual site model of potentially complete exposure pathways for the Sagemoor maximally exposed individual shown in Figure 4.4 is also applicable to the collective dose calculations. The primary distinction between the maximally exposed individual and collective dose calculations is the use of population-average values for certain exposure variables in place of reasonable upper bound values. Exposure variable input values related to residency and recreational exposure times, intake rates for foods and other media, and agricultural pathway assumptions for the collective dose calculations are provided in Appendix D. The collective dose calculation employs population data from the 2010 census broken out according to direction and distance in order to coincide with air dispersion and deposition modeling conducted within the GENII Version 2.10 computer code ([PNNL-14583, Rev 3a](#)).

The annual collective dose is reported in units of person-rem (person-sievert), which is the sum of doses to members of the exposed population. The total collective dose calculated for this population in 2011 was 0.86 person-rem (0.0086 person-sievert) per year (Table 4.5; Figure 4.5), which is less than the 2010 collective dose of 1.1 person-rem (0.011 person-sievert) ([PNNL-20548](#)). Water pathway contributions assigned to the 200 Areas contributed approximately 90 percent of the total collective dose of 0.86 person-rem, with the remaining collective dose attributable to air pathways.

The primary radionuclides and exposure pathways contributing to the collective dose are as follows:

- **Air Releases:** Consumption of food products grown downwind from the Hanford Site contributed approximately 80 percent of the of the total air pathways collective dose of 0.12 person-rem. The remaining air pathways collective dose is related to inhalation. Virtually all of the 300 Area food and inhalation air pathways doses, which account for 80 percent of the air pathways collective dose, are due to releases of tritium. Iodine-129, via consumption of food products, was the largest contributor to air pathways collective dose from the 200 Areas. Air releases from the 100 and 400 Areas had negligible contributions to the air pathways collective dose.
- **Water Releases:** Consumption of drinking water withdrawn from the Columbia River downstream of the Hanford Site contributed approximately 95 percent of the total water pathways collective dose of 0.75 person-rem. Consumption of food products grown with Columbia River irrigation water and consumption of Columbia River fish each contributed approximately another 2 percent. Naturally occurring isotopes of uranium (uranium-234, uranium-235, and uranium-238) from releases assigned to the 200 Areas were the largest contributors (over 80 percent) to the drinking water collective dose.

**Table 4.5 Collective Pathway Doses (2011)**

(Within a 50-Mile (80-Kilometer) Radius)

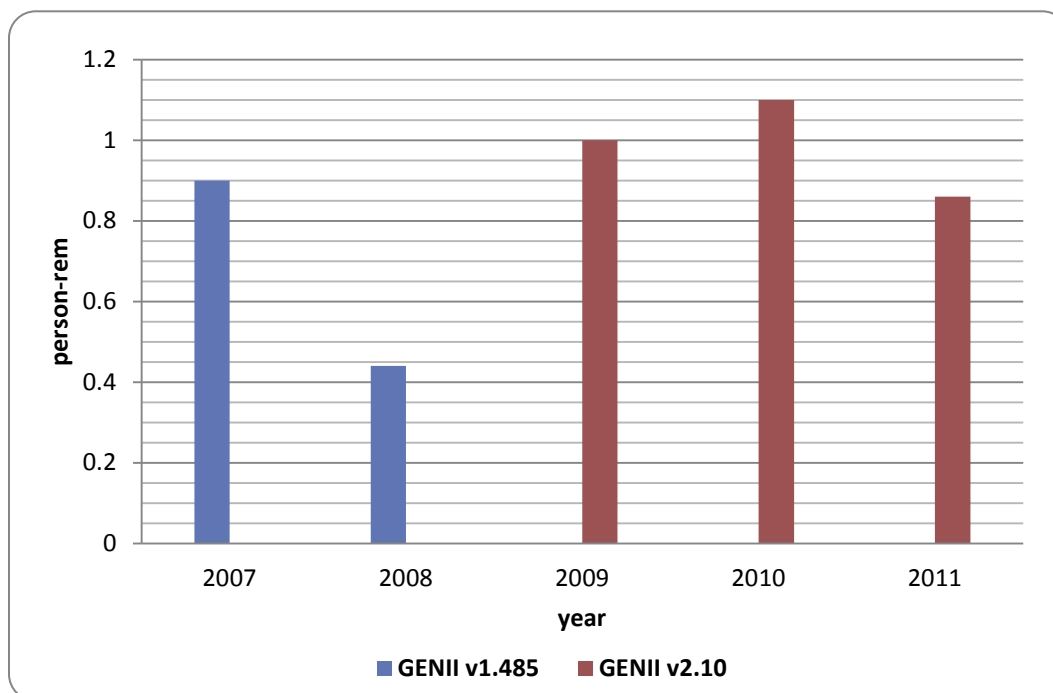
Release Type / Exposure Pathway	Dose Contributions from Operational Areas, Person-Rem <sup>(a)</sup>				
	100 Areas <sup>(b)</sup>	200 Areas	300 Area	400 Area	Pathway Total
<b>Air</b>					
Food Ingestion	1.1e-04	1.3E-02	8.3E-02	2.7E-06	9.6E-02
Inhalation	1.9E-03	3.5E-03	1.4E-02	1.8E-05	1.9E-02
External, Soil Ingestion	6.4E-07	1.4E-05	3.0E-06	5.6E-08	1.8E-05
<b>Subtotal Air</b>	<b>2.0E-03</b>	<b>1.7E-02</b>	<b>9.7E-02</b>	<b>2.1E-05</b>	<b>1.2E-01</b>
<b>Water</b>					
Irrigation (food and soil ingestion; external)	9.0E-08	1.5E-02	NA	NA	1.5E-02
Recreation (river water and sediments; external and ingestion)	1.1E-08	1.4E-03	NA	NA	1.4E-03
Fish Ingestion	6.2E-08	1.2E-02	NA	NA	1.2E-02
Drinking Water	4.0E-06	7.2E-01	NA	NA	7.2E-01
<b>Subtotal Water</b>	<b>4.2E-06</b>	<b>7.5E-01</b>	<b>NA</b>	<b>NA</b>	<b>7.5E-01</b>
<b>Air and Water Total</b>	<b>2.0E-03</b>	<b>7.6E-01</b>	<b>9.7E-02</b>	<b>2.1E-05</b>	<b>8.6E-01</b>

(a) To convert person-rem to International System dose units (person-Sievert), divide by 100.

(b) 100 Areas water-related doses are based on measured discharges from the 1908-K Outfall, which ceased releases in March 2011.

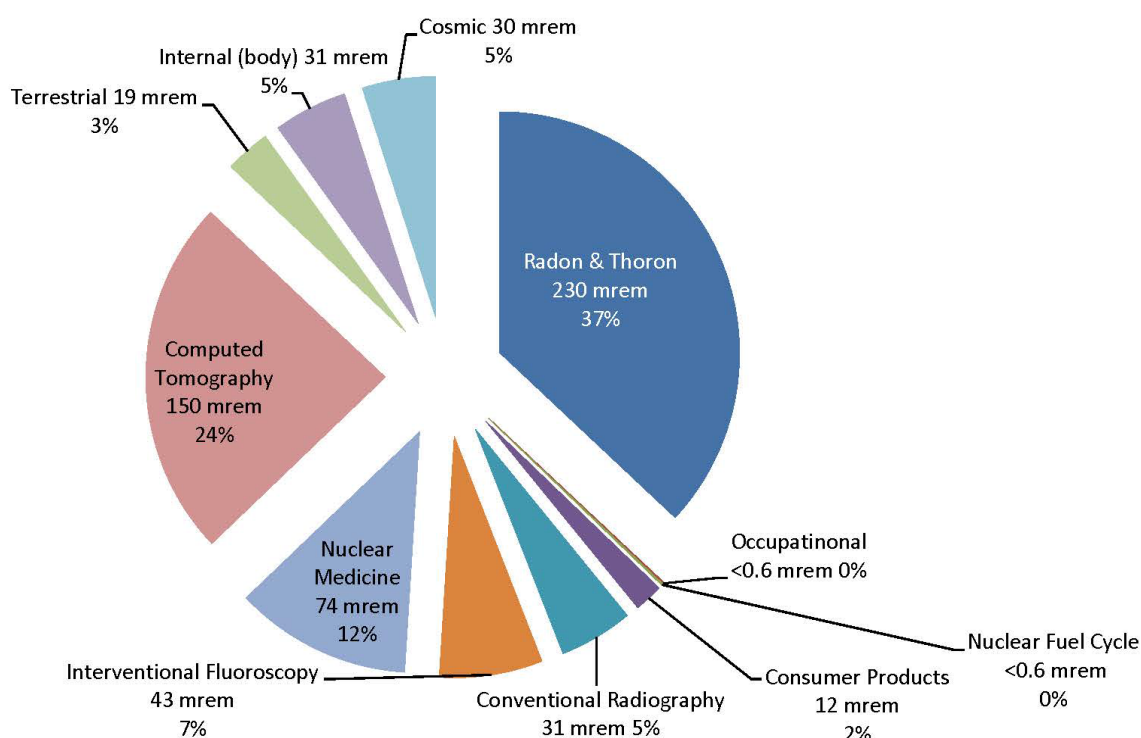
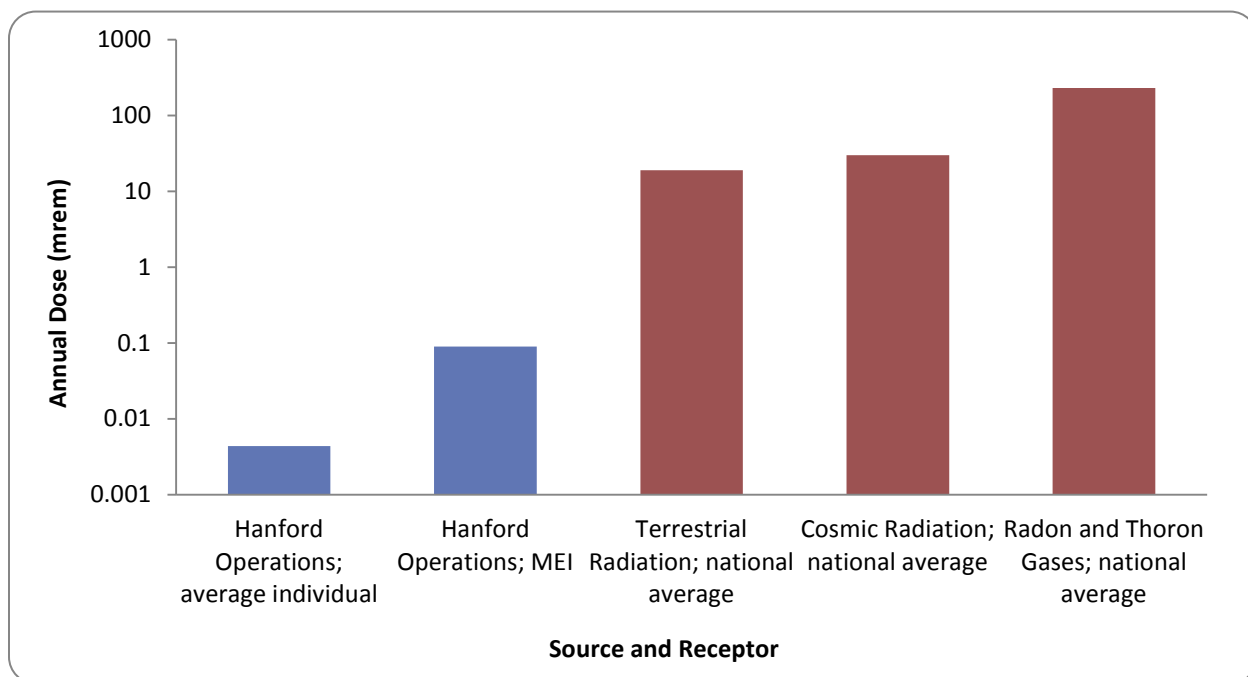
NA: Not applicable.

All liquid discharges reflected in the difference between upstream and downstream radionuclide concentrations are assigned to the 200 Area.

**Figure 4.5      Collective Total Dose (2007 through 2011)***(Within 50-Mile (80-Kilometer) Radius)*

The dose for the maximally exposed individual in 2011 was 0.09 millirem (0.9 microsievert) per year ([Section 4.2.1](#)). The average individual dose from Hanford Site operations in 2011, based on the 50-mile (80-kilometer) radius population exposed to air emissions and the Tri-Cities populations exposed to water pathways releases to the Columbia River, was approximately 0.0044 millirem (0.044 microsievert). To place the average individual estimated dose into perspective, it may be compared with doses received from other routinely encountered sources of radiation. The National Council on Radiation Protection issued Report 160 in March 2009 that estimated the overall average exposure to ionizing radiation for the average American to be 620 millirem (6,200 microsievert) per year (National Council on Radiation Protection and Measurements 2009 [[NCRP 2009](#)]). Approximately 50 percent of the 620 millirem (6,200 microsievert) per year average annual dose is related to natural sources, with the remaining 50 percent attributable primarily to medical procedures.

The most relevant sources for comparing dose from environmental media include natural terrestrial and cosmic background radiation, and inhalation of naturally occurring radon (Figure 4.6). Average annual individual background dose related to terrestrial radiation (19 mrem [190 microsievert]), cosmic background radiation (30 mrem [300 microsievert]), and radon (radon-222) and thoron (radon-220) gases (230 mrem [2,300 microsievert]) are shown relative to Hanford Site operational doses in Figure 4.7. The calculated radiological doses from Hanford Site operations in 2011 were a small percentage of national average annual doses from these natural background sources.

**Figure 4.6 Annual Average Radiological Doses in the United States from Various Sources (National Council on Radiation Protection and Measurement [2009])****Figure 4.7 Comparison of Doses from Hanford Site Operations with Annual Average Radiological Doses from Natural Sources**

### 4.2.3 Compliance with *Clean Air Act* Standards

Historically at the Hanford Site, there has been one primary expression of radiological risk to an offsite individual—this is the maximally exposed individual dose; however, the maximally exposed individual dose is currently calculated by two different methods in response to two different requirements. One maximally exposed individual dose computation is required by DOE O 458.1, Chg 2 and is calculated using the GENII computer code as described in [Section 4.2.1](#). This calculation considers all reasonable environmental pathways (e.g., from releases to both air and water) that maximize a hypothetical individual's offsite exposure to the Hanford Site's radiological liquid effluents and air emissions. A second estimate of maximally exposed individual dose is required by the *Clean Air Act* and must be calculated using an EPA dose modeling computer code (CAP-88) or other methods accepted by the EPA for estimating offsite exposure. The Hanford Site stack emissions and emissions from diffuse and unmonitored sources (e.g., windblown dust) are considered in the offsite dose, and are based solely on an airborne radionuclide emissions pathway.

In addition to complying with the all-pathways dose limits established by DOE O 458.1, Chg 2, officials managing DOE facilities are required to demonstrate their facilities comply with standards established by EPA for airborne radionuclide emissions under the *Clean Air Act* in 40 CFR 61, Subpart H. This regulation specifies that no member of the public shall receive a dose greater than 10 millirem (100 microsievert) per year from exposure to airborne radionuclide emissions (other than radon) released at DOE facilities. Whereas DOE uses the GENII computer code at the Hanford Site to determine dose to the all-pathways maximally exposed individual, EPA requires the use of the CAP-88 computer code ([EPA 402-R-00-004](#)) or other EPA-approved computer models to demonstrate compliance with the requirements in 40 CFR 61, Subpart H. The assumptions embodied in the CAP-88 computer code differ slightly from standard air pathways assumptions used with the GENII computer code; therefore, air-pathway doses calculated by the two codes may differ somewhat. In principle, the maximally exposed individual for air pathways assessed under 40 CFR 61, Subpart H, may be evaluated at a different location from the all-pathways maximally exposed individual if dose from the water pathways exceeds that from air pathways (Appendix D).

The *Clean Air Act* regulation also requires that an annual report for each DOE facility be submitted to EPA that supplies information about atmospheric emissions for the preceding year and any potential contributions to offsite dose. For more detailed information about 2011 air emissions at the Hanford Site, refer to DOE's report to EPA, *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2011* ([DOE/RL-2012-19](#)).

#### 4.2.3.1 Dose to an Offsite Maximally Exposed Individual

Using CAP-88, the maximally exposed offsite individual for air pathways in 2011 was in the Sagemoor area of Franklin County, approximately 0.8 mile (1.4 kilometers) east of the 300 Area, across the Columbia River (Figure 4.2). The potential air pathway dose from stack emissions to a maximally exposed individual at that location calculated using the CAP-88 computer code was determined to be 0.024 millirem (0.24 microsievert) per year, which is less than 1 percent of the EPA standard of 10 mrem (100-microsievert) per year. The CAP-88 result is approximately one-half of the air pathway dose for stack emissions calculated with GENII (Table 4.1). Both the CAP-88 and GENII air pathways doses were dominated by release of tritium from the 300 Area.

Dose related to radon-220 and radon-222 is not included in the dose calculated for compliance with the EPA standard in 40 CFR 61, Subpart H, but is regulated by the 10-millirem (100-microsievert) per year standard

established by Ecology in WAC 246-247. However, neither isotope was emitted as a result of Hanford Site activities in 2011; consequently, no member of the public incurred a dose from these two isotopes.

#### **4.2.3.2 Maximum Dose to Non-U.S. Department of Energy Workers at the Hanford Site**

DOE has recently allowed private businesses to locate their activities and personnel on some regions of the Hanford Site. The EPA Region 10 Office and the Washington State Department of Health provided guidance to RL that, when demonstrating compliance with 40 CFR 61 standards, it should evaluate potential doses to non-DOE employees who work at facilities within the Hanford Site but who are not under direct DOE control. This has created the need to calculate a maximum dose for an onsite individual who is employed by a non-DOE business and works within the boundary of the Hanford Site.

Doses to members of the public employed at non-DOE facilities at locations outside access-controlled areas on the Hanford Site (those requiring DOE-access authorization for entry) were evaluated in the 2011 EPA air emissions report ([DOE/RL-2012-19](#)) as possible maximally exposed individuals. These locations included the Columbia Generating Station operated by Energy Northwest and the Laser Interferometer Gravitational Wave Observatory operated by the University of California (Figure 4.2). The non-DOE worker dose due to stack emissions from these facilities was calculated using the CAP-88 computer code assuming full-time occupancy because EPA guidance does not currently allow for adjustment of such doses to account for less than full-time occupancy. Even assuming an employee is continuously present, the estimated doses to non-DOE onsite workers in 2011 were lower than the dose to an offsite maximally exposed individual at Sagemoor ([DOE/RL-2012-19](#)).

#### **4.2.3.3 Dose from Diffuse and Fugitive Radionuclide Emissions**

The December 15, 1989, revisions to the *Clean Air Act* (40 CFR 61, Subpart H) required DOE facilities to estimate the dose to a member of the public for radionuclides released from all potential sources of airborne radionuclides. DOE and EPA interpreted the regulation to include diffuse (widespread) and fugitive (unintended) emissions, as well as emissions from monitored point sources (i.e., stacks). EPA has not specified or approved standardized methods to estimate diffuse airborne emissions because of the wide variety of sources at DOE sites. The method developed at the Hanford Site to estimate potential diffuse emissions is based on environmental monitoring measurements of airborne radionuclides at the site perimeter ([DOE/RL-2012-19](#)).

The Sagemoor location across the Columbia River from the 300 Area was chosen for purposes of demonstrating compliance with the maximally exposed individual dose standard for diffuse and fugitive emissions ([DOE/RL-2012-19](#)). The estimated dose from diffuse emissions to a maximally exposed individual at Sagemoor in 2011 was calculated using the CAP-88 computer code to be 0.018 millirem (0.18 microsievert) per year. Therefore, the potential combined dose from stack emissions and diffuse emissions during 2011 at the Sagemoor location was 0.042 millirem (0.42 microsievert) per year, well below the 10 millirem (100-microsievert) per year standard in 40 CFR 61, Subpart H.

#### **4.2.4 Special Case Dose Estimates**

The exposure assumptions used to calculate the dose to the maximally exposed individual were selected to provide a scenario yielding a reasonable upper bound dose estimate. The maximally exposed individual dose calculations are based on measurements of radionuclide releases from stack emissions and discharges to the Columbia River, followed by modeling of environmental transport to offsite receptors at a specific location.

Other exposure scenarios exist that could have resulted in significant individual doses. Two such scenarios include 1) an individual who consumed contaminated wildlife that migrated from the Hanford Site, and 2) an individual who drank water from a groundwater supply well at FFTF in the 400 Area. The potential doses resulting from these scenarios are examined in the following sections.

#### **4.2.4.1 Outdoor Recreationalist Dose**

Wildlife have access to Hanford Site areas that are contaminated with radioactive materials and have the potential to acquire radioactive contamination and migrate offsite. Wildlife sampling was conducted at the Hanford Site to estimate radionuclide tissue concentrations in animals from the site that could potentially have been hunted offsite.

Radionuclide samples were collected in 2011 from Canada goose and cottontail rabbit. Various tissues were sampled, including bone, liver, and muscle tissue. For the purpose of estimating dose from ingestion of game meat, only radionuclide concentrations in muscle tissue are employed. Radionuclides detected in Canada goose and cottontail rabbit muscle in 2011 included potassium-40, a primordial radioisotope not of Hanford Site origin, and various gamma radiation-emitting radionuclides including isotopes of cesium and europium. These gamma-emitting radionuclides are produced in the process of nuclear fission and are present in the regional environment due to worldwide fallout from historic nuclear weapons tests as well as potentially due to Hanford Site operations.

The concentrations of gamma-emitting radionuclides other than cesium-137 in cottontail rabbit muscle were indistinguishable from zero. All concentrations of gamma-emitting radionuclides in Canada goose muscle were indistinguishable from zero. Cesium-137 concentrations in cottontail rabbit muscle ranged from 0.0012 pCi/g (0.044 Bq/kg) to 0.083 pCi/g (3.1 Bq/kg), with an average concentration of 0.035 pCi/g (1.3 Bq/kg). Cottontail rabbits were collected from the 200–East Area, 200–West Area, and 100-N Area and there was no correlation of muscle tissue concentration with each operating area. In fact, both the lowest and highest cesium-137 concentrations were from the 200-West Area. This suggests that the variability in measured cesium-137 concentrations may not be related to environmental contamination.

Listed below are estimates of the radiological doses that could have resulted if cottontail rabbit containing the average and maximum cesium-137 concentrations measured in 2011 were consumed.

- The dose from eating 2.2 pounds (1 kilogram) of rabbit meat that contains the maximum concentration of cesium-137 (0.083 pCi/g [3.1 Bq/kg]) measured in a rabbit harvested from the 200-West Area is estimated to be 0.0040 millirem (0.04 microsievert).
- The dose from eating 2.2 pounds (1 kilogram) of rabbit meat that contains the average concentration of cesium-137 (0.035 pCi/g [1.3 Bq/kg]) from rabbits harvested from the 200–West Area, 200–East Area, and 100-N Area is estimated to be 0.0017 millirem (0.017 microsievert).

The dose estimates were derived using a cesium-137 ingestion dose factor of  $5.0 \times 10^{-5}$  mrem/pCi ( $1.4 \times 10^{-2}$  microsievert/Bq) from ICRP Report 72 ([ICRP 1996](#)) in the following manner:

$$0.083 \text{ pCi cesium-137/g} \times 1 \text{ kg} \times 1,000 \text{ g/kg} \times 4.8 \times 10^{-5} \text{ mrem/pCi} = 0.0040 \text{ millirem}$$

$$0.035 \text{ pCi cesium-137/g} \times 1 \text{ kg} \times 1,000 \text{ g/kg} \times 4.8 \times 10^{-5} \text{ mrem/pCi} = 0.0017 \text{ millirem}$$

#### **4.2.4.2 Onsite Drinking Water Dose**

Drinking water was sampled and analyzed during 2011 in accordance with applicable regulations (40 CFR 141); tap water samples were collected from the 100-K Area, 100-N Area, 200-West Area, and



400 Area. The annual average radionuclide concentrations measured during 2011 were below applicable drinking water standards. Tritium was the only radionuclide identified above detection limits and only in the 400 Area drinking water samples.

Based on four quarterly samples, the annual average 400 Area drinking water tritium concentration was 1,600 pCi/L (59 Bq/L). Assuming a consumption rate of 0.26 gallon (1 liter) per day for 250 working days at FFTF, the potential annual worker dose in 2011 would be approximately 0.03 millirem (0.3 microsievert). This estimate is well below EPA's drinking water dose limit of 4 millirem (40 microsievert) per year for radionuclides such as tritium in public drinking water supplies. The dose estimate was derived using a tritium ingestion dose factor of  $6.7 \times 10^{-8}$  mrem/pCi ( $1.8 \times 10^{-5}$  microsievert/Bq) from ICRP Report 72 ([ICRP 1996](#)) in the following manner:

$$1,600 \text{ pCi tritium/L} \times 1 \text{ L/day} \times 250 \text{ d/year} \times 6.7 \times 10^{-8} \text{ mrem/pCi} = 0.03 \text{ millirem/year.}$$

#### 4.2.5 Doses from Non-U.S. Department of Energy Sources

Doses from non-DOE sources was not quantified in 2011 because the maximally exposed individual dose of 0.09 millirem (0.9 microsievert) per year from DOE-related sources ([Section 4.2.1](#)) was far below the threshold of 25 millirem (250 microsievert) per year at which the contribution of non-DOE sources must be included. DOE O 458.1 paragraph 4.e (1)(c) states that dose evaluations to demonstrate compliance with the public dose limit must include:

- The dose to members of the public from DOE-related exposure sources only, if the projected DOE-related dose to the representative person or maximally exposed individual is 25 millirem (0.25 millisievert) in a year or less. If the DOE-related dose is greater than 25 millirem in a year, the dose to members of the public must include major non-DOE sources of exposure and dose from DOE-related sources.
- Before it was superseded by the release of DOE O 458.1 in 2011, DOE O 5400.5, Chg 2, provided the applicable requirements for radiation protection of members of the public. Chapter II, Paragraph 7, of DOE O 5400.5, Chg 2, has a reporting requirement for a combined dose due to DOE and other manmade sources that exceeds 100 millirem (1,000 microsievert) per year. Therefore, earlier Hanford Site environmental reports have routinely evaluated dose contributions from various non-DOE industrial sources of radiation exposure on or near the Hanford Site. In 2010, these included a commercial, low-level radioactive waste burial ground at the Hanford Site operated by U.S. Ecology; a nuclear power-generating station at the Hanford Site operated by Energy Northwest; a nuclear-fuel production plant operated near the site by AREVA NP, Inc.; a commercial, low-level radioactive waste treatment facility operated near the site by Perma-Fix Northwest, Inc.; and a commercial decontamination facility operated near the site by PN Services (Figure 4.2). The total individual dose from non-DOE source activities in 2010 was conservatively estimated at about 0.004 millirem (0.04 microsievert) per year. The *Hanford Site Environmental Report for Calendar Year 2010* is online at <http://msa.hanford.gov/msa/FileDisplay.cfm?FileID=1467&confirm=true>.

#### 4.2.6 Dose to Non-Human Biota

Upper estimates of the radiological dose to aquatic organisms were made in accordance with the DOE O 458.1, Chg 2, interim requirement for management and control of liquid discharges. The current dose limit for native-aquatic animal organisms is 1 rad (10 milligray) per day. The proposed dose limit for riparian or terrestrial wildlife is 0.1 rad (1 milligray) per day.

Concentration guides for assessing doses to biota are very different from the DOE-derived concentration standards used to assess radiological doses to humans. A tiered approach is used to estimate radiological doses to aquatic and terrestrial biota. This method uses the RESRAD-BIOTA computer code (DOE/EH-0676; DOE/STD-1153-2002) to compare radionuclide concentrations measured by routine monitoring programs to a set of conservative biota concentration guides (BCGs). BCGs are the water or sediment concentrations of a radionuclide that would produce 1 rad (10 milligray) per day for aquatic biota or 0.1 rad (1 milligray) per day for riparian or terrestrial wildlife. For samples containing multiple radionuclides, a sum of fractions is calculated to account for the contribution to dose from each radionuclide relative to the dose limit. If the sum of fractions exceeds 1.0, then the dose limit has been exceeded. If the initial estimated screening value (Tier 1) exceeds the guideline (sum of fractions more than 1.0), additional screening calculations are performed (Tier 2 or Tier 3) to evaluate more accurately exposure of the biota to the radionuclides. The process may culminate in a site-specific assessment requiring additional sampling and study of exposure. Biota-dose screening assessments were conducted using surveillance data collected in 2011 from on and around the Hanford Site.

Researchers used the RESRAD-BIOTA computer code to evaluate potential effects on biota from the maximum concentrations of radionuclides measured in Columbia River sediment and water as tabulated in Appendix D. Most of the locations located on the Columbia River had samples collected from riverbank springs or seeps that carry groundwater contaminants into the Columbia River. Concentrations in springs or seeps are greater than those observed in the river water, and provide another level of conservatism in the biota dose assessment process. The results of the screening calculations listed in Table 4.6 show the concentrations in all Columbia River sediment and water samples passed the Tier 1 screen, indicating that the calculated doses were below dose limits (sum of fractions less than one). Most of the estimated dose is associated with uranium isotopes, which are the key radionuclides for the biota dose assessment. The sum of fractions tends to be greater at locations where uranium water concentrations were estimated from sediment (and not measured). Further documentation of the Columbia River biota dose calculations is provided in Appendix D.

**Table 4.6 Estimated Doses to Biota associated with Columbia River Sediment and Water**  
(Using RESRAD-BIOTA<sup>(a)</sup> Computer Code)

Location	Media Evaluated for Key Radionuclides	Tier 1 Screen	
		Sum of Fractions <sup>(b)</sup>	Pass or Fail
Priest Rapids Dam	Sediment, Water <sup>(c)</sup>	0.26	Pass
100-B Area	Sediment, Water <sup>(c)</sup>	0.15	Pass
100-K Area	Sediment, Water <sup>(c)</sup>	0.14	Pass
100-N Area	Sediment <sup>(c)</sup> , Water	<0.01	Pass
100-D Area	Sediment, Water <sup>(c)</sup>	0.06	Pass
100-H Area	Sediment, Water	0.03	Pass
White Bluffs Slough	Sediment, Water <sup>(c)</sup>	0.22	Pass
300 Area Springs	Sediment <sup>(c)</sup> , Water	0.08	Pass
McNary Dam	Sediment, Water <sup>(c)</sup>	0.31	Pass

(a) A screening method to estimate radiological doses to aquatic and riparian biota.

(b) A sum of fractions is calculated to account for the contribution to dose from each radionuclide. If the sum of fractions exceeds 1.0, then the dose guideline has been exceeded and further screening (Tier 2 or Tier 3) is required. The sum of fractions has been rounded to two figures with a maximum of two decimal points. Maximum concentrations and the BCGs are presented in Appendix D.

(c) The biota dose assessment requires concentration data for both sediment and water. If one of these media is not measured then it is estimated by using the default water to sediment partition coefficient. The footnote next to sediment means that sediment was estimated from water (water was measured) and footnote next to water means that water was estimated from sediment (sediment was measured).

Biota dose calculations also were completed for West Lake, which is located on the Central Plateau of the Hanford Site. West Lake is a vernal pool or ephemeral wetland that fills with water during the winter and generally becomes smaller or dries up entirely in other seasons. West Lake is part of the 200 Area Unplanned Release Waste Group Operable Unit (200-UR-1 Operable Unit), and is planned for supplemental characterization ([DOE/RL-2009-121](#)). The results of these planned investigations will be presented in the appropriate CERCLA remedial action document for the 216-N-8 waste site. In parallel with these planned CERCLA studies, this program has been collecting sediment data annually. In addition, other media (water and biota) have been collected from West Lake on a less regular schedule. Both sediment and water samples were collected in 2011 and data tabulated (Appendix C, Tables C.1 and C.2).

The results of the screening calculations listed in Table 4.7 show the West Lake sediment and water concentrations failed the Tier 1 and Tier 2 screens. The Tier 1 screen was based on the maximum concentration and the Tier 2 screen was based on the average concentrations of two water samples. The estimated biota dose for Tiers 1 and 2 was almost entirely due to the measured concentration of uranium in water and the assumed potential for uptake from water to aquatic biota.

The default bioaccumulation factor for uranium isotopes from water to aquatic biota is 1000. This means that the concentration in tissues would be 1000 times that measured in water. Site-specific data from West Lake support a much lower uranium bioaccumulation factor. Aquatic biota (brine flies) and water were sampled concurrently in 2000 and 2007 (PNNL-13478, [DOE/RL-2007-50](#)). The maximum concentration of any of the uranium isotopes in brine flies was 0.77 pCi/g in 2007. The maximum uranium-238 water concentration was 1400 pCi/L in 2007. The bioaccumulation factor is calculated by dividing the biota concentration (in pCi/g) by the water concentration (in pCi/ml). Therefore, the maximum bioaccumulation factor for uranium would be less than one. A bioaccumulation factor of one was used for the Tier 3 biota dose calculation as a somewhat protective measure of site-specific uranium uptake into the food chain. The Tier 3 biota dose calculations resulted in sum of fractions less than one, indicating that the calculated doses were below dose limits. Further documentation of the West Lake biota dose calculations is provided in Appendix D.

**Table 4.7. Estimated Doses to Biota associated with West Lake**

(Using RESRAD-BIOTA<sup>(a)</sup> Computer Code)

<b>Tier</b>	<b>Exposure Assumptions</b>	<b>Sum of Fractions<sup>(b)</sup></b>	<b>Pass or Fail</b>
1	Maximum Sediment, Water Concentration and Default Bioaccumulation	12	Fail
2	Average Sediment, Water Concentration and Default Bioaccumulation	5.1	Fail
3	Average Sediment, Water Concentration and Site-specific Bioaccumulation	0.13	Pass

(a) A screening method to estimate radiological doses to aquatic and riparian biota.

(b) A sum of fractions is calculated to account for the contribution to dose from each radionuclide. If the sum of fractions exceeds 1.0, then the dose guideline has been exceeded and further screening (Tier 2 or Tier 3) is required.

#### 4.2.7 Radiological Dose in Perspective

Scientific studies (National Research Council 1980, 1990; United Nations Science Committee on the Effects of Atomic Radiation, 1988) have been performed to estimate the possible risk from exposure to low levels of

radiation. These studies provide information to government and scientific organizations for use in recommending radiological dose limits and standards for public and occupational safety.

Although no increase in the incidence of health effects from low doses of radiation actually has been confirmed by the scientific community, regulatory agencies cautiously assume that the probability of these types of health effects occurring due to exposure to low doses (down to zero dose) is the same per unit dose as the health effects observed after an exposure to much higher doses (e.g., in atomic bomb survivors, individuals receiving medical exposure, or, historically, painters of radium dials). This concept is known as the “linear no-threshold” hypothesis. Under these assumptions, public exposure to radiation from current Hanford Site releases, exposure to natural background radiation (which is hundreds of times greater), and exposure to very high levels of radiation each increases an individual’s probability or chance of developing a detrimental health effect (primarily cancer) proportional to the dose received.

Scientists do not fully agree on how to translate the available epidemiological data on health effects from high radiological doses into the numerical probability (risk) of detrimental effects from low radiological doses. Some scientific studies have indicated that low radiological doses may result in beneficial rather than adverse effects. Because cancer is a common disease in the general population and may be attributable to many other causes besides radiation (e.g., genetic defects, natural and man-made chemicals, and natural biochemical reactions in the body), some scientists doubt that the risk from low-level radiation exposure can ever be conclusively proven. In developing *Clean Air Act* regulations, EPA used a probability of approximately 4 per 10 million ( $4 \times 10^{-7}$ ) for the risk of developing a fatal cancer after receiving a dose of 1 millirem (10 microsievert) (EPA 520/1-89-005). Additional data (National Research Council, 1990) support the reduction of even this small risk value, possibly to zero, for certain types of radiation when the dose is spread over an extended time. Guidance from the Interagency Steering Committee on Radiation Standards (ISCORS 2002) recommends that agencies assign a risk factor of 6 per 10 million ( $6 \times 10^{-7}$ ) for developing a fatal cancer after receiving a dose of 1 millirem (10 microsievert).

One approach for providing perspective on calculated risks related to low-dose radiation exposures is to compare them to risks involved in other typical activities. Table 4.8 compares the estimated risks from various radiological doses to the risks of some activities encountered in everyday life.

**Table 4.8. Estimated Risk from Various Activities and Exposures**

Activity or Exposure Per Year	Risk of Fatality
Home accidents	$100 \times 10^{-6(a)}$
Firearms (sporting accidents)	$10 \times 10^{-6(a)}$
Flying as an airline passenger (cross-country roundtrip – accidents)	$8 \times 10^{-6(a)}$
Recreational boating (accidents)	$6 \times 10^{-6(a)}$
Riding or driving 483 km (300 mi) in a passenger vehicle	$2 \times 10^{-6(a)}$
Natural background radiological dose (310 mrem [3,100 $\mu$ Sv]) for 70 year	0 to $13,000 \times 10^{-6(b)}$
Dose of 1 mrem (10 $\mu$ Sv) for 70 year	0 to $40 \times 10^{-6(b)}$
Flying as an airline passenger (cross-country roundtrip – radiation)	0 to $6 \times 10^{-6(b)}$
Dose to the hypothetical, maximally exposed individual (2011 dose rate) living near the Hanford Site for 70 year	0 to $4 \times 10^{-6(b)}$

(a) Real actuarial values

(b) Upper bound calculated using  $6 \times 10^{-7}$  risk of developing a fatal cancer after receiving a dose of 1 millirem (10 microsievert) (ISCORS, 2002).

### 4.3 Radiological Release of Hanford Site Property

*JW DeMers*

Principle requirements for the control and release of DOE property containing residual radioactivity are in [DOE O 458.1](#), *Radiation Protection of the Public and the Environment*. These requirements are designed to ensure the following:

- Property is evaluated, radiologically characterized—and where appropriate—decontaminated before release
- Residual radioactivity level in property to be released is as near background levels as reasonably practicable, as determined through DOE's ALARA process requirements, and authorized limits
- All property releases are appropriately certified, verified, documented, and reported; public participation needs are addressed; and processes are in place to maintain appropriate records.

No property with detectable residual radioactivity above authorized levels was released in 2011 from the Hanford Site. The site contractors prepared for transitioning from DOE O 5400.5, Chg 2, to the new order, [DOE O 458.1](#), *Radiation Protection of the Public and the Environment*, which is scheduled for 2012 implementation.

#### 4.3.1 Radiological Clearance for Potentially Contaminated Personal Property with Hard-to-Detect Radionuclides

In the process of performing environmental remediation or related support activities, Hanford Site contractors encounter a wide variety of contaminated personal property including consumables, office items, tools and equipment, and debris. Final disposition of these materials depends on whether the property is considered radiologically contaminated, and whether the disposal of such property is subject to CERCLA requirements. Radiologically contaminated property is disposed at ERDF if subject to CERCLA requirements, and if not, at the Central Waste Complex in the 200-West Area. Personal property that has contamination levels below approved DOE control and release guidelines ([DOE O 458.1](#)) are considered for release if the property can be reused. Hanford Site contractors routinely encounter a wide variety of radionuclide mixtures ranging from essentially pure plutonium to fission and activation products. Included in these fission and activation products are low-energy beta emitters, such as carbon-14, iron-55, nickel-59, nickel-63, selenium-79, technetium-99, palladium-107, and europium-155 that are difficult or impossible to detect with routine field-survey methods (i.e., hard-to-detect radionuclides).

Traditionally, field detectable or easy-to-detect radionuclides have been used as an analog for the entire mixture of radionuclides encountered during work activities. The control and release criteria ([DOE O 458.1](#)) have been adjusted downward to account for the portion of the activity that is not detectable by field survey methods. As the ratio of hard-to-detect radionuclides to easy-to-detect radionuclides increases, the criteria are reduced to a point where the adjusted limits are difficult or impossible to verify with field survey instruments. Decades of radioactive decay have reduced the contributions of easy-to-detect radionuclides to such low levels that current control and release methodologies are no longer sufficient for verifying that contaminant levels comply with the existing, approved DOE property release guidelines in [DOE O 458.1](#).

Accordingly, in May 2006, a request to DOE was submitted by WCH (DOE contractor for the River Corridor Closure Contract) to increase the release criteria (authorized limits) for hard-to-detect radionuclides. The requested authorized limits would apply only to beta-gamma surface contamination on potentially contaminated equipment and materials, and exclude volumetric contamination (contamination that is

distributed throughout the volume of the property), contamination in or on persons, unrestricted release of metals, and alpha-surface contamination. Detailed radiological analyses were performed to demonstrate these authorized limits would be protective of human health and the environment. Based on these analyses, the authorized limits would result in a dose of less than 1 millirem (10 microsievert) in any year to the maximally exposed individual and a collective dose of less than 10 person-rem (0.1 person-sievert) to any exposed population. These authorized limits (Table 4.9) were reviewed by RL and DOE HQ personnel and approved for use by WCH in May 2007. RL provided conditional approval in 2008 to CHPRC and Fluor Hanford, Inc. to use the hard-to-detect authorized limits.

WRPS submitted a request to ORP in June 2009 for approval to use these hard-to-detect authorized limits. ORP provided conditional approval for this request in June 2009. MSA submitted a request to RL in October 2009 for approval to use these hard-to-detect authorized limits. RL provided conditional approval for this request in November 2009.

Over 10,000 individual items (primarily small items such as flashlights, hard hats, radios, cameras, pens and pencils, respiratory protection [air-purifying respirator masks, powered air-purifying respirator blower packs, hoses, and belts]; radiological control instruments [hand-held survey instruments, supplemental dosimetry instruments, and air sampling equipment]; and industrial hygiene instruments [oxygen meters, temperature gauges, and air samplers]) were radiologically cleared in 2011 using these hard-to-detect authorized limits. The estimated total residual radioactivity for these items was less than 5 curies, but no property with detectable residual radioactivity was released from the Hanford Site in 2011 using these hard-to-detect authorized limits.

**Table 4.9      Approved Release Criteria (Authorized Limits) for Select Hard-to-Detect Radionuclides<sup>(a)</sup>  
for Residual Beta-Gamma Surface Contamination**

Average	Maximum	Removable
50,000 dpm/100 cm <sup>2</sup>	150,000 dpm/100 cm <sup>2</sup>	10,000 dpm/100 cm <sup>2</sup>

(a) Carbon-14, iron-55, nickel-59, nickel-63, selenium-79, technetium-99, palladium-107, and europium-155  
DPM = disintegrations per minute

### 4.3.2 Radiological Clearance for Ion-Exchange Resin for Offsite Shipment and Regeneration

Remedial actions are currently in progress at the Hanford Site for the treatment of groundwater containing hexavalent chromium. Although there are no current unacceptable human health risks from contaminants in the groundwater—primarily because exposure is precluded by DOE Hanford Site controls—a qualitative ecological risk assessment concluded that hexavalent chromium concentrations in groundwater exceeds the EPA ambient water quality criterion of 10 µg/L (0.01 ppm) for protection of freshwater aquatic life. These remedial actions are, therefore, necessary to protect ecological receptors along the Hanford Reach of the Columbia River.

Remedial actions involve the use of pump-and-treat systems to extract groundwater containing hexavalent chromium from specific target areas. The groundwater is treated using an ion-exchange resin treatment process to remove hexavalent chromium, and the treated groundwater is then returned to the aquifer using injection wells. Once saturated, the spent resin is removed from the pump-and-treat system and the resin is prepared for shipment to an offsite facility for regeneration and reuse. Resin regeneration requires chemical washing to release the bound hexavalent chromium.



Based on past Hanford Site activities and the results of characterization sampling, this resin could contain residual radioactivity. Characterization sampling results also were used to determine specific radionuclides of concern for this residual radioactivity. For any potential residual radioactivity, [DOE O 458.1](#) requires that the residual radioactivity not exceed established guidelines, or that radiological release criteria (i.e., authorized limits) be developed and submitted to the applicable DOE field office. Guidelines have not been established for volumetric residual radioactivity for the radionuclides of concern for the resin. Fluor Hanford, Inc., the Hanford Site contractor responsible for these remedial actions, submitted a request to RL in January 2007 for authorized limits to permit offsite shipment and resin regeneration.

Requested authorized limits were developed using realistic and conservative radiation dose analyses based on the 'likely use' and 'worst-plausible use' scenarios. The expected end-use (i.e., likely-use scenario) for this resin was as a filtration media in groundwater remediation. The worst-use scenario was use of the resin in another groundwater remediation system outside of the Hanford Site. Detailed radiological analyses were performed to demonstrate that these authorized limits would be protective of human health and the environment. Based on these analyses, the authorized limits would result in a dose of less than 1 millirem (10 microsievert) in any year to the maximally exposed individual, and a collective dose of less than 10 person-rem (0.1 person-sievert) to any exposed population.

RL coordinated review of this authorized limit request with the U.S. Nuclear Regulatory Commission. Based on a review of DOE's process for developing authorized limits, the U.S. Nuclear Regulatory Commission established that coordination was appropriate to ensure that site-specific release limits and survey and review protocols were appropriate and acceptable. The U.S. Nuclear Regulatory Commission indicated that on a case-by-case basis, radioactive material has been transferred to unlicensed entities based on an impact analysis that has demonstrated such a release would result in exposure of less than 1 millirem/year (10 microsievert/year) to any individual and a minimal collective dose. The analyses performed for these authorized limits indicate that any actual releases would meet these criteria. Following review by RL and DOE HQ personnel, these authorized limits (Table 4.10) were approved in August 2007 for use by Fluor Hanford, Inc. CHPRC assumed responsibility from Fluor Hanford, Inc., in October 2008 for all Hanford Site groundwater remedial actions. In anticipation of this transfer of responsibility in September 2008, CHPRC submitted a request to RL for approval to use the authorized limits for resin previously approved for Fluor Hanford, Inc. RL approved this request in October 2008 CHPRC.

Approximately 127,440 pounds (57,800 kilograms) of resin was shipped offsite in 2011 for regeneration under these approved authorized limits.

**Table 4.10**      **Approved Authorized Limits for Offsite Shipment and Regeneration of Ion-Exchange Resin**

Radionuclide	Authorized Limit(pCi/g)
Tritium	100,000
Strontium/yttrium-90	21,000
Technetium-99	400,000
Uranium-233	3,700
Uranium-234	3,700
Uranium-235 plus short-lived progeny	390
Uranium-238 plus short-lived progeny	3,000



### **4.3.3 Granular Activated Carbon for Offsite Shipment and Regeneration Radiological Clearance**

Carbon tetrachloride was found in the unconfined aquifer beneath the 200-West Area in the mid-1980s. Groundwater monitoring indicated the carbon tetrachloride plume was widespread and concentrations were increasing. An expedited response action was initiated in 1992 to extract carbon tetrachloride from the vadose zone in the 200-ZP-2 Operable Unit, currently designated as the 200-PW-1 Operable Unit, in the 200-West Area. The 200-PW-1 Operable Unit soil-vapor extraction system includes vapor-phase granular activated carbon canisters to remove carbon tetrachloride from the extracted vapors prior to discharge. This facility was in full operation by 1995.

Workers installed a groundwater pump-and-treat system in 1996 in a second operable unit (200-ZP-1 Operable Unit) to treat contaminated groundwater in the unconfined aquifer. The system includes an air-stripping unit that volatilizes carbon tetrachloride in the groundwater and then discharges the carbon tetrachloride vapors through granular activated carbon canisters that are identical to the large, carbon-steel granular activated carbon canisters in the 200-PW-1 Operable Unit soil-vapor extraction system.

Each of these systems use granular activated carbon canisters to capture the volatile organic compounds removed during the extraction process. When a granular activated carbon canister has reached volatile organic compound saturation, it is removed from the system and the granular activated carbon is prepared for shipment to an offsite facility for regeneration and reuse. Regeneration of the granular activated carbon requires heating it in a hearth furnace to remove the captured volatile organic compounds.

Based on past Hanford Site activities and the results of characterization sampling, this granular activated carbon could contain residual radioactivity. Characterization sampling results were used to determine specific radionuclides of concern for this residual radioactivity. For any potential residual radioactivity, ([DOE O 458.1](#)) requires that the residual radioactivity not exceed established guidelines, or that radiological release criteria (i.e., authorized limits) be developed and submitted to the applicable DOE field office. Following review by RL and HQ personnel in October 2010, approved authorized limits for offsite shipment and regeneration of granular activated carbon (Table 4.11) was approved for use by CHPRC.

Approximately 17,280 pounds (7,840 kilograms) of granular activated carbon was shipped offsite in 2011 for regeneration under these approved modified authorized limits.

**Table 4.11**      **Approved Modified Authorized Limits for Offsite Shipment and Regeneration of Granular Activated Carbon**

<b>Radionuclide</b>	<b>Authorized Limit (pCi/g)</b>
Tritium	300,000
Carbon-14	3,000
Cobalt-60	21
Selenium-79	2,000
Strontium-90	100
Technetium-99	500
Iodine-129	50
Cesium-137	80
Europium-152	40
Europium-154	40
Europium-155	700
Protactinium-231	10
Thorium-232 plus progeny	6
Uranium-234	100
Uranium-235	100
Neptunium-237	50
Plutonium-238	26
Uranium-238 plus short-lived progeny	100
Plutonium-239	24
Plutonium-240	2,472
Americium-241	29

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## 5.0 Environmental Restoration and Waste Management

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Environmental restoration and waste management activities continued on the Hanford Site during 2011. The following sections describe ongoing Hanford Site River Corridor closure, cleanup and remediation, facility decommissioning, waste management operations, underground waste storage tank status, construction of the WTP and its associated facilities, and research activities related to waste cleanup.

### 5.1 River Corridor Closure

*JA Lerch*

The River Corridor includes the Hanford Site 100 and 300 Areas, which border the Columbia River. The River Corridor includes nine deactivated plutonium-production reactors, numerous support facilities, and liquid- and solid-waste disposal sites. DOE's award of the River Corridor Closure Contract to WCH in 2005 allowed cleanup actions to continue in the 100 and 300 Areas with completion as a primary focus. The principle goals of DOE's River Corridor Closure Contract are to complete the following:

- Deactivate, decontaminate, decommission, and demolish excess facilities
- Place former production reactors in an interim safe and stable condition
- Remediate liquid- and solid-waste disposal sites
- Meet all regulatory requirements
- Determine the adequacy of the current cleanup criteria in protecting human health and the environment
- Prepare the Hanford Site's River Corridor for transition to long-term stewardship (surveillance and maintenance).

The Mission Completion Project is addressing the last two items under the River Corridor Closure Contract. Key project scope includes assessment and integration activities and long-term stewardship transition support.

#### 5.1.1 Assessment and Integration

The Tri-Party Agencies agreed in 1991 that interim remedial actions in the 100 and 300 Areas could be implemented by relying on streamlined qualitative risk assessments to establish interim action cleanup levels. Waste site cleanup under interim action RODs was initiated during the mid-1990s, and is scheduled to be completed under the River Corridor Closure Contract by 2015. In parallel, WCH is responsible to conduct risk assessment activities and provide technical support for developing integrated source and groundwater RI/FS reports and proposed plans to establish final action cleanup decisions for the River Corridor.

**River Corridor Baseline Risk Assessment.** Human health and ecological risk assessments have been completed to evaluate the impacts from Hanford Site releases to the upland, riparian, and near shore areas of the River Corridor. The *River Corridor Baseline Risk Assessment, Volume II: Human Health Risk Assessment* (DOE/RL-2007-21, Vol. II, [Part 1](#) and [Part 2](#), Rev. 0) was issued in August 2011. The *River Corridor Baseline Risk Assessment, Volume I: Ecological Risk Assessment* (DOE/RL-2007-21, Vol. I, [Part 1](#) and [Part 2](#), Rev. 0) was issued in March 2012. These reports present a comprehensive assessment of the River Corridor, addressing all relevant sources of contamination, exposure pathways, and contaminants. The reports also provide an analysis of relevant uncertainties and recommendations. Preliminary remediation goals that are protective of human health and the environment are proposed to support development of final action cleanup

decisions through the RI/FS process for the River Corridor. The risk assessment results are being reflected in the River Corridor RI/FS reports.

**Remedial Investigation of Hanford Site Releases to the Columbia River.** The *Remedial Investigation Work Plan for Hanford Site Releases to the Columbia River* ([DOE/RL-2008-11](#)) was issued in September 2008 and the associated field investigation activities have been completed. Results from the field investigation and historical data are being used to develop human health and ecological risk assessments to evaluate potential impacts to the Columbia River from Hanford Site releases. The *Columbia River Component Risk Assessment, Volume I, Screening-Level Ecological Risk Assessment* (DOE/RL-2010-117, [Vol. I, Part 1](#), Rev. 0) was issued in August 2011; and *Columbia River Component Risk Assessment, Volume II, Baseline Human Health Risk Assessment, Part 1* (DOE/RL-2010-117, [Vol. II](#), Draft A) was issued in June 2011. The *Columbia River Component Risk Assessment, Volume II: Baseline Human Health Risk Assessment* (DOE/RL-2010-117, [Vol. II](#), Draft A) was issued for regulatory review in January 2012 and is anticipated to be issued in Fall 2012. The risk assessment results are being reflected in the River Corridor RI/FS reports.

**River Corridor RI/FS Process.** Field investigation activities and development of draft integrated source and groundwater RI/FS reports and proposed plan documents for the six River Corridor decision areas (100-B/C, 100-K, 100-N, 100-D/H, 100-F/IU-2/IU-6, and 300 Area) continued. Draft RI/FS reports for the 100-K Area ([DOE/RL-2010-97](#)) and 300 Area ([DOE/RL-2010-99](#)) decision areas were submitted for regulatory review in September and December 2011, respectively. Draft RI/FS reports for the four remaining decision areas are scheduled to be submitted to the regulators for review by the end of CY2012 in accordance with Tri-Party Agreement Milestone [M-015-00D](#). Public review of proposed actions and development of final action RODs for the six decision areas are anticipated to range from 2012 to 2014.

### 5.1.2 Long-Term Stewardship

The long-term stewardship task is focused on achieving interim closure and transition of surveillance and maintenance responsibilities within the River Corridor from the cleanup contractor to the site service contractor, which administers the long-term stewardship program for DOE. Within the River Corridor Closure Contract, key elements of the long-term stewardship work include preparing interim remedial action reports for each CERCLA-source operable unit and developing long-term stewardship transition and turnover package documents.

Transition and turnover packages were prepared in 2011 for Segments 1 and Segment 2 of the 100-F/IU-2/IU-6 Area. These packages describe the completion of site assessment activities, removal of facilities, removal of miscellaneous debris, and site remediation to interim action RODs for a specific parcel of land. Interim remedial action reports also were prepared and issued for the 100-BC-1 Operable Unit ([DOE/RL-2011-49](#)) and Segment 1 of the 100-F/IU-2/IU-6 Area ([DOE/RL-2011-48](#)).

In preparation for the long-term stewardship transition, waste site (orphan site) evaluations are performed, utilizing a systematic approach to reviewing land parcels and identifying potential orphan sites in the River Corridor that are not currently identified in existing CERCLA decision documents. Orphan site evaluations include comprehensive reviews of historical documentation, field investigations, and geophysical surveys. The orphan site evaluation process was completed in 2011 with the issuance of the following reports: Segment 3 of the 100-F/IU-2/IU-6 Area ([OSR-2010-0004](#)), Segment 4 of the 100-F/IU-2/IU-6 Area ([OSR-2011-0001](#)), and Segment 5 of the 100-F/IU-2/IU-6 Area ([OSR-2011-0002](#)).

## 5.2 Cleanup and Remediation Activities

The following sections describe ongoing cleanup and remediation activities at the Hanford Site.

### 5.2.1 100 Area

#### 5.2.1.1 100-B/C, 100-D, 100-F, 100-K, 100-H, and 100-N Areas Waste Sites

*DG Saueressig*

This section describes ongoing cleanup and remediation activities in the 100 Area.

The 100 Area waste sites vary in complexity and waste type. Typical waste sites include waste burial grounds, liquid effluent waste sites, burn pits, retired septic systems, piping systems, and miscellaneous waste sites. Full-scale remediation of waste sites in the 100 Areas began in 1996. The primary focus early in the cleanup process was to address waste sites receiving liquid waste because those sites generally contained significant quantities of contaminants and served as potential sources for groundwater contamination. The 100 Area remediation activities were performed during 2011 in the 100-B/C, 100-D, 100-F, 100-K, 100-H, and 100-N Areas. Activities included sampling to determine if suspected waste sites exceeded cleanup objectives; sampling to confirm that cleanup objectives had been met; physical excavation operations; waste sorting and segregation; waste treatment; and waste disposal, backfill, and revegetation. Remediation activities focused on waste burial grounds and miscellaneous waste sites. The waste burial grounds require cleanup but also present a significant health and safety risk to workers due to incomplete disposal records and the potential for discovering unknown material from past disposal practices. Characterization of unknown material is critical to ensure worker safety and proper management of the waste for potential treatment and disposal. Discovery of an unknown material requires additional time and planning, to ensure proper protective gear is used in the field when characterizing the material, and to verify that limits and controls identified in approved authorization documents required by DOE are adequate for the work scope. If authorization documents do not adequately cover the material discovered, work is stopped until documentation can be revised and work safely restarted. Based on characterization results, additional waste treatment may be required before disposal.

Miscellaneous waste sites vary in the nature and extent of contamination and are generally smaller-size areas when compared to waste burial grounds. Sampling requirements for determining if a miscellaneous waste site requires cleanup or complies with post-cleanup goals can vary significantly from one waste site to another. The interim action RODs for 100 Area waste sites authorizes remediation activities. Waste generated from the cleanup of waste sites is disposed at ERDF in the 200 Area. This centralized disposal facility is the primary disposal pathway, but other disposal options are available if the material does not meet the waste acceptance criteria for the facility.

A total of 1,315,200 tons (1,193,100 metric tons) of contaminated soil from 100 Area remediation activities in 2011 were disposed at ERDF. Quantities and respective locations are as follows:

- 286,200 tons (259,600 metric tons) from the 100-B/C Area
- 312,200 tons (283,200 metric tons) from the 100-D Area
- 129,900 tons (117,800 metric tons) from the 100-F Area
- 87,300 tons (79,200 metric tons) from 100-H Area
- 170,600 tons (154,800 metric tons) from the 100-K Area
- 329,000 tons (298,500 metric tons) from the 100-N Area.

### 5.2.1.2 100-K Area Waste Sites

*JL Hammons and DL Klages*

Remediation activities were performed in multiple locations in the 100-K Area. Activities conducted in 2011 included sampling to determine if suspected waste sites exceed cleanup objectives, sampling to confirm that cleanup objectives had been met, physical excavation operations, waste sorting and segregation, waste treatment, and waste disposal.

The waste sites vary in complexity, waste type, nature and extent of contamination. Typical waste sites include liquid effluent waste sites, retired septic systems, piping systems, and miscellaneous waste sites. Sampling requirements for determining whether a waste site requires cleanup or complies with post-cleanup goals can vary significantly from one waste site to another.



**Figure 5.1. 100-K Area**

The 100-K Area waste sites are authorized for remediation activities through interim action RODs approved by the Tri-Party Agencies. Waste generated from the cleanup of waste sites is disposed at ERDF. This centralized disposal facility is the primary disposal pathway; however, other disposal options are available if the material does not meet the waste acceptance criteria for ERDF.

A total of 185,000 tons (167,795 metric tons) of contaminated soil from 100-K Area remediation activities in 2011 were disposed at ERDF. Nine waste sites were closed following remediation (100-K-77, 120-KW-1, 120-KW-2, 120-KW-3, 120-KW-4, 100-K-109, 130-KE-1, 118-KE-2, and 118-KW-2). In addition, two waste sites were confirmed to require removal, five waste sites began remediation activities, 23 waste sites from 2010 continued to be remediated, and four new waste sites were discovered.

### 5.2.1.3 K Basins

*BM Barnes and DJ Watson*

The 100-K Area remediation activities included facility demolition, waste site remediation, cleanout of the K West Basin, and groundwater pump-and-treat operations. The *American Recovery and Reinvestment Act of 2009* funding increased decontamination and demolition of structures in the 100-K Area (Figure 5.1). The K West Basin and the Cold Vacuum Drying Facility are the only remaining operating nuclear facilities. The K West Basin is undergoing cleanout that involves removing radioactive contaminated sludge and debris as a precursor to facility deactivation and demolition. For nearly 30 years, the basins stored 2,300 tons (2,100 metric tons) of N Reactor spent fuel and a small quantity of slightly irradiated single-pass reactor fuel (from other Hanford Site reactors). In October 2004 the major cleanup effort to remove the fuel was completed.

This fuel corroded during storage and the fuel washing and packaging process left behind approximately 989 cubic feet (28 cubic meters) of sludge. The sludge was segregated into four streams for subsequent removal and disposition: 1) K East Basin floor and pit sludge, which was transferred to underwater storage containers in the K West Basin; 2) K West Basin floor and pit sludge, which is currently being stored in



underwater storage containers in the K West Basin; 3) K West Basin knock-out-pot sludge, generated during the fuel washing and packaging process, and currently stored in underwater containers in the K West Basin; and 4) K West Basin settler tube sludge, generated during the fuel washing and packaging process, are currently stored in underwater storage containers in the K West Basin.

Floor and pit sludge is a non-homogenous mixture of debris that includes windblown sand and environmental particulates; concrete fragments from the basin walls; corrosion products from fuel canisters and fuel racks; fuel cladding pieces; tiny pieces of corroded uranium (uranium oxides, hydrates, and hydrides); ion-exchange resin beads; polychlorinated biphenyls (PCBs); and fission products. Sludge has been defined as any material that is less than or equal to 0.25 inch (0.64 centimeter) in size. The project's CERCLA remedial design documentation will describe the means of sludge treatment and location of the national repository for sludge disposal. The K West Basin fuel cleaning system transferred sludge generated from the cleaning of fuel to either knock-out-pots or settler tanks. Knock-out-pots collect particles greater than 0.02 inch (500 microns) in size by using either a downstream strainer or an internal screen. Settler tanks, a series of horizontal tubes downstream of the knock-out-pots, allow particles less than 0.02 inch (500 microns) to settle and not be recirculated.

#### **5.2.1.3.1 K Basins Progress on Defense Nuclear Facilities Safety Board Recommendations**

##### **RA Quintero**

No changes occurred in 2011 to the K Basins Sludge Treatment Project commitment dates contained in the DOE Implementation Plan ([DOE 2002](#)) and its revision ([DOE 2005](#)) for stabilizing the nuclear materials identified in Defense Nuclear Facilities Safety Board Recommendation 2000-1 ([DNFSB 2000-1](#)). Revisions to the implementation plan commitment dates for completing K Basins sludge treatment and packaging are in development.

In a periodic report to Congress, dated June 15, 2011, the DNFSB identified two new issues regarding Sludge Treatment Project management and engineering ([DNFSB 2011](#)). The new issues concerned integrating safety into design and safety basis development. In a response letter dated June 30, 2011, ([DOE 2011](#)) DOE noted that resolutions to these safety concerns were in progress.

#### **5.2.1.3.2 100-K Area Remediation Progress and Accomplishments**

- 105-KE Reactor Building interim safe storage activities continued in FY2011 with the removal of the administrative, control room, rod racks, and fan rooms in support of encapsulation
- Construction of the 189-K Water Treatment Facility was completed and brought on line, leading the way to the deactivation and demolition of the much larger water treatment facilities used originally to support the operation of the K Reactors
- Demolished and disposed of the following:
  - ‡ 1706-KE, 1706-KEL, and 1706-KER below-grade structures
  - ‡ 183-KE Chlorine Vault
  - ‡ 185-K Potable Water Treatment Plant
  - ‡ 1908-KE Effluent Water Monitoring Station
  - ‡ 183.1-KE Head House
  - ‡ 183.2-KE Sedimentation Basins (commenced decontamination and decommissioning, continuing thru FY2012)

- ‡ 183.3-KE Filter Basins (commenced decontamination and decommissioning, continuing thru FY2012)
  - ‡ 183.4-KW Clearwell
  - ‡ 183.4-KE Clearwell
  - ‡ 183.5-KE Lime Feeder Building
  - ‡ 183.6-KE Lime Feeder Building
  - ‡ 183.7-KW Pipe Tunnel
  - ‡ 190-KW Process Water Pump House
  - ‡ 190-KE Process Water Pump House
  - ‡ 1717-K Maintenance/Transportation Shop
  - ‡ 181-KE River Pump House
  - ‡ 181-KW River Pump House
  - ‡ 1720-K Office and Telephone Exchange.
- Ceased discharges to the Columbia River and terminated the NPDES industrial discharge permit and storm water discharge permit
  - Completed alternatives analysis of various technologies for treating and packaging sludge using sludge simulants
  - Completed laboratory analyses of sludge samples from six-engineered containers located at the K West Basin.
  - Completed pretreatment of the knock-out-pot sludge and final design associated with the knock-out-pot sludge processing system for packaging and removal of this sludge stream from the K West Basin
  - Continued design for K West Basin modifications and new Annex, which will be used for removing sludge stored in the underwater-engineered containers (included mock-up testing of the engineered container retrieval and transfer system at the 400 Area Maintenance and Storage Facility)
  - Continued groundwater pump-and-treat operations
  - Continued waste site remediation, including those sites associated with the original water treatment facilities and the K East Basin
  - Continued testing of systems and components at the Maintenance and Storage Facility located in the 400 Area for deployment to the K West Basin in support of processing knock-out-pot sludge. The knock-out-pot sludge will undergo separation into streams: one stream managed as fuel; one stream managed as waste; and another stream for the retrieval, transfer, and loading of sludge in underwater containers into sludge transfer and storage containers for removal from K West Basin as waste.

### 5.2.2 200 Area (Central Plateau)

*PA Burke*

The Central Plateau is a 75-square-mile (194-square-kilometer) region near the center of the Hanford Site, which includes the area designated in the *Hanford Comprehensive Land Use Plan Environmental Impact Statement* ([DOE/EIS-0222](#)) and ROD (64 FR 61615) as the Industrial-Exclusive Area, a rectangular area of about 20 square miles (52 square kilometers) in the center of the Central Plateau. The Industrial-Exclusive Area contains the 200-East and 200-West Areas, used primarily for the Hanford Site nuclear fuel processing and waste management and disposal activities. The Central Plateau also encompasses the CERCLA 200 Area National Priorities List site. The Central Plateau has a large physical inventory of chemical processing and

support facilities, tank systems, liquid- and solid-waste disposal and storage facilities, utility systems, administrative facilities, and groundwater monitoring wells.

The *Hanford Site Cleanup Completion Framework* ([DOE/RL-2009-10](#)) defines the path forward for cleanup at the Hanford Site. The framework document defines the main components of cleanup and two main geographic areas—the River Corridor and the Central Plateau. As a result of the goals established in [DOE/RL-2009-10](#), the Tri-Party Agencies developed changes to the Tri-Party Agreement that reflect the path forward for Central Plateau cleanup.

The Central Plateau includes two principal cleanup areas (see Figure 8.1):

- **Inner Area.** This area contains major nuclear fuel processing, waste management, and disposal facilities, and is defined as the final footprint area of the Hanford Site that will be dedicated to permanent waste management and containment of residual contamination. The Inner Area is anticipated to be approximately 10 square miles (26 square kilometers) and will remain under federal ownership and control for as long as potential hazards exist.
- **Outer Area.** This area is defined as areas of the Central Plateau beyond the boundary of the Inner Area. Completing cleanup for the approximately 65-square-mile (168-square-kilometer) Outer Area will reduce the active footprint of cleanup for the Central Plateau to the Inner Area.

### 5.2.2.1 Inner Area

The Inner Area (anticipated to encompass approximately 10 square miles [26 square kilometers]) is the projected final footprint region of the Hanford Site. Dedicated to waste management and residual contamination containment, it will remain under federal ownership and control as long as potential hazards exist. Operable units within the Inner Area include those described in the following subsections.

#### 5.2.2.1.1 200-PW-1, 200-PW-3, 200-PW-6, and 200-CW-5 Operable Units

This operable unit group includes 22 soil waste sites located in the 200-East and 200-West Areas that are contaminated with plutonium from processing activities at the Plutonium Finishing Plant (PFP) and the Plutonium Uranium Extraction Plant (PUREX). Specific sites are listed in the *Tri-Party Agreement Action Plan*, [Appendix C](#). At EPA's request, the Tri-Party Agencies agreed to retain the 200-PW-1, 200-PW-3, 200-PW-6, Operable Unit group and the 200-CW-5 Operable Unit and consolidate them into a single decision (Table 5.1).

The *Record of Decision Hanford 200 Area Superfund Site 200-CW-5 and 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units* ([DOE, EPA, and Ecology, 2011](#)) was issued in December 2011. The selected remedy in the ROD addresses soils and subsurface disposal structures contaminated primarily with plutonium and cesium, two settling tanks, and associated pipelines. The remove, treat, and dispose approach for contaminated soil and debris will be used to address plutonium contaminated soils and subsurface structures, and consists of the following: 1) Remove a portion of contaminated soil, structures, and associated debris; 2) treat these removed wastes as required to meet disposal requirements at ERDF ([Section 5.4.3.7](#)) or waste acceptance criteria for offsite disposal at the Waste Isolation Pilot Plant in Carlsbad, New Mexico; and 3) dispose at ERDF or Waste Isolation Pilot Plant. The 200-CW-5 Operable Unit, also known as the Z-Ditches, will use the remove, treat, and dispose approach to excavate contaminated soils and dispose at ERDF or the Waste Isolation Pilot Plant, as appropriate.

**Table 5.1. Central Plateau Operable Unit Structure**

New Operable Unit Group	Description	Predecessor Operable Units		Lead Regulatory Agency
Inner Area				
200-PW-1/3/6, 200-CW-5	Plutonium-contaminated soil sites located near the Plutonium Finishing Plant (PFP) and cesium-contaminated sites near the Plutonium Uranium Extraction Plant (PUREX)	No change		EPA
200-WA-1 and 200-BC-1	Soil waste sites located in the 200-West Inner Area that are not included in the 200-SW-2, 200-CR-1, 200-PW-1, 200-PW-6, 200-CW-5, and 200-IS-1 Operable Units; Soil waste sites in the BC Cribs and Trenches	200-BC-1 200-LW-1/2 200-MG-1/2 200-MW-1 200-PW-2/4	200-SC-1 200-TW-1/2 200-UR-1 200-UW-1	EPA
200-EA-1	200-East Inner Area that are not included in the 200-SW-2, 200-CB-1, 200-CP-1, and 200-PW-3 Operable Units	200-CS-1 200-IS-1 200-LW-1/2 200-MG-1/2	200-MW-1 200-PW-2/4 200-SC-1 200-TW-1/2 200-UR-1	Ecology
200-IS-1(a)	Pipelines, diversion boxes, etc., in the 200-IS-1 Operable Unit			Ecology
200-SW-2	Solid waste burial grounds and waste sites in the footprint of the burial grounds	200-CW-1 200-MG-1/2	200-SW-2	Ecology
200-DV-1	Selected soil waste sites in the Inner Area with deep vadose zone contamination	200-TW-1/2	200-PW-5	Ecology
200-CB-1	B Plant Canyon; associated waste sites	200-IS-1 200-MG-1/2 200-MW-1	200-PW-2/4 200-UR-1	Ecology
200-CP-1	PUREX Canyon; Associated waste sites	200-IS-1 200-MG-1/2	200-MW-1 200-UR-1	Ecology
200-CR-1	Reduction-Oxidation Plant (REDOX) Canyon; associated waste sites	200-IS-1 200-MG-1/2	200-UR-1	EPA
Outer Area				
200-OA-1, 200-CW-1, 200-CW-3	Sites located in the Outer Area	200-CS-1 200-CW-1 200-CW-3 200-IS-1 200-MG-1/2	200-MW-1 200-SW-2 200-UR-1 200-UW-1	EPA

Three of the six 200-PW-1 waste sites, also known as the High-Salt Waste Group, will use the remove, treat, and dispose approach to excavate the highest concentrations of contaminated soils, located up to 2 feet (.6 meters) below the bottom of the disposal structure, and dispose at Waste Isolation Pilot Plant. An evapotranspiration barrier will be constructed over the remaining waste in these waste sites.

**200-PW-3 Operable Unit:** This operable unit, also known as the Cesium-137 Waste Group, will require that three of the five waste sites receive additional backfill to achieve coverage of at least 15 feet (4.57 meters)

depth. Contamination at the other two waste sites is deeper than 15 feet (4.57 meters) from the ground surface and will not require additional backfill.

**200-PW-6 Operable Unit:** This operable unit and three of the six 200-PW-1 waste sites, also known as the Low-Salt Waste Group, will use the remove, treat, and dispose approach to excavate a significant portion, approximately 90 percent, of the contaminated soils to a depth of 33 feet (10 meters) below ground surface, and dispose at ERDF or Waste Isolation Pilot Plant, as appropriate. An evapotranspiration barrier will be constructed over the remaining waste in these waste sites. A soil vapor extraction system is being used to remove and treat carbon tetrachloride contamination at waste sites in the High-Salt Waste Group and will continue to be used until vadose zone cleanup levels are met. Soil covers will be used to provide coverage to a depth of at least 15 feet (4.57 meters) over cesium-contaminated soils. This consists of maintaining or enhancing the existing soil cover with additional backfill.

Institutional controls and long-term monitoring will be required for waste sites in the 200-CW-5, 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units where waste is left in place and precludes unrestricted land use.

#### **5.2.2.1.2 200-WA-1/200-BC-1 Operable Unit (200-West Inner Area)**

This operable unit group includes soil waste sites located in the BC Cribs and Trenches and soil waste sites in the Inner Area portion of the 200-West Area not included in the 200-CR-1, 200-CW-5, 200-IS-1, 200-PW-1, 200-PW-6, and 200-SW-2 Operable Units. Specific sites are listed in the *Tri-Party Agreement Action Plan*, [Appendix C](#). Additional sites may be added to the 200-WA-1/200-BC-1 Operable Unit as new waste sites in the geographic area are discovered or created (e.g., soil that is determined to require additional evaluation or remediation following demolition of a structure). The *Remedial Investigation/Feasibility Study Work Plan 200-WA-1 and 200-BC-1 Operable Units* ([DOE/RL-2010-49](#)) was issued in December 2011. In addition, DOE obtained approval of the *216-U-8 Crib and 216-U-12 Vadose Zone Characterization Sampling and Analysis Plan* ([DOE/RL-2009-94](#)), which supports the 200-WA-1 Operable Unit remedial investigation.

#### **5.2.2.1.3 200-EA-1 Operable Unit (200-East Inner Area)**

This operable unit consolidates the remaining Inner Area sites in the 200-East Area except for the environmental media underlying tank farm waste management areas (WMA), landfills in the 200-SW-2 Operable Unit, PUREX, B Plant Canyon, and several waste sites with deep vadose zone contamination that are adjacent to WMA environmental media sites. Specific sites are listed in the *Tri-Party Agreement Action Plan*, [Appendix C](#). Additional sites may be added to the 200-EA-1 Operable Unit as new waste sites in the geographic area are discovered or created (e.g., soil that is determined to require additional evaluation or remediation following demolition of a structure). The 200-EA-1 Operable Unit will make use of a comprehensive application of the technical cleanup principles for the Inner Area developed for the 200-WA-1 Operable Unit.

Analysis for the 200-EA-1 Operable Unit will follow the same pattern as the 200-WA-1 Operable Unit and will utilize the same technical basis documents and comprehensive alternatives evaluation to clearly demonstrate how selected remedies for each fit within the framework of impacts from the entire Inner Area. The 200-EA-1 Work Plan has not been initiated.

#### **5.2.2.1.4 200-IS-1 Operable Unit**

This operable unit includes inactive waste transfer pipelines and pipeline components in the 200-IS-1 Operable Unit and soil waste sites in the Inner Area portion of the 200-East Area that are not included in the canyon area

operable units or in the tank farm WMAs. Specific sites are listed in the *Tri-Party Agreement Action Plan*, [Appendix C](#).

The Tri-Party Agencies agreed to utilize a coordinated CERCLA remedial action and RCRA corrective action process for cleanup decisions in the pipelines operable unit group. The *200-IS-1 Operable Unit Pipeline System Waste Sites RFI/CMS and RI/FS Work Plan* ([DOE/RL-2010-114](#)) was issued in September 2011.

#### **5.2.2.1.5 200-SW-2 Operable Unit (Burial Grounds)**

This operable unit includes 24 landfills located in the 200-East and 200-West Areas. Three soil waste sites located within the boundary of one of the burial grounds were added to the 200-SW-2 Operable Unit during restructuring. Specific sites are listed in the *Tri-Party Agreement Action Plan*, [Appendix C](#). Portions of the burial grounds listed in the *Hanford Facility Dangerous Waste Permit* (WA7890008967) include treatment, storage, and disposal facilities. DOE is working with Ecology to remove unused areas from the permit scope.

The Tri-Party Agencies agreed to use a coordinated CERCLA remedial action and RCRA corrective action process for cleanup decisions in the 200-SW-2 Operable Unit. The *200-SW-2 Radioactive Landfills Group Operable Unit RCRA RFI/CMS and RI/FS Work Plan* ([DOE/RL-2004-60](#)) was issued in October 2011.

#### **5.2.2.1.6 200-DV-1 Operable Unit (Deep Vadose Zone)**

This operable unit includes 44 soil waste sites located in the 200-East and 200-West Areas. The sites in this operable unit were previously located in the 200-TW-1/2 and 200-PW-5 Operable Units. Specific sites are listed in the *Tri-Party Agreement Action Plan*, [Appendix C](#). Additional sites may be transferred from other operable units if deep vadose zone contamination is present and the selected remedy is not protective of groundwater. Criteria and methods for identifying and transferring those sites will be defined in the forthcoming 200-DV-1 Operable Unit Work Plan.

Work on the 200-DV-1 Operable Unit is being closely coordinated with the ongoing RFI/CMS process for tank farm WMA C. Initial decisions are planned for 2015, although resolution for the more difficult issues, including tank farm closure, may span several decades. Near-term decisions will balance the need to take action based on best available scientific and technical knowledge or deferring decisions, pending research and technology development for targeted problems. The *Long-Range Deep Vadose Zone Program Plan* ([DOE/RL-2010-89](#)), issued in October 2010, summarizes the state of knowledge about contaminant cleanup challenges faced by the deep vadose zone beneath the Central Plateau and the approach to solving those challenges.

#### **5.2.2.1.7 200-CB-1 Operable Unit (B Plant Canyon)**

This operable unit includes the B Plant Canyon Building (221-B) and the Waste Encapsulation and Storage Facility, along with exterior ventilation system components for each of the structures (e.g., high-efficiency particulate air filters, sand filter), and 17 soil waste sites within the vicinity. Specific sites are listed in the *Tri-Party Agreement Action Plan*, [Appendix C](#). Additional sites may be added to the 200-CB-1 Operable Unit as new waste sites in the geographic area are discovered or created (e.g., soil that is determined to require additional evaluation or remediation following demolition of a structure). Sites near the B Plant Canyon currently assigned to the 200-IS-1 Operable Unit may be reassigned to the 200-CB-1 Operable Unit, pending the outcome of discussions among the Tri-Party Agencies. Cesium and strontium capsules located in the Waste Encapsulation and Storage Facility are not included in the scope of the 200-CB-1 Operable Unit. The work plan for B Plant Canyon continued in 2011.



**5.2.2.1.8 200-CU-1 Operable Unit (U Plant Canyon)**

This operable unit includes the U Plant Canyon Building (221-U) and other structures included in the 2005 ROD for the U Plant Canyon ([DOE, EPA, and Ecology, 2005](#)). The U Plant Canyon Disposition Initiative is a pilot project for disposition of the five canyon buildings in the 200-East and 200-West Areas. Implementation of the selected remedial action (close in place – partially demolished structure) continued in 2011.

**5.2.2.1.9 200-CP-1 Operable Unit (PUREX Canyon)**

This operable unit includes the PUREX Canyon Building (202-A), PUREX Storage Tunnels (218-E-15 and 218-E-16), exterior components of the ventilation system for each structure (e.g., deep bed filters), and 20 soil waste sites in the vicinity. Planning activities for PUREX Canyon continued in 2011. Specific sites are listed in the *Tri-Party Agreement Action Plan*, [Appendix C](#). Additional sites may be added to the 200-CP-1 Operable Unit as new waste sites in the geographic area are discovered or created (e.g., soil that is determined to require additional evaluation or remediation following demolition of a structure). Sites near the PUREX Canyon currently assigned to the 200-IS-1 Operable Unit may be reassigned to the 200-CP-1 Operable Unit, pending the outcome of discussions among the Tri-Party Agencies.

**5.2.2.1.10 200-CR-1 Operable Unit (Reduction-Oxidation [REDOX] Canyon)**

This operable unit includes the Reduction-Oxidation (REDOX) Canyon Building (202-S), exterior components of the ventilation system (e.g., filters), and 12 soil waste sites located in the vicinity. Specific sites are listed in the *Tri-Party Agreement Action Plan*, [Appendix C](#). Additional sites may be added to the 200-CR-1 Operable Unit as new waste sites in the geographic area are discovered or created (e.g., soil that is determined to require additional evaluation or remediation following demolition of a structure). Sites near the REDOX Canyon currently assigned to the 200-IS-1 Operable Unit may be reassigned to the 200-CR-1 Operable Unit, pending the outcome of discussions among the Tri-Party Agencies. Planning activities for the REDOX Canyon were initiated in 2010.

**5.2.2.2 Outer Area**

The Outer Area is defined as all areas of the Central Plateau beyond the boundary of the Inner Area. The Outer Area covers approximately 65 square miles (168 square kilometers) and contains more than 90 waste sites and structures scattered throughout the largely undisturbed sagebrush-steppe habitat. Most of the waste sites in the Outer Area are small near-surface sites that will be removed for treatment as needed for onsite disposal or sampled to confirm that no additional action is required; apart from implementing appropriate institutional controls. The largest components of Outer Area remediation are ponds where cooling water and chemical sewer effluents were discharged and the BC Control Area where surface contamination was spread through animal intrusion.

**5.2.2.2.1 200-OA-1, 200-CW-1, and 200-CW-3 Operable Units (Outer Area)**

Soil waste sites in the Outer Area requiring cleanup are assigned to one of the following three operable units:

- **200-CW-1 Operable Unit.** Contains ponds that were used for discharging large volumes of cooling water and other effluents with low levels of contamination or that were only potentially contaminated. There are 14 sites in the 200-CW-1 Operable Unit, including eight ponds and associated sewer lines, control structures, and unplanned releases.



- **200-CW-3 Operable Unit.** Contains 16 sites that were associated with operating the 200-North Area, a small complex initially used for temporary storage of spent nuclear fuel and later for storing miscellaneous materials and rail cars. The soil waste sites (trenches, small ponds, septic tanks, and sewer lines) were cleaned up as part of interim actions conducted from 2005 through 2010.
- **200-OA-1 Operable Unit.** Contains the remaining soil waste sites in the Outer Area that require cleanup under CERCLA, currently totaling 63 sites (debris and solid waste dumping areas, small liquid discharge sites, septic and sewer system components, and unplanned releases). Additional sites could be added as cleanup progresses and sites are discovered, or as existing non-CERCLA sites are reclassified.

The 200-OA-1, 200-CW-1 and 200-CW-3 Operable Unit group incorporates soil waste sites from several previous operable units. Work was initiated in 2010 on the 200-OA-1, 200-CW-1, and 200-CW-3 Operable Units RI/FS work plan and continued in 2011. The *200-CW-3 Operable Unit Interim Remedial Action Report* ([DOE/RL-2011-58](#)) was issued in September 2011. The summary of waste site remediation activities, cleanup verification processes, and cost information will support developing a final remedial action for the Outer Area of the Hanford 200 Area National Priorities List site.

#### **5.2.2.2.2 Nonradioactive Dangerous Waste Landfill and Solid Waste Landfill**

The Nonradioactive Dangerous Waste Landfill (NRDWL) and Solid Waste Landfill are located in the Outer Area and are not included in the operable units described above. The NRDWL is a RCRA-permitted disposal facility for dangerous waste generated at the Hanford Site that was not contaminated with radioactive materials. The NRDWL received dangerous waste from 1975 through 1985, as well as asbestos waste through 1988, and sanitary solid waste during 1976. The Solid Waste Landfill is a non-RCRA solid waste landfill north of the NRDWL. The Solid Waste Landfill received non-dangerous and nonradioactive solid waste, including paper, construction debris, asbestos, and lunchroom waste from 1973 through March 1996. The Solid Waste Landfill also received up to 1.3 million gallons (5 million liters) of sewage and 100,000 gallons (380,000 liters) of garage wash water.

Because the NRDWL is a RCRA-permitted treatment, storage and disposal site, closure is being managed in accordance with WAC-173-303, *Dangerous Waste Regulations*. The Solid Waste Landfill is regulated under WAC 173-350, *Solid Waste Handling Standards*. Evaluation of the closure actions are being conducted in accordance with the NEPA.

### **5.2.3 300 Area**

#### *DE Faulk*

Remediation efforts in 2011 focused on the 300-FF-2 Operable Unit waste sites. The 300-FF-2 Operable Unit ROD ([EPA/ROD/R10-01-119](#)) authorized remediation activities for the 300-FF-2 Operable Unit, which began in September 2002. Remediation activities included sampling to determine if suspected waste sites exceeded cleanup objectives; sampling to confirm that cleanup objectives were met; conducting physical excavation operations; sorting and segregating waste; sampling, treating, and disposing of waste; and backfilling and revegetating affected sites.

Waste burial grounds require cleanup, but also present a significant health and safety risk to workers as a result of incomplete waste disposal records and the potential for discovering unknown material from past disposal practices. This unknown material may require further characterization. Characterization is critical to ensure worker safety and proper management of waste for potential treatment and disposal. Discovery of unknown material requires additional time and planning to ensure proper protective gear is used in the field when

characterizing the material, and to verify that limits and controls identified in approved work authorization documents are adequate for the work scope. If work authorization documents do not adequately cover the material discovered, work is stopped until the documents can be revised and work can be safely restarted. Based on the characterization results, additional waste treatment may be required before disposal.

Waste generated from the cleanup of waste sites in the 300-F-2 Operable Unit is disposed at ERDF ([Section 5.4.3.7](#)) located on the Central Plateau and other EPA-approved disposal facilities. Approximately 68,300 tons (62,000 metric tons) of contaminated soil from the 300-FF-2 Operable Unit were disposed in 2011 at ERDF. Remediation of waste sites located in the northern part of the 300 Area began in 2009 and is ongoing. Remediation continued to focus primarily on waste sites north of Apple Street, with some remediation undertaken at waste sites south of Apple Street.



**Figure 5.2** 618-10 and 618-11 Burial Grounds

The 618-10 Burial Ground, located just west of Route 4 South, operated from 1954 to 1963 and is approximately 5.2 acres (2.1 hectares) in size. The 618-11 Burial Ground, located close to the Energy Northwest Columbia Generating Station in Richland, Washington, operated from 1962 through 1967 and is approximately 8.6 acres (3.5 hectares) in size. Both burial grounds (Figure 5.2) received waste including transuranic material from the 300 Area laboratory facilities. The burial grounds consist of multiple trenches, vertical pipe

units, and caissons. Significant challenges for remediation are present at the 618-10 and 618-11 Burial Grounds. The *Sampling and Analysis Plan for Characterization of the 618-11 Burial Ground* ([DOE/RL-2011-02](#)) was issued in February 2011. Non-intrusive characterization field activities were completed in 2010. The results of the intrusive characterization of 618-10 Burial Ground disposal trenches involving the construction of a series of test pits designed to investigate waste forms and validate planned remediation are detailed in the *Field Investigation Report for the 618-10 Burial Ground Intrusive Sampling* (WCH-437). Remediation of the 618-10 Burial Ground trenches began in April 2011 and continued through 2011.

### 5.3 Facility Decommissioning Activities

This section provides information regarding the transition of Hanford Site facilities from stabilization to surveillance and maintenance and eventual decommissioning. Decommissioning activities include the interim safe storage of plutonium production reactors; and the deactivation and decommissioning of facilities in the 100, 200, 300, and 400 Areas, and ancillary reactor facilities.

#### 5.3.1 100 Area

*CD McCurley*

Deactivation, decontamination, decommissioning, and demolition activities in the 100 Area included demolition actions at 100-N Area, 100-D Area, and 100-H Area, which were conducted as non-time-critical

removal actions under CERCLA. Construction actions also were completed to support non-time-critical removal actions planned for 2012. These actions are summarized below.

**100 Area facilities demolished in 2011:**

- 105-N Transfer Bay
- 116-N Exhaust Air Stack (below grade)
- 117-N Exhaust Air Filter House
- 117-NVH Valve Control House
- 186-N Alternate Potable Water Plant
- 1902-N Export Water Tie-In Building
- 1902-N81 Fire Protection Valve House
- 1903-N Septic System
- 1926-N Valve Pit
- HO-64-4265 Potable Water Trailer
- HO-64-6383 Office Trailer
- HO-64-6387 Sampler's Trailer
- MO-229 Office Trailer
- MO-848 Office Trailer
- West side of the 105-N Reactor Building Complex above and below grade rooms (i.e., Zone II Exhaust Fan Room, portion of the Drain Piping Tunnel below the 105-NA Emergency Diesel Enclosure).

**100 Area construction activities completed in 2011, in support of future decommissioning, deactivating, decontaminating, and demolishing activities:**

- 114-D Bat Roost Tower (to provide habitat for bats after the 183-D Headhouse has been demolished)
- Benches in the Columbia River to facilitate demolition of the 181-N River Pumphouse, 181-NE Hanford Generating Project (HGP) River Pumphouse, and 1908-NE HGP Outfall in 2012
- Electrical system and instrumentation on the 105-N/109-N safe storage enclosure
- Roof on the 105-N/109-N safe storage enclosure.

**Demolition and pre-demolition work began or continued on the following facilities:**

- 105-NE Fission Products Trap
- 105-N Fuel Storage Basin and Lift Station
- 181-N River Pumphouse
- 181-NE HGP River Pumphouse
- 182-N High Lift Pumphouse
- 1143-N Carpenter/Paint Shop
- 1908-NE HGP Outfall
- MO-403 Office Trailer (1119-N).

### 5.3.2 200 Area (Central Plateau)

Central Plateau facilities include buildings and waste sites in the 200-East, 200-West, and 200-North Areas, as well as those on the adjoining Fitzner/Eberhardt Arid Lands Ecology Reserve Unit. The transition toward decommissioning encompasses surveillance, maintenance, and deactivation activities.

#### 5.3.2.1 Plutonium Finishing Plant Decommissioning Progress

WG Cox

The PFP began processing plutonium nitrate solutions into metallic plutonium during 1949 for shipment to nuclear weapons-production facilities. Operation of this plant continued into the late 1980s (Figure 5.3). DOE issued a shutdown order for the PFP in 1990 and, in 1996, authorized the deactivation and transition of plutonium-processing portions of the facility in preparation for decommissioning.



Figure 5.3. Plutonium Finishing Plant Before Demolition

Workers at the PFP complex completed a large and multi-faceted effort in 2004 to stabilize, immobilize, repackage, and/or properly dispose of nearly 19.8 tons (18 metric tons) of plutonium-bearing materials in the plant. Workers then focused on decontaminating and deactivating the processing facilities while still providing for the safe and secure storage of nuclear materials until final disposition.

All special nuclear materials and remaining stored fuel elements were removed from the plant by the end of 2009, and security was downgraded. In addition, the removal and disposal of process equipment, chemicals, glove boxes, and hoods from the buildings began, continuing through 2011. Significant accomplishments at the PFP during 2011 include the following:

##### 5.3.2.1.1 234-5Z, Plutonium Finishing Plant

- Removed 72 percent (168 of 232) of all PFP glove boxes and hoods, including glove boxes and support systems from the Analytical Lab, Standards Lab, Process Development Lab, Radioactive Acid Digestion Test Unit Process Area, and the PFP Vault complex
- Removed 66 percent of all asbestos
- Removed 51 percent of process transfer lines
- Removed 22 percent of process vacuum piping
- Removed PFP Vault complex (2736-Z, 2736-ZA, 2736-ZB, 2736-ZC, 2721-Z, 2731-ZA and nitrogen generator system)
- Completed deactivation and cleanout of all process equipment and associated ducting from the PFP Vault complex and adjacent ancillary buildings (2736-Z, 2736-ZA, 2736-ZB, 2736-ZC, 2721-Z, 2731-ZA and the nitrogen generator system).
- Demolition of two ancillary buildings (2721-Z and 2736-ZA).

##### 5.3.2.1.2 236-Z, Plutonium Reclamation Facility

Removed 25 of 196 pencil tanks in 2011 from the Plutonium Reclamation Facility.



### 5.3.2.2 Other Central Plateau Facilities and Structures Surveillance, Maintenance, and Deactivation

*PT Karschnia*

Other Central Plateau facilities include interim-status RCRA treatment, storage, and disposal units awaiting closure are the: 1) Canyon buildings (PUREX Plant, B Plant, Reduction-Oxidation [REDOX] Plant, and U Plant); 2) three operating major air emission stacks; and 3) one operating minor emission stack.

Disposition of U Plant and the 209-E Criticality Mass Laboratory began in 2010 using funding from the *American Recovery and Reinvestment Act of 2009*. Deactivation and demolition of 209-E and its associated exhaust system to slab on grade was completed in December 2011. Grouting of the 221-U Building and shutdown of its associated exhaust system in preparation for demolition of the upper portion of the canyon building was completed in September 2011. Further progress in 2011 included removing the buildings and debris on the Fitzner/Eberhardt Arid Lands Ecology Reserve. The remaining contaminated rail cars in the 200-North Area were removed in 2011.

Surveillance, maintenance, and decontamination or stabilization of approximately 1,000 waste sites continued in 2011, including former waste disposal cribs, ponds, ditches, trenches, unplanned release sites, and waste burial grounds. Periodic surveillances, radiation surveys, and pesticide and herbicide applications were performed at these sites. Timely responses to identified problems were initiated. The overall objective is to maintain these sites in safe and stable condition and prevent contaminants from spreading in the environment. In addition, waste sites were remediated during 2011 by the Soil and Groundwater Remediation Project using *American Recovery and Reinvestment Act of 2009* funding.

### 5.3.2.3 Canyon Disposition Initiative

*BJ Dixon*

The Canyon Disposition Initiative was created to investigate the potential for using the five former chemical separations facilities (B Plant, T Plant, U Plant, PUREX Plant, and REDOX Plant) in the 200 Areas as disposal facilities for Hanford Site remediation waste rather than demolishing these canyon buildings.

The U Plant was selected as the pilot project for the Canyon Disposition Initiative (Figure 5.4). The remaining canyon buildings are to be addressed on a case-by-case basis, building on previous canyon disposition work.



**Figure 5.4. U Plant**

Planning and sampling activities to support preparation of a CERCLA feasibility study for implementing the Canyon Disposition Initiative at U Plant began in the mid-1990s. In fall 2005, EPA issued the 221-U Facility (Canyon Disposition Initiative) ROD (DOE, EPA, Ecology, 2005), selecting the close in place - partially demolished structure alternative for the remediation of the 221-U Facility. In accordance with the ROD, process equipment already in the plant will be consolidated into the belowground plant process cells. In addition, the cells, two lower galleries, and other void spaces will be filled with grout; the exterior walls and roof will be collapsed in place; and the site will be covered with a barrier.

Implementation of the selected alternative began in 2009 for the 221-U Facility. Beginning in 2009 and continuing through 2011, process equipment on the canyon deck was moved to specific belowground cells within the canyon structure, Cell 30 Tank D-10 was removed from the canyon (canyon void space grouted) and transferred to the Central Waste Complex for interim storage pending final treatment, packaging, and shipment to the Waste Isolation Pilot Plant. The hot pipe trench, piping and electrical galleries, drain header, process sewer, and ventilation tunnel and ducts were filled with grout in accordance with the *Remedial Design/Remedial Action Work Plan for the 221-U Facility* ([DOE/RL-2006-21](#)). These activities completed three of the five major remedy components: 1) Equipment size reduction and placement; 2) Cell 30 Tank D-10 contents disposition; and 3) canyon void space grouting.

### 5.3.3 300 Area

#### CP Strand

Deactivation, decontamination, decommissioning, and demolition activities in the 300 Area continued to focus on removing physical barriers to perform remedial actions in the 300-FF-2 Operable Unit. These activities were conducted as non-time-critical removal actions under CERCLA in accordance with *Action Memorandum #1 for the 300 Area Facilities* ([DOE and EPA 2005](#)), *Action Memorandum #2 for the 300 Area Facilities* (DOE and EPA 2006a), and *Action Memorandum #3 for the 300 Area Facilities* ([DOE and EPA 2006b](#)).

Additionally, the *Memorandum for General Hanford Site Decommissioning Activities* ([DOE/RL-2010-22](#)) authorized deactivation, decontamination, decommissioning, and demolition activities for a portion of the 337 Complex.

During decommissioning and decontamination activities at the 324 Building in late 2009, a breach in the Radiochemical Engineering B-Cell floor liner was noted in the bottom of a sump. Radiological dose measurements of approximately 14,000 rad/hour were observed at the failure location, indicating a possible release occurred during past operations from the 324 Building. Casings containing closed-end push probes were installed in November 2010 under B-Cell at the northern corner of the 324 Building. Dose measurements taken from these probes showed peak radiation readings of 8,900 rad/hour, confirming a significant source term from within B-Cell had been released to the soil column beneath the 324 Building. Additional probes to greater depths, and reviews of downgradient monitoring wells, confirmed that contamination had not come into contact with the groundwater. Characterization sampling of the contaminated soils has been performed and ongoing engineering evaluations are being used to develop a retrieval methodology that is protective of both workers and the environment.

The following 300 Area buildings and structures were demolished in 2011:

- 309 Plutonium Recycle Test Reactor above-grade (Figure 5.5)
- 308A High Bay above-grade
- 315C Sedimentation Pond and 315D Recycle Pump Station
- 320 Nuclear Research Building and boiler annex.
- 3714 Soils Laboratory
- 3717C Materials Archive Building
- 340B Rail Car Load-Out Building
- 340A Liquid Waste Storage Facility



Figure 5.5. 309 Building Demolition

- 340 Neutralization Facility above grade
- 352E Switch Station
- MO-270 and MO-271 Mobile Offices.

Facility deactivation, characterization, and demolition planning is ongoing for the balance of surplus buildings located in the 300 Area.

### 5.3.4 400 Area

CD McCurley

Deactivation, decontamination, decommissioning, and demolition activities were conducted on 14 buildings located in the 400 Area. These activities were conducted as non-time-critical removal actions under CERCLA in accordance with the *Removal Action Work Plan for River Corridor General Decommissioning Activities* (DOE/RL-2010-34). The following buildings were demolished in 2011:

- 4701B Guard Station
- 4706 Support Services Building
- 4719 Medical Aid Station
- 4722B Carpenter Shop
- 4726 Storage Building
- 4727 Flammable Storage Building
- 4734D Warehouse
- 4760 Construction Contractor Shop
- 4790 Patrol Headquarters
- 4791TC Warehouse
- 4814 Warehouse
- 4831 Flammable Storage Building
- 4843 Warehouse.

In addition, demolition of the 4702 Office Building began in 2011 and will continue into 2012.

#### 5.3.4.1 Fast Flux Test Facility (FFTF)

LC Tuott

FFTF (Figure 5.6) is a DOE-owned, formerly operating 400-megawatt (thermal) liquid-metal cooled (sodium) research and test reactor located at the 400 Area on the Hanford Site. Built in the late 1970s, the original purpose of the facility was to develop and test advanced fuels and materials for the Liquid Metal Fast Breeder Reactor Program and to serve as a prototype facility for future Liquid Metal Fast Breeder Reactor Program facilities; other missions were subsequently pursued. FFTF operated from April 1982 to April 1992 and provided the nuclear industry with significant advances in fuel performance, medical isotope production, material performance, and passive and active safety systems testing. The reactor was placed in a standby mode in



Figure 5.6. Fast Flux Test Facility



December 1993. After multiple studies, a decision was made to complete facility deactivation, including removing all nuclear fuel, draining the sodium systems, and deactivating systems and equipment to place the facility in a low-cost, long-term surveillance and maintenance condition, which was completed in June 2009.

FFTF remains in a long-term surveillance and maintenance condition. Routine surveillances are performed on an annual basis. Final decommissioning of FFTF depends on the outcome of the *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* ([DOE/EIS-0391](#)). The resultant ROD will determine the final end state for FFTF.

## 5.4 Waste Management Operations

*WE Toebe*

This section provides information regarding Hanford Site liquid and solid waste management.

### 5.4.1 Waste Classifications

Hanford Site cleanup operations result in the generation of solid wastes that must be evaluated for proper management. Solid wastes are reviewed against procedures in WAC 173-303-070(3) and are classified as dangerous when the criteria for this classification are met. The radionuclides in solid waste are exempt from evaluation under WAC 173-303-070(3), but are subject to evaluation and categorization as transuranic, high-level, or low-level waste under the *Atomic Energy Act of 1954*. Wastes that contain constituents regulated under both WAC 173-303 and the *Atomic Energy Act of 1954* are classified as mixed wastes.

Radioactive and/or mixed wastes are managed in several ways. High-level waste is stored in large underground single- and double-shell tanks or in capsules. Low-level waste typically is stored in tanks or containers. The method used to store low-level waste depends on the source, composition, and waste concentration. Transuranic waste is stored in vaults or on aboveground storage pads in a manner to enable its retrieval. A DOE annual report lists the dangerous and mixed wastes that are generated, treated, and disposed onsite or shipped offsite ([DOE/RL-2011-16](#)). Dangerous and mixed wastes are treated, stored, and prepared for disposal at several Hanford Site facilities. Dangerous waste generated at the site is shipped offsite for treatment and/or disposal. Some types of dangerous waste, such as used lead–acid batteries and aerosol products (e.g., spray paint), are shipped offsite for recycling.

Waste that does not contain hazardous or radioactive substances is non-regulated waste. Historically, non-regulated waste generated at the Hanford Site was disposed onsite. Beginning in 1999, non-regulated waste (including refuse, asbestos-containing waste, and drummed nonhazardous waste) has been disposed at municipal or commercial solid waste disposal facilities. Since 1996, medical waste has been shipped to a commercial medical waste treatment and disposal facility. Non-regulated waste originates at several areas across the Hanford Site. Examples include construction debris, office trash, cafeteria waste, and packaging materials. Other materials and items classified as non-dangerous waste include solidified filter backwash and sludge from the treatment of Columbia River water, failed and broken equipment and tools, air filters, uncontaminated used gloves and other clothing, and certain chemical precipitates (i.e., oxalates). Non-regulated demolition waste from 100 Area decommissioning projects was buried in situ (in place) or in designated disposal locations on the Hanford Site.

## 5.4.2 Solid Waste Inventories

JF Berger

The Solid Waste Information and Tracking System is a computer database used to track a portion of mixed and radioactive waste at the Hanford Site, primarily non-CERCLA containerized waste managed by CHPRC, MSA, and WRPS. The database does not include all waste from WCH, ERDF, or any PNNL wastes. The database also does not include high-level radioactive waste volumes managed at Hanford Site tank farms.

Quantities for both mixed and radioactive wastes generated onsite or received from offsite sources and disposed at the Hanford Site from 2007 through 2011, as tracked by the Solid Waste Information and Tracking System database, are shown in Tables 5.2 and 5.3. Quantities of dangerous waste shipped offsite from 2007 through 2011, as tracked by the database, are shown in Table 5.4. Hanford Site solid waste management is discussed in [Section 5.4.3](#).

**Table 5.2 Solid Waste<sup>(a)</sup> Quantities Generated on the Hanford Site (2007 through 2011)**

Waste Category		2007	2008	2009	2010	2011
Mixed	tons	259	346	281	286	522
	kilograms	235,000	314,000	255,000	260,000	474,000
Radioactive	tons	330	398	696	725	4022
	kilograms	300,000	361,000	632,000	658,000	3,649,000

(a) Solid waste includes containerized liquid waste.

**Table 5.3. Solid Waste<sup>(a)</sup> Quantities Received on the Hanford Site from Offsite Sources (2007 through 2011)**

Waste Category		2007	2008	2009	2010	2011
Mixed(b)	tons	195	459	257	152	320
	kilograms	177,000	416,000	233,000	138,000	291,000
Radioactive <sup>(b)</sup>	tons	185	445	196	388	257
	kilograms	168,000	404,000	178,000	352,000	233,000

(a) Solid waste includes containerized liquid waste. Solid waste quantities do not include U.S. Navy reactor compartments.

(b) Total includes Hanford Site-generated waste treated by an offsite contractor and returned as newly generated waste. Includes both low-level radioactive and transuranic waste.

**Table 5.4. Dangerous Waste<sup>(a)</sup> Quantities Shipped Off the Hanford Site (2007 through 2011)**

Waste Category		2007	2008	2009	2010	2011
Containerized	tons	53	128	47	55	53
	kilograms	48,000 <sup>(b)</sup>	116,000 <sup>(b)</sup>	42,800 <sup>(b)</sup>	49,700 <sup>(b)</sup>	47,800 <sup>(b)</sup>
	tons	39	56	79	37	43
	kilograms	35,100 <sup>(c)</sup>	50,900 <sup>(c)</sup>	71,300 <sup>(c)</sup>	33,900 <sup>(c)</sup>	38,700 <sup>(c)</sup>
Bulk Solids – Total	tons	—	—	83	230	146
	kilograms	0	0	74,800	208,600	132,500
Dangerous	tons	—	—	3.8	20	26
	kilograms	—	—	3,430	18,000	23,600
Non-radioactive	tons	—	—	79	210	120
	kilograms	—	—	71,400	190,600	108,900
Bulk Liquids – Total	tons	107	221	2	0	0
	kilograms	96,700 <sup>(d)</sup>	201,000 <sup>(d)</sup>	2,050 <sup>(d)</sup>	0 <sup>(d)</sup>	0 <sup>(d)</sup>
Dangerous	tons	16	57	2	0	0
	kilograms	14,300	51,900	2,050	0	0
Non-radioactive	tons	91	164	0	0	0
	kilograms	82,400	149,000	0	0	0
<b>Totals</b>	<b>tons</b>	<b>198</b>	<b>405</b>	<b>211</b>	<b>322</b>	<b>242</b>
	<b>kilograms</b>	<b>180,000</b>	<b>367,000</b>	<b>191,000</b>	<b>292,000</b>	<b>219,000</b>

(a) Does not include Toxic Substances Control Act waste

(b) Dangerous waste only

(c) Mixed waste (radioactive and dangerous)

(d) Bulk liquid classifications are not readily available prior to 2007.

### 5.4.3 Solid Waste Management

*JF Berger*

Solid waste management includes treatment, storage, and disposal of solid waste produced as a result of Hanford Site operations or received from offsite sources authorized by DOE to ship waste to the Hanford Site. These facilities are operated and maintained in accordance with state and federal regulations and facility permits. The following sections describe specific waste treatment, storage, and disposal locations at the Hanford Site.

#### 5.4.3.1 Central Waste Complex

*PT Karschnia and DE Nester*

The Central Waste Complex, a solid waste storage facility located in the 200-West Area, receives waste from sources on the Hanford Site and from offsite sources that are authorized by DOE to ship waste to the Hanford Site for treatment, storage, and disposal. The majority of waste received at the Central Waste Complex is generated from ongoing cleanup, research, and development activities at the Hanford Site. Waste types include low-level, mixed low-level, transuranic, and PCB radioactive. The current volume of waste stored totals approximately 364,870 cubic feet (10,330 cubic meters).

The Central Waste Complex can store as much as 735,000 cubic feet (20,800 cubic meters) of waste. This capacity is adequate to store the projected volumes of generated waste from the activities identified above, assuming on-schedule treatment and disposal of the stored waste.

An outdoor storage area was constructed in 2007 to store large containers of suspect transuranic waste from waste retrieval operations. The volume of waste currently stored in the outdoor expansion area is 207,156 cubic feet (5,866 cubic meters).

The Central Waste Complex is currently operating under a RCRA Part A interim status permit. Drafting of the Central Waste Complex RCRA Part B Permit Application for final status began in June 2008 and continued through 2011. Ecology is preparing to reissue the *Hanford Facility Dangerous Waste Permit* ([WA7890008967, Rev. 9](#)), incorporating the Central Waste Complex. The draft permit is scheduled to be issued for public comment in May 2012.

#### **5.4.3.2 Waste Receiving and Processing Facility**

*LC Tuott*

The Waste Receiving and Processing Facility began operating in 1997 with the mission to analyze, characterize, and prepare drums and boxes of low-level, mixed, and transuranic wastes for disposal. The 52,000-square-foot (4,800-square-meters) facility, along with two 21,500-square-foot (2,000-square-meters) storage buildings, is located north of the Central Waste Complex on the Central Plateau.

Waste destined for the Waste Receiving and Processing Facility includes stored waste as well as newly generated waste from current Hanford Site cleanup activities. The waste consists primarily of contaminated cloth, paper, rubber, metal, and plastic (i.e., debris). Processed waste that qualifies as low-level radioactive waste and meets disposal requirements is buried at the Hanford Site. Low-level radioactive waste not meeting burial requirements is processed at the Waste Receiving and Processing Facility for onsite burial or prepared for future treatment at other onsite or offsite treatment, storage, and disposal facilities. Waste determined to be transuranic is certified and packaged for shipment to the Waste Isolation Pilot Plant for permanent disposal.

In 2011, the Waste Receiving and Processing Facility dispositioned and shipped 50 cubic yards (38 cubic meters) of low-level waste offsite. In addition to these shipments, 933 cubic yards (713 cubic meters) of transuranic waste were sent to the Waste Isolation Pilot Plant for disposal, and 78 cubic yards (60 cubic meters) were sent to the Advanced Mixed Waste Treatment Facility in Idaho for treatment, certification, and subsequent shipment to the Waste Isolation Pilot Plant.

The Waste Receiving and Processing Facility is operating under interim status standards according to the *Hanford Facility Dangerous Waste Permit* ([WA7890008967](#)), Waste Receiving and Processing Facility Part A Form. Drafting of the Waste Receiving and Processing Facility RCRA Part B Permit Application for final status began in June 2008 and continued through 2011. Ecology is preparing to reissue the *Hanford Facility Dangerous Waste Permit* ([WA7890008967, Rev. 9](#)) and incorporating the Waste Receiving and Processing Facility. The draft permit is scheduled to be issued for public comment in May 2012.

### 5.4.3.3 T Plant Complex

*PT Karschnia*

The T Plant Complex (Figure 5.7) is located in the 200-West Area and provides solid waste treatment, storage, and decontamination services for the Hanford Site, as well as for offsite facilities. Workers performed the following activities in 2011:

- Sampled, characterized, treated, and repackaged numerous containers and boxes of waste to meet waste acceptance criteria and land disposal restriction requirements
- Repackaged 233 containers (55-gallon [208-liter] drum equivalents) of transuranic waste to meet offsite waste acceptance criteria and eventual disposal at the Waste Isolation Pilot Plant
- Used a super-compactor in the 221-T Canyon to crush 402 empty waste containers, conserving landfill space in onsite disposal units.



**Figure 5.7. T Plant Complex**

The T Plant Complex is operating under interim status standards in accordance with the *Hanford Facility Dangerous Waste Permit* (WA7890008967), T Plant Complex Part A Form. Ecology is preparing to reissue the *Hanford Facility Dangerous Waste Permit* ([WA7890008967, Rev 9](#)), incorporating the T Plant Complex. The draft permit is scheduled to be issued for public comment in May 2012.

### 5.4.3.4 Low-Level Burial Grounds

*DE Nester and LC Petersen*

The low-level burial grounds consist of eight separate burial grounds. Two burial grounds are located in the 200-East Area and six are located in the 200-West Area. These burial grounds are regulated under the *Atomic Energy Act of 1954*. Two of the burial grounds are being used for the disposal of low-level waste and mixed waste (i.e., low-level radioactive waste with a dangerous waste component regulated by WAC 173-303). The 218-W-5 Burial Ground is designated as low-level waste, located in the 200-West Area, and contains Trenches 31 and 34. The 218-E-12B Burial Ground is designated as low-level, located in the 200-East Area, and contains Trench 94. Trench 94 is dedicated for the disposal of defueled U.S. Navy reactor compartments. Trenches that contain mixed low-level waste are regulated under RCRA. Five of the burial grounds in the 200-West Area were used for disposing low-level waste and/or retrievable storage of transuranic waste, as were portions of the 218-E-12B Burial Ground. The 218-W-6 Burial Ground has never received waste.

The low-level burial grounds have operated under interim status standards in accordance with the *Hanford Facility Dangerous Waste Permit* (WA7890008967), Low-Level Burial Grounds Part A Form since 1985. Ecology is preparing to reissue the *Hanford Facility Dangerous Waste Permit* ([WA7890008967, Rev. 9](#)), incorporating the low-level burial grounds. The draft permit is scheduled to be issued for public comment in May 2012. In addition, the low-level burial grounds are included in *200-SW-2 Radioactive Landfills Group Operable Units RCRA Facility Investigation/Corrective Measures Study/Remedial Investigation/Feasibility Study Work Plan* ([DOE/RL-2004-60](#)). The plan outlines proposed characterization and remediation activities for specified burial grounds in the 200-East and 200-West Areas.

DOE issued a ROD (69 FR 39449-39456) on June 23, 2004, for the Solid Waste Program on the Hanford Site. Part of the ROD stated that DOE would dispose low-level waste in lined disposal facilities. Disposal of U.S. Navy reactor compartments in Trench 94 was not affected by this ROD.

While some of the low-level burial grounds contain only low-level waste and mixed low-level waste, suspect transuranic waste previously had been placed in retrievable storage. Retrieval of suspect transuranic retrievably stored waste occurred in the following burial grounds:

- 218-W-4C Burial Ground was initiated in October 2003 in accordance with the Tri-Party Agreement (Change Number [M-91-03-01](#)), and removal of waste from trenches in this burial ground was completed in May 2008
- 218-W-4B Burial Ground was initiated in January 2007
- 218-W-3A Burial Ground was initiated in August 2007
- 218-E-12B Burial Ground was initiated in February 2011.

Retrieval of suspect transuranic retrievably stored waste in the 218-W-4B, 218-W-3A, and 218-E-12B Burial Grounds continued through September 2011 at which time retrieval activities were shutdown due to reprioritization of work at the Hanford Site. Retrieval activities in these burial grounds are planned to resume in FY2015.

In 2011, 62,960 cubic feet (1,783 cubic meters) of retrievably stored waste were retrieved from the low-level burial grounds. Since August 19, 1987, no transuranic waste has been placed in the low-level burial grounds without specific DOE approval.

#### **5.4.3.4.1 Low-Level Waste Burial Ground 218-W-5, Trenches 31 and 34**

Trenches 31 and 34 are rectangular landfills with approximate base dimensions of 250 x 100 feet (76 x 30 meters). The floor of the excavation slopes slightly (nominally 1:3), giving a variable depth of 30 to 40 feet (9 to 12 meters). These trenches comply with WAC 173-303 requirements for double liners and leachate removal/collection systems. The floor and sides of the trenches are covered with a layer of soil 3.3 feet (1 meter) deep to protect the liner system during landfill operations. A recessed section at the end of each excavation houses a sump for leachate collection. Ramps along the perimeter walls provide vehicle access to the bottom of each trench.

These lined disposal units were originally designated for mixed low-level waste. Disposal of low-level waste in the unlined trenches ceased June 23, 2004. Since that date, Trenches 31 and 34 have accepted low-level waste and mixed low-level wastes for disposal. Disposal in Trench 31 began in May 2005, and disposal in Trench 34 began in September 1999.

In 2011, a total of 62,960 cubic feet (1,783 cubic meters) of waste were disposed in Trenches 31 and 34 as follows:

- Trench 34 has approximately 182,340 cubic feet (5,164 cubic meters) of waste in 5,288 waste packages. During summer 2004, the first operational layer of waste packages was covered with compacted gravel and soil, and the covering of the second waste layer was initiated. At the end of 2011, Trench 34 was filled to approximately 82 percent of waste capacity.



- Trench 31 has approximately 179,590 cubic feet (5,086 cubic meters) of waste in 3,186 waste packages. During summer 2009, the first operational layer of waste packages was covered with compacted gravel and soil, and the covering of the second waste layer was initiated. Trench 31 is filled to approximately 50 percent of waste capacity.
- Treatment of legacy mixed low-level waste continued at the Hanford Site during 2011. The majority of waste was treated offsite and returned to the Hanford Site following treatment for disposal in Trenches 31 and 34. A small volume of treated waste was disposed at an offsite commercial disposal unit. On a pretreatment volume basis, 32,840 cubic feet (930 cubic meters) of waste was treated prior to disposal.

Treatment of mixed wastes at offsite commercial waste processors in 2011 met the performance objectives of Tri-Party Agreement Milestones [M-091-42](#) (small package contact-handled mixed low-level waste) and [M-091-43](#) (large package and/or remote-handled mixed low-level waste).

#### **5.4.3.4.2 Low-Level Waste Burial Ground, Trench 94**

*JA Conley*

One defueled U.S. Navy reactor compartment was received in 2011 and placed in low-level waste burial ground, Trench 94 (218-E-12B Burial Ground), bringing the total number of reactor compartments received to 123. All U.S. Navy reactor compartments shipped to the Hanford Site for disposal originated from decommissioned nuclear-powered submarines or cruisers. Decommissioned submarine reactor compartments are approximately 33 feet (10 meters) in diameter, 47 feet (14.3 meters) long, and weigh between 1,000 and 1,500 tons (900 and 1,400 metric tons). Decommissioned cruiser reactor compartments are approximately 33 feet (10 meters) in diameter, 42 feet (12.8 meters) high, and weigh approximately 1,500 tons (1,362 metric tons).

#### **5.4.3.5 Waste Encapsulation and Storage Facility**

*FM Simmons*

The Waste Encapsulation and Storage Facility (Figure 5.8), located in the 200-East Area, was constructed in 1970 and 1971 on the west end of B Plant and became operational in 1974. The mission of the Waste Encapsulation and Storage Facility was encapsulation and storage of cesium chloride and strontium fluoride salts that had been separated from the Hanford Site's high-level radioactive tank waste. The facility is a two-story, 20,000-square-foot (1,860-square-meters) building, 157 feet (48 meters) long and 40 feet (12 meters) high, constructed of steel-reinforced concrete and partitioned into seven hot cells, a hot cell service area, operating areas, building service areas, and a pool cell area. The hot cells are labeled A through G, and activities within the hot cells are performed remotely using manipulators. Waste and drum load-out can be performed in Hot Cell A. Hot



**Figure 5.8. Waste Encapsulation and Storage Facility**



Cells B through E are on cold standby status. Only Hot Cells F and G remain active for cesium and strontium capsule storage. The operating areas and other building service areas associated with the hot cells provide areas for instrumentation monitoring, utility support, or manipulator repair as required.

The Waste Encapsulation and Storage Facility is a storage only unit for strontium and cesium encapsulated salts in double-containment stainless-steel capsules in underwater pool cells; and does not generate regulated waste. The water provides cooling and shielding for the capsules that are considered sealed sources. The Waste Encapsulation and Storage Facility is operating under interim status standards in accordance with the *Hanford Facility Dangerous Waste Permit* (WA7890008967), Waste Encapsulation and Storage Facility Part A Form. Ecology is preparing to reissue the *Hanford Facility Dangerous Waste Permit* ([WA7890008967, Rev. 9](#)), incorporating the Waste Encapsulation and Storage Facility. The draft permit is scheduled to be issued for public comment in May 2012.

#### 5.4.3.6 Integrated Disposal Facility

*PT Karschnia*

The Integrated Disposal Facility (Figure 5.9) is a newly constructed, unused landfill that is not actively operating. Located in the south-central part of the 200-East Area, the landfill is an expandable RCRA hazardous waste-compliant unit (i.e., a double high-density polyethylene-lined trench with leachate collection and a leak detection system). The landfill is divided lengthwise (north to south) into two distinct cells: the east cell is for disposal of low-level radioactive waste (non-RCRA permitted), and the west cell is for disposal of low-level mixed waste (radioactive and RCRA regulated hazardous waste).



**Figure 5.9. Integrated Disposal Facility**

The *Hanford Facility Dangerous Waste Permit* (WA7890008967), Integrated Disposal Facility Part A Form process design disposal capacity is 2.89 million cubic feet (82,000 cubic meters). In addition, the Integrated Disposal Facility is referenced in the *Draft Tank Closure and Waste Management Environmental Impact Statement* ([DOE/EIS-0391](#)) as a future disposal option for Hanford Site wastes.

#### 5.4.3.7 Environmental Restoration Disposal Facility

*MA Casbon*

ERDF is located near the 200-West Area, and is a massive landfill regulated by the EPA. The facility began operations in July 1996 and serves as the central disposal site for contaminated waste removed during Hanford Site cleanup operations conducted under CERCLA regulations. The total available expansion area of the ERDF site was authorized in a 1995 ROD ([EPA/ROD/R10-95/100](#)) to cover as much as 1.6 square miles (4.1 square kilometers). To provide a barrier to prevent contaminant migration from the in-ground facility, ERDF is constructed to RCRA Subtitle C minimum technology requirements, which includes a double liner and leachate collection system (40 CFR 264.301). Remediation waste disposed in the facility includes soil, rubble, or other solid waste materials contaminated with hazardous, low-level radioactive, or mixed (combined hazardous and radioactive) low-level waste.

Designed to be expanded as needed, ERDF comprises a series, cells, or disposal areas. Each pair of cells (Cells 1 through 8) is large enough to hold approximately 1.4 million tons (1.27 million metric tons) of material. Two 'super cells', each the equivalent of a pair of existing cells, were constructed using *American Recovery and Reinvestment Act* funds and completed in January 2011. The upgrades included new maintenance facilities, additional dump ramps and additional transfer areas for waste containers – all of which enhance the safety of increased, daily operations. The total constructed trench capacity of ERDF is 16.4 million tons (14.9 million metric tons); Cells 1 and 2 are full with an interim cover, Cells 3 and 4 are full, Cells 5 and 6 are being filled and near operational capacity, Cells 7 and 8 are approximately half-full, and disposal in Super Cells 9 and 10 began in the first half of CY2011.

#### 5.4.4 Liquid Waste Management

*LC Petersen*

Facilities are operated on the Hanford Site to store, treat, reduce, and dispose of various types of liquid effluent generated by site cleanup activities. These facilities are operated and maintained in accordance with state and federal regulations, and facility permits.

##### 5.4.4.1 200 Area Effluent Treatment Facility

The 200 Area Effluent Treatment Facility (Figure 5.10), located in the 200-East Area, treats liquid effluent to remove toxic metals, radionuclides, and ammonia, in addition to destroying organic compounds. The treatment process constitutes best available technology and includes pH adjustment; filtration; ultraviolet light and peroxide oxidation to destroy organic compounds; reverse osmosis to remove dissolved solids; and ion exchange to remove the last traces of contaminants. The facility began operating in December 1995 and has a maximum treatment capacity of 150 gallons (570 liters) per minute. Storage and treatment activities are managed in accordance with the *Hanford Facility Dangerous Waste Permit* ([WA7890008967](#)), and effluent discharges are managed in accordance with limitations set forth in the State Waste Discharge Permit ST-4500 ([ST 4500](#)) and with the 200 Area Effluent Treatment Facility Delisting Permit.



**Figure 5.10. 200 Area Effluent Treatment Facility and Liquid Effluent Retention Facility**

The treated effluent is stored in tanks, sampled and analyzed, and discharged via a dedicated pipeline to the State-Approved Land Disposal Site (also known as the 616-A Crib). This disposal site is located just north of the 200-West Area and is an underground drain field. The percolation rates for the field have been established by site testing and evaluation of soil characteristics. Tritium in the liquid effluent from the Effluent Treatment Facility cannot be practically removed, and the location of the disposal site maximizes the time for migration of the tritium to the Columbia River to allow for radioactive decay (the half-life of tritium is 12.35 years).

The volume of wastewater treated and disposed in 2011 was approximately 19.9 million gallons (75.3 million liters). This wastewater was primarily CERCLA-regulated wastewater (groundwater from the 200-UP-1 and 200-ZP-1 Operable Units in the 200-West Area).

#### **5.4.4.2 Liquid Effluent Retention Facility**

The Liquid Effluent Retention Facility (Figure 5.10), located in the 200-East Area, consists of three RCRA-compliant surface basins used to store temporarily process condensate from the 242-A Evaporator, groundwater from various operable unit pump-and-treat systems, leachate from ERDF and from low-level waste burial ground Trenches 31 and 34, and other aqueous waste. The Liquid Effluent Retention Facility provides a steady flow and consistent pH for the 200 Area Effluent Treatment Facility feed. Each basin has a maximum capacity of 7.8 million gallons (29.5 million liters) and each basin is constructed of two flexible, high-density polyethylene membrane liners. A system is provided to detect, collect, and remove leachate from between the primary and secondary liners in the event of leakage. Beneath the secondary liner is a soil and bentonite clay barrier, should both the primary and secondary liners fail. Each basin has a floating membrane cover constructed of very low-density polyethylene to keep out windblown soil and weeds and to minimize evaporation of small amounts of organic compounds and tritium that may be present in the basin contents. The facility began operating in April 1994 and receives liquid waste resulting from cleanup activities regulated by both RCRA and CERCLA. Historically, RCRA and CERCLA wastewaters were segregated in the surface basins and processed with different disposal destinations. However, the ROD for ERDF was amended in 2007 to allow receipt of all RCRA and CERCLA waste ([DOE, EPA, and Ecology 2007](#)). Therefore, segregation of RCRA and CERCLA wastewater is no longer required. Treatment and storage activities at the Liquid Effluent Retention Facility are managed in accordance with the *Hanford Facility Dangerous Waste Permit* (WA7890008967).

The volume of wastewater received for interim storage in 2011 was approximately 18.3 million gallons (69.3 million liters). The majority of wastewater received at the Liquid Effluent Retention Facility was pipeline-transported contaminated groundwater from operable unit pump-and-treat systems, totaling approximately 16 million gallons (60.6 million liters). The basin volume also included approximately 1.8 million gallons (6.8 million liters) of CERCLA-regulated leachate from ERDF. Approximately 0.5 million gallons (1.9 million liters) of wastewater were received from various facilities by tanker trucks that included approximately 0.4 million gallons (1.5 million liters) of leachate from low-level waste Burial Ground 218-W-5, Trenches 31 and 34. No process condensate was received from the 242-A Evaporator in 2011.

The volume of wastewater being stored in the Liquid Effluent Retention Facility at the end of 2011 was 16.8 million gallons (63.6 million liters).

#### **5.4.4.3 200 Area Treated Effluent Disposal Facility**

The 200 Area Treated Effluent Disposal Facility, located east of the 200-East Area, is a collection and disposal system for non-RCRA waste streams. The individual waste streams must be treated or otherwise comply with best available technology and all known available and reasonable treatment methods in accordance with *Submission of Plans and Reports for Construction of Wastewater Facilities* ([WAC 173-240](#)), which is the responsibility of the generating facilities. Effluent discharges comply with the limitations established in State Waste Discharge Permit ST-4502 ([ST 4502](#)).

The 200 Area Treated Effluent Disposal Facility consists of approximately 11 miles (18 kilometers) of buried pipelines connecting three pumping stations, the 6653 Building (known as the disposal sample station), and 5-acre (2-hectare) disposal ponds. The facility began operating in April 1995 and has a capacity of 3,400 gallons (12,900 liters) per minute. The volume of unregulated effluent disposed in 2011 was 14.2 million gallons (53.8 million liters).

#### 5.4.4.4 242-A Evaporator

##### *AL Hummer*

The 242-A Evaporator (Figure 5.11), located in the 200-East Area, concentrates dilute liquid tank waste by evaporation. The resultant water vapor is captured, condensed, filtered, sampled, and sent to the nearby Liquid Effluent Retention Facility for further treatment and disposal before being returned to the double-shell tanks. This process reduces the volume of liquid waste sent to double-shell tanks for storage and reduces the potential need for additional double-shell tanks.



**Figure 5.11. 242-A Evaporator**

The *American Recovery and Reinvestment Act of 2009* funded the majority of the upgrade activities in 2011 to extend the 242-A Evaporator service life through 2032. These upgrades are described in the following paragraphs.

Field construction of a new K-1 Building Exhauster was completed. The new building exhauster system was installed to replace the original K-1 ventilation system, which had been in operation since the construction of the 242-A Evaporator. The original K-1 ventilation system was isolated from the 242-A Evaporator and the exhaust stack was capped. The new K-1 Building Exhauster was successfully tested prior to turning over to facility operations for day-to-day use. It now provides ventilation for the radiologically contaminated hot side of the 242-A Evaporator including facility modifications planned for CY2012.

Instrumentation upgrades and replacements continued in 2011 in the 242-A Evaporator to support continued operations. Facility lighting was upgraded in certain locations, and fixtures that were original to the facility were replaced, some of which contained PCB ballasts. Critical spare parts were procured including components to rebuild the PB-1 Recirculation Pump and a new PB-2 Slurry Pump.

Waste volume reduction activities at the 242-A Evaporator are managed in accordance with the *Hanford Facility Dangerous Waste Permit* (WA7890008967); however, in CY2011 the 242-A Evaporator did not perform waste volume reduction activities.



## 5.5 Underground Waste Storage Tanks

*AL Hummer*

Most Hanford Site waste is stored in 149 large underground single-shell (single-walled) tanks and 28 double-shell (double-walled) tanks located on the Central Plateau near the center of the site. A grouping of tanks is referred to as a farm. This section provides information about the single-shell tanks and double-shell tanks on the Hanford Site, and activities that occurred in 2011 related to their operation and closure.

### 5.5.1 Single-Shell Tank System

*AL Hummer*

The single-shell tank system includes 149 tanks that were constructed between the years 1943 and 1964 to store mixed waste generated on the Hanford Site; 67 of the tanks are assumed to have leaked in the past. Pumpable liquids in the single-shell tanks were transferred to the newer and safer

double-shell tanks several years ago under the Interim Stabilization Program to help prevent additional environmental releases. Approximately 569,600 gallons (2,156,155 liters) of radioactive and hazardous waste were removed from single-shell tanks C-104, C-107, C-108, and C-111 in 2011 and transferred to safer double-shell tank storage, leaving approximately 29.5 million gallons (112 million liters) of waste in the single-shell tanks.

The single-shell tank system is undergoing closure and is currently managed under the *Hanford Facility Dangerous Waste Permit*, Single-Shell Tank System Part A Form. Ecology is preparing to reissue the *Hanford Facility Dangerous Waste Permit* ([WA7890008967, Rev. 9](#)) for public comment in May 2012; the single-shell tank system will be reserved.

### 5.5.2 Double-Shell Tank System

*AL Hummer*

The double-shell tank system contains 28 double-shell tanks constructed between the years 1968 and 1986, the tanks contain liquids and settled solids from past nuclear operations, including waste transfers from older single-shell tanks. The double-shell tank system storage capacity is approximately 33 million gallons (126 million liters), and stores radioactive and chemical waste. Storage space within the double-shell tank system is being managed to store waste pending treatment by the WTP, or a supplemental treatment process, and includes emergency pumping space available at all times for 1 million gallons (3.8 million liters).

The double-shell tank system is operating under interim status standards in accordance with the *Hanford Facility Dangerous Waste Permit*, Double-Shell Tank System Part A Form. Ecology is preparing to reissue the *Hanford Facility Dangerous Waste Permit* ([WA7890008967, Rev. 9](#)), incorporating the double-shell tank system. The draft permit is scheduled to be issued for public comment in May 2012.



**Figure 5.12. 241-C and 241-AN Tank**

At the end of 2011, there were 26 million gallons (98 million liters) of waste in the double-shell tanks. Quantities of liquid waste generated in 2011 and stored in underground storage tanks are provided in the *Hanford Site Annual Dangerous Waste Report Calendar Year 2011* ([DOE/RL-2012-16](#)). Table 5.5 summarizes the liquid waste generated and stored from 2007 through 2011 in underground storage tanks.

**Table 5.5 Tank Farm System Quantities of Liquid Waste<sup>(a)</sup> Generated and Stored<sup>(b)</sup> (2007 through 2011)**

Type of Waste	Units	2007	2008	2009	2010	2011
Double-Shell Tanks (waste added)	Gallons	1,559	85	325	412	113
	Liters	5,901	322	1,230	1,560	428
Double-Shell Tanks (year-end volume)	Gallons	26,695	26,778	25,971	25,835	25,948
	Liters	101,052	101,366	98,311	97,796	98,224
242-A Evaporator volume evaporated	Gallons	1,189	0	960	548	0
	Liters	4,500	0	3,634	2,074	0
Single-Shell Tanks volume pumped	Gallons	1,147 <sup>(d)</sup>	69 <sup>(d)</sup>	102 <sup>(d)</sup>	240 <sup>(d)</sup>	560 <sup>(d)</sup>
	Liters	4,342 <sup>(d)</sup>	262 <sup>(d)</sup>	386 <sup>(d)</sup>	909 <sup>(d)</sup>	2120 <sup>(d)</sup>

(a) Quantity of liquid waste is defined as liquid waste sent to double-shell underground storage tanks during these years, rounded to the nearest 1,000; and does not include containerized (e.g., barreled) waste included in the solid waste category.

(b) Multiply volumes shown by 1,000.

(c) Volume does not include dilution or flush water.

(d) Volume does include dilution or flush water.

### 5.5.3 Progress on Defense Nuclear Facilities Safety Board Recommendations for the Underground Waste Storage Tanks and Associated Facilities

*LM Gamache*

Throughout 2011, ORP and its contractors met with and provided information to the DNFSB and its technical staff to resolve concerns regarding Hanford Site underground storage tank farm projects. The following issues were addressed in 2011:

- Installation of corrosion and erosion sensors to measure the wall thinning of pipe bends in waste transfer piping in portable valve boxes associated with single-shell tank retrievals
- Upgrade of permanently installed equipment instrument readings used to take an action to prevent or mitigate an accident as directed in a Technical Safety Requirement
- Upgrade of double-shell tank primary tank ventilation systems
- Revisions to the *Tank Farms Documented Safety Analysis* ([RPP-13033](#)) to implement the following:
  - ‡ Removal of the allowance for drip leakage from waste transfer piping and hose-in-hose transfer lines during waste transfers
  - ‡ Update to the planned design and operational improvement listing for life-cycle testing of safety-significant values to show a schedule for completion of testing
  - ‡ Addition of a new planned design and operational improvement listing for the development of a plan for performing testing of non-metallic materials exposed to tank waste to more closely resemble the irregular/occasional or episodic exposures to tank farms low dose rate radiation, waste chemistry, and temperatures



- Work planning and control.

A suite of corrective actions took place in 2011 to address an ORP issue concerning work planning and control processes and the associated implementation. The corrective actions focused on developing and implementing the contractor's (WRPS) process of containing the necessary controls to ensure rigorous, consistent implementation. ORP and WRPS participated in the Energy Facility Contractors Group work planning and control team and WRPS further participated in developing the URS Corporation work control standard. WRPS has identified that the gaps to support implementation of the URS Corporation standard are minor; WRPS intends to implement the standard in FY2012 followed by a corporate assessment of implementation. WRPS performed an end-point assessment at the end of 2011 to evaluate the effectiveness of the completed corrective actions to improve work instruction/procedure development and use, and overall effectiveness of the WRPS work planning process. The overall performance in work planning and control has improved as demonstrated by a decrease in consequential issues, and a strong foundation for the work control and planning process will result in successful work planning and control, if followed.

Mechanisms are in place to address work scope definition, hazard identification and control selection, work release, and administrative portions of work control. However, weaknesses were observed in using change control to ensure field activities remain aligned with the instructions and approved controls. These weaknesses are representative of an ongoing culture change. Additional actions will be taken to ensure compliance with work instructions, self-correction of instructions in response to changing conditions, and recognizing the need for clarification or changes to the initial controls.

Throughout FY2011, WRPS has been pursuing a continuous improvement approach to achieve its expectations for rigorous conduct of operations. WRPS has improved in some areas, but continued focus on ongoing actions is necessary to safely and efficiently support the planned increase in operational tempo. WRPS will continue to utilize conduct of operations coaches to ensure supervisors and work crews have a solid understanding of disciplined conduct of operations, Integrated Safety Management System, radiological controls, and work planning and control. WRPS has engaged management and workers in improvement forums and has made organizational changes to improve ownership, accountability, and access to program subject matter experts. Specific improvements have been pursued in work instructions/technical procedures, control of work by fieldwork supervisors, housekeeping, shift turnover, and radiological controls. These improvements were evident while completing the tank farms stimulus work, tank waste transfers, and the safe initial operations of the C-107 Mobile Arm Retrieval System in October 2011.

#### **5.5.4 Vadose Zone Program**

*SJ Eberlein*

Vadose zone program personnel are responsible for implementing the Tank Farm RCRA Corrective Action Program through field characterization, laboratory analyses, technical analyses, risk assessment for past tank leaks, and installation of interim measures that will reduce the threat from contaminants until permanent solutions can be found. Results of vadose zone investigations and interim measures, conducted the first 10 years of the project, are documented in the *RCRA Facility Investigation Report for Hanford Single-Shell Tank Waste Management Areas* ([DOE/ORP-2008-01](#)).

Vadose zone program personnel installed several direct-push boreholes for soil sampling and geophysical logging in the C, BY, and S Tank Farms in 2011 and completed additional surface geophysical surveys in WMAs C and BY. Monitoring was conducted at the two interim surface barriers (one that covers a portion of the 241-T Tank and one that covers all of the 241-TY Tank Farm). These two surface barriers cover areas

where soil has been contaminated due to past leaks from tanks or tank associated equipment, and reduces water infiltration through the contaminated soil.

#### **5.5.4.1 Direct-Push Boreholes and Sampling**

Direct-push technology, using a hydraulic hammer unit to evaluate subsurface contamination in the vadose zone, was deployed in three tank farms during 2011. Several direct-push boreholes were made in the C Tank Farm as part of the Phase II RCRA investigation of that WMA. The hydraulic hammer unit also was deployed in the eastern portions of BY Tank Farm and in S Tank Farm to assess the extent of contamination in support of a proposed interim barrier in that farm.

#### **5.5.4.2 Surface Geophysical Exploration**

Surface geophysical exploration is a combination of surface-deployed geophysical techniques, including pole-to-pole electrical resistivity, electro-magnetic induction, magnetic gradiometry, and ground-penetrating radar used to help define the presence and distribution of buried infrastructure so that those features may be considered during resistivity data analysis. The depth to which the resistivity measurements interrogate the subsurface is determined by the distance between electrode pairs (the farther apart, the deeper the interrogation). Resistivity is an indirect measure of several subsurface phenomena (e.g., moisture distribution, saline contaminants, and soil texture); the greater the depth of interrogation, the lower the resolution of the analysis.

Surface geophysical exploration was performed in 2011 at the BY Tank Farm ([RPP-RPT-49129](#), [RPP-RPT-50758](#)). A survey was performed of a third unplanned release in waste site UPR-200-E-82 located in C Tank Farm ([RPP-RPT-50052](#)).

#### **5.5.4.3 Interim Surface Barriers**

The effectiveness of the T Tank Farm interim surface barrier at reducing infiltration is assessed through a barrier-monitoring program ([PNNL-16538](#)). Pre-barrier data were collected and a monitoring report for FY2007 was issued in January 2008 ([PNNL-17306](#)). The most recent post-barrier data were compiled into a FY2010 monitoring report issued in January 2011 ([PNNL-20144](#)). The barrier is resulting in slow drying of the vadose zone as water, which would normally recharge the surface, is diverted; barrier monitoring continues. A second interim barrier was constructed during 2010 at TY Tank Farm; monitoring is underway at the second barrier.

Two interim barriers were designed to be placed over most of the tanks in the SX Tank Farm. Modified asphalt was selected as the impermeable surface, and an evapotranspiration basin will be located south of the SY Tank Farm to redirect any runoff back to the atmosphere. The design and monitoring plan was approved by Ecology for future construction.

## 5.6 Waste Treatment and Immobilization Plant

HM Groce

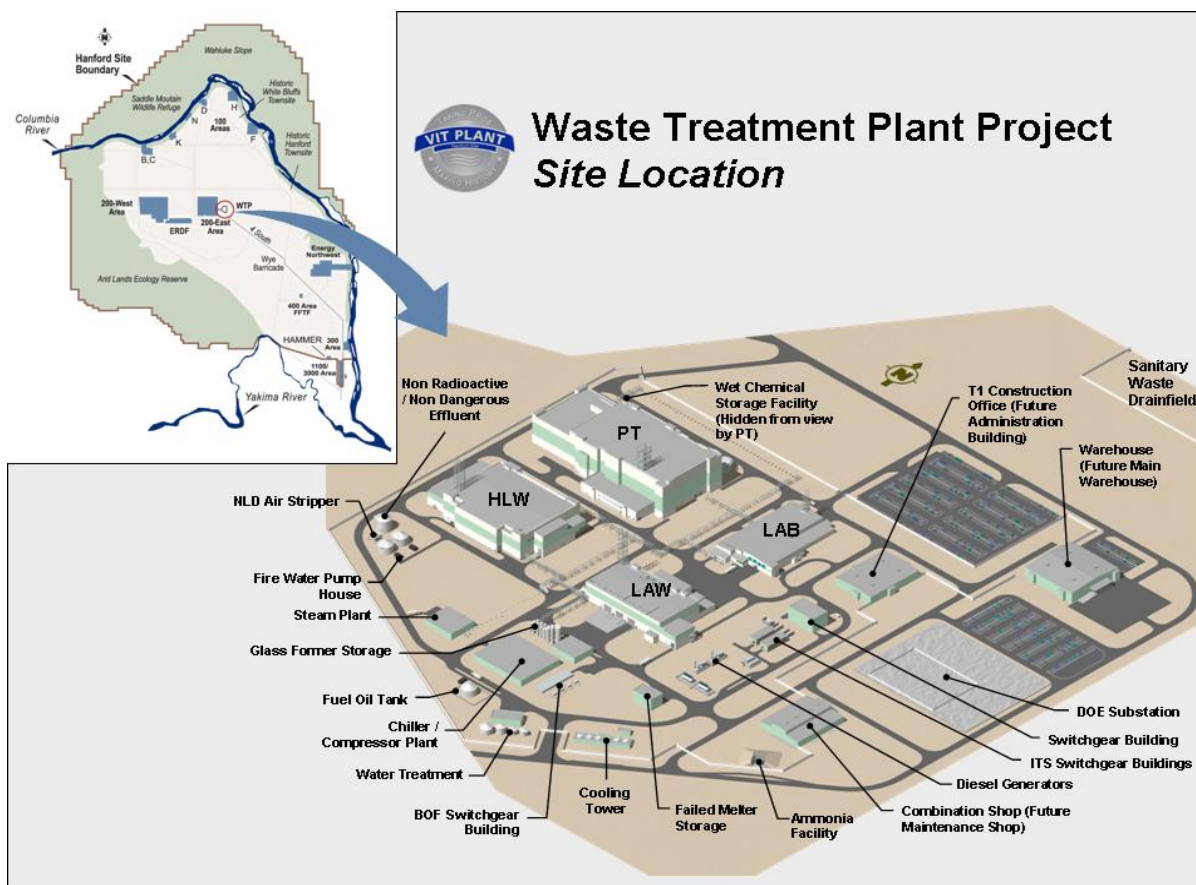
The WTP is being built on 65 acres (26 hectares) located on the Central Plateau in the 200-East Area (Figure 5.13) to treat radioactive and hazardous waste stored in 177 underground tanks. The WTP comprises four major facilities (Pretreatment Facility, High-Level Waste Vitrification Facility, Low-Activity Waste Vitrification Facility, and Analytical Laboratory), along with 20 support buildings and the associated underground utilities (balance of facilities). Construction of the WTP is managed in accordance with the *Hanford Facility Dangerous Waste Permit* (WA7890008967).



Figure 5.13. Waste Treatment and Immobilization Plant

**Pretreatment Facility.** Hanford Site contractors have made significant progress on the WTP. The fifth elevation of concrete walls was completed at the Pretreatment Facility, reaching the 98-feet (30-meters) elevation. A 102-ton (93-metric ton) protective shield door also was placed in the facility.

**High-Level Waste Vitrification Facility.** Construction crews for the High-Level Waste Vitrification Facility installed a 10-ton (9-metric ton) air-filtration duct and engineers completed the civil, structural, and architectural design of the facility.



**Low-Activity Waste Vitrification Facility.** Workers set a 65-foot-long (20-meters-long) carbon dioxide vessel at the Low-Activity Waste Vitrification Facility, installed a series of panels as part of the facility cooling system, and put in place a nearly 100-ton (90-metric ton) carbon bed adsorber as part of the facility's air-filtration system.

**Analytical Laboratory.** The Analytical Laboratory crew continued installing the auto-sampling equipment and fume hood stations for the facility's analytical process areas.

**Balance of Facilities.** The Balance of Facilities crew completed construction of the water treatment building where water will be filtered and treated to be used throughout the WTP. Additional progress included commodity and facility support installations.

The WTP construction site was awarded the DOE Voluntary Protection Program Superior Star status in September 2011 for outstanding safety and health programs. Superior Star status is awarded to sites that previously earned Voluntary Protection Program Star status and continue to maintain safety performance and active employee engagement in safety initiatives.

The WTP is approximately 63 percent complete as of January 31, 2012, including the following:

- Approximately 86 percent design complete
- Approximately 63 percent construction complete on the Balance of Facilities
- Approximately 68 percent construction complete on the Low-Activity Waste Facility
- Approximately 77 percent construction complete on the Analytical Laboratory
- Approximately 42 percent construction complete on the Pretreatment Facility
- Approximately 39 percent construction complete on the High-Level Waste Vitrification Facility.

From project inception through January 2012, the WTP crew placed 5.9 million cubic feet (168,202 cubic meters) of concrete; erected 19,000 tons (17,200 metric tons) of structural steel; installed 327,000 linear feet (99,600 meters) of pipe; and 304,000 linear feet (92,600 meters) of cable and wire.

### **5.6.1 Waste Treatment and Immobilization Plant Progress on Defense Nuclear Facilities Safety Board Recommendations**

*LM Gamache*

Throughout 2011, ORP and its contractors met with and provided information to the DNFSB and its technical staff to resolve commitments and review the following technical topics regarding the WTP Project.

#### **5.6.1.1 Defense Nuclear Facility Safety Board Recommendation 2010-2**

The DNFSB issued Recommendation [2010-2](#), Pulse Jet Mixing at the WTP on December 17, 2010, which DOE accepted on February 10, 2011.

The DNFSB's recommendation documented their position that testing and analysis completed to date have been insufficient to establish, with confidence, that the pulse jet mixing and transfer systems at the WTP will perform adequately at full scale. The DNFSB's letter identified five unresolved technical concerns:

- Limitations of the small-scale testing program
- Modeling of the mixing performance
- Tank waste characterization and feed certification
- Planned WTP process vessel modifications

- Limitations of pulse jet mixer controller and instrumentation testing.

The DNFSB included seven sub-recommendations, which are being addressed by DOE in DNFSB Recommendation 2010-2 Implementation Plan. The sub-recommendations are as follows:

1. Develop a Large-Scale Test Plan to address issues raised by the DNFSB, Consortium for Risk Evaluation with Stakeholder Participation, and PNNL.
2. Develop waste simulants that envelope the complete range of physical properties for high-level waste (High-Level Waste Vitrification Facility) in the Hanford tank feed.
3. Complete verification and validation of any computation models used by the WTP.
4. Demonstrate the ability to obtain representative samples in all WTP vessels.
5. Define the impact of limitations on WTP mixing, transfer systems on waste retrieval and delivery, and demonstrate that waste acceptance criteria can be reliably enforced.
6. Establish functional design criteria for heel dilution, pump-out, and inspection, and demonstrate these systems through large-scale testing.
7. Following large-scale testing, identify any remaining technical and safety-related risks and establish suitable risk management strategies.

Since January 2011, DOE has worked cooperatively with the DNFSB on specific actions DOE will take to address the DNFSB's recommendations. The Implementation Plan was submitted to the DNFSB on November 10, 2011, by the Secretary of Energy.

#### **5.6.1.2 Defense Nuclear Facility Safety Board Recommendation 2011-1**

The DNFSB issued Recommendation [2011-1](#), Safety Culture at the WTP on June 9, 2011, which DOE accepted on June 30, 2011. The recommendation stated the DNFSB position that both DOE and contractor project management behaviors reinforce a subculture at WTP that deters the timely reporting, acknowledgement, and ultimate resolution of technical safety concerns. The DNFSB identified two findings; 1) A Chilled Atmosphere Adverse to Safety Exists, and 2) DOE and Contractor Management Suppress Technical Dissent. The three recommendations the DNFSB included are as follows:

1. Assert federal control at the highest level and direct, track, and validate the specific corrective actions be taken to establish a strong safety culture within the WTP.
2. Conduct an Extent of Condition Review to determine whether safety culture weaknesses are limited to the WTP.
3. Conduct a non-adversarial review of Dr. Tamosaitis' removal and current treatment by DOE and contractor management and the affects to the safety culture.

DOE is committed to establishing and maintaining a strong nuclear safety culture. It is DOE's policy and practice to design, construct, and operate nuclear facilities in a manner that ensures adequate protection of workers, the public, and the environment. DOE developed a comprehensive action plan to address DNFSB's specific recommendation to strengthen the safety culture at the WTP. Among several other actions identified, ORP and its contractors have engaged and supported independent reviews. On December 1, 2011, the Independent Safety and Quality Culture Assessment team issued their report and findings from the nuclear safety and quality culture in-depth assessment at the WTP. The team identified the following findings:

1. No widespread evidence of a chilled atmosphere adverse to safety, and no widespread evidence that DOE and contractor management suppress technical dissent.



2. Lack of effective and timely disposition of technical and safety issues.
3. Safety construct implementation, which includes the assumptions, guidance, criteria, and processes used to evaluate and document the safety basis for design, construction, and operation, does not support project schedule.
4. Communications not fully supportive of safety culture.

The Independent Safety and Quality Culture Assessment team supplied supporting statements and recommendations for each finding that can be found in a report at [www.ISQCAT.com](http://www.ISQCAT.com).

#### **5.6.1.3 Pretreatment Facility - Hydrogen in Piping and Ancillary Vessels**

BNI assembled an independent review team (IRT) in 2010 to evaluate a new design approach for the hydrogen in piping and ancillary vessels of the Pretreatment Facility. The team charter was to review the design criteria and methodology developed to address safety-related issues and the effects of postulated hydrogen events in piping and components in the Pretreatment Facility. The review was intended to ensure the criteria and methodology provide a technically defensible and conservative approach to ensure the safety and reliability of the WTP design of piping and ancillary vessels. The independent review team concluded that: *On the basis of its technical reviews described in subsequent chapters of this report [IRT report], the IRT concludes that the new design approach for HPAV [hydrogen in piping and ancillary vessels] affected piping and components is acceptable provided BNI improves the models, assumptions, and methodology involved in the approach to resolve the IRT's findings. The independent review team identified 35 findings essential to improve the models, assumptions, and methodology of the hydrogen in piping and ancillary vessels design approach.*

The resolution to the findings and recommendations was completed on January 5, 2012, and the IRT accepted the resolutions. BNI is performing examples of the quantitative risk assessment approach implementing the IRT findings and recommendations. These will be reviewed by the IRT, ORP, and DNFSB staff prior to any design implementation. These reviews are expected to be completed by July 2012.

#### **5.6.1.4 Structural Issues**

The Summary Structural Reports were finalized for the Pretreatment Facility and High-Level Waste Vitrification Facility to summarize the calculation methodologies for the structural design based on the revised ground motion criteria. The original Summary Structural Reports were updated to incorporate the modified design methodology along with DBFSB staff review comments incorporated in 2008. In following up with further DNFSB staff reviews, ORP formally submitted Revisions 1 and 2 of the Pretreatment Facility and High-Level Waste Vitrification Facility Summary Structural Reports to the DNFSB on April 9, 2009, and September 30, 2009, respectively.

In December 2009, DNFSB raised a concern about the concrete and steel composite behavior/performance of the WTP facility structures. In response to the DNFSB's concern, ORP and the ORP Peer Review Team, worked with BNI to develop a streamline (hybrid) modeling technique and evaluation approach that reduced the potential cost and schedule impacts to the project while providing verification of adequate analyses of WTP facility structures. This approach was finalized following discussions with DNFSB staff on March 26, 2010, to reach an agreement prior to preceding with reevaluation through analysis of the quarter representative finite element models of the WTP. Successful completion of this effort and peer review team quarterly reviews in December 2010, the DNFSB concluded that all the issues relating to composite steel behavior/structural steel design issues on the WTP are closed.



Additionally, through DOE Peer Review Team Quarterly Review discussions on System for Analysis of Soil-Structure Interaction Computer Code on the application of System for Analysis of Soil-Structure Interaction - Subtraction and Direct Methods on WTP's High-Level Waste Vitrification Facility foundation, ORP and BNI documented a comparative and reliable technical justification between the stated methods. This justification document is being reviewed by the DOE Peer Review Team and results will be reported early 2012. Final versions of the Summary Structural Reports will be issued during 2012/2013 at the completion of the WTP structural design, while incorporating required interim updates requested by DNFSB staff. ORP has been actively providing quarterly updates on the ORP Peer Review Team input.

## 5.7 Scientific and Technical Contributions to Hanford Site Cleanup

*PR Bredt and MD Freshley*

PNNL supported DOE and its contractors in 2011, as well as the DOE Office of Science and DOE Office of Technology Innovation and Development, addressing Hanford Site challenges in chemical and nuclear waste processing and subsurface science and remediation. The support included performing evaluations, analyzing data, providing reviews, preparing and operating special facilities, and creating new technologies to address site cleanup challenges. The 2011 PNNL contributions to Hanford Site Cleanup are provided in the paragraphs below.

**Deep Vadose Zone Applied Field Research Initiative.** In the area of subsurface science and remediation, a major area of emphasis is the Deep Vadose Zone Applied Field Research Initiative. The Deep Vadose Zone Applied Field Research Initiative is providing a technical basis to quantify, predict, and monitor natural and post-remediation contaminant discharge from the vadose zone to the groundwater, and to facilitate developing in situ solutions that limit this discharge and protect water resources. This knowledge is being used to transform fundamental science innovation into practical applications deployed by Hanford Site contractors and across the DOE complex. The Deep Vadose Zone Applied Field Research Initiative developed advanced geophysical imaging technology to characterize contaminants in the vadose zone.

In collaboration with the DOE Office of Science, the initiative developed an advanced electrical resistivity and induced polarization geophysical inversion code that enables scientists to create three-dimensional images to characterize and monitor subsurface environments in situ. This technology is being deployed at the Hanford Site to assist site contractors in locating the spatial extent of vadose zone contamination. In addition, the initiative developed a technical basis for vadose zone foam amendment delivery, and optimized foam formulation and generation methods, conducted experiments for design and testing for scale-up, characterized physical, hydrological, and geochemical and biological understanding of foam behavior in vadose zone environments, and developed methods to simulate vadose zone foam delivery. The project also conducted research to quantify the role of geochemical and hydrogeologic heterogeneities on the mass discharge of technetium in the vadose zone and completed laboratory work to test and validate geophysical methods for monitoring ammonia gas uranium remediation.

In support of the deep vadose zone treatability test program, field work to support desiccation field treatability tests was performed. Methods were developed to apply and interpret cross-hole geophysical measurements to monitor the desiccation process over time at the field scale. In particular, specialized techniques were applied for processing of data from cross-hole electrical resistivity tomography and ground-penetrating radar measurements in collaboration with scientists from Lawrence Berkeley National Laboratory. These results are being integrated with the overall assessment of the field treatability test results and provide the primary data to

quantify progress over time and the volumetric extent of the desiccation process in the field. Electrical resistivity tomography was used to characterize baseline conditions and monitor changes in water content during desiccation. Results of the field test are being compiled into a field test report scheduled to be issued in FY2012. In addition, support was provided by conducting experiments that provide scale-up information for the ammonia-gas uranium sequestration technology that is planned for future field testing. Laboratory studies were performed to examine soil wicking using super-absorbent polymers as an alternative technology evaluation under the treatability test effort and the findings were documented in a manuscript.

**Vadose Zone Soil Vapor Extraction of Organics.** A key question for Hanford Site contractors and DOE is determining how much contamination must be removed to be protective of groundwater and is soil vapor extraction or another passive remedy most effective to meet this goal? The *Treatability Test Plan for Characterization of Vadose Zone Carbon Tetrachloride Source Strength Using Tomographic Methods at the 216-Z-9 Site* ([DOE/RL-2010-79](#)) was completed and submitted to EPA in October 2010. The field treatability test was conducted in FY2011 at the 216-Z-9 Site. This key effort focused on obtaining information about the remaining persistent sources in the vadose zone to enable site contractors to calculate the groundwater concentration that will result from the existing vadose zone contamination and develop the technical basis to quantify soil vapor extraction performance and characterize the nature of persistent vadose zone contaminant sources. Application of this mass-flux based framework provides a scientifically defensible basis to assess soil vapor extraction performance and support closure decision.

The soil vapor extraction approach was incorporated into the *Record of Decision Hanford 200 Area Superfund Site 200-CW-5 and 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units* ([DOE, EPA, and Ecology, 2011](#)). This ROD defines remediation goals for a soil vapor extraction system treating carbon tetrachloride. In addition, studies on vapor-phase vadose zone contamination and its impact on groundwater continued during 2011. A treatability test was conducted at the 200-PW-1 Operable Unit to evaluate the use of vadose zone contaminant source characterization to support soil vapor extraction performance and end state analysis. The test was conducted based on the *Treatability Test Plan for Characterization of Vadose Zone Carbon Tetrachloride Source Strength Using Tomographic Methods at the 216-Z-9 Site* ([DOE/RL-2010-79](#)). The field test activities were completed in FY2011, and the test report is scheduled to be completed in FY2012.

**100 Area Research.** Researchers have been testing phytoextraction using willow shrubs for potential use at the 100-N Area for extracting strontium-90 from the riparian zone. Results showed that coyote willows could be effective at producing enough biomass to efficiently remove strontium-90 from the riparian zone along the Columbia River. The project is on hold pending the outcome of the ongoing CERCLA RI/FS process for the 100-N Area.

**300 Area Research.** Research continued in the 300 Area to characterize the uranium-contaminated subsurface, examine fundamental science issues important to contaminant transport and groundwater remediation, and support future cleanup decisions at DOE sites. Significant progress in 2011 included backfilling wells to eliminate well-bore flows and hydrologic testing of the upper aquifer zone, geophysical monitoring of winter precipitation through the vadose zone, an extended passive experiment to monitor uranium release from the lower vadose zone to groundwater. Results will be used to update the conceptual model for uranium contamination in the 300 Area in support of the 300-FF-5 Operable Unit RI/FS.

A range of cleanup technologies and remedial alternatives were evaluated to address localized groundwater contamination from uranium and tritium within the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units. The Draft A: *Remedial Investigation Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units* ([DOE/RL-2010-99](#)) report describes the data that were gathered (Chapter 2) and analyzes identified

contaminants and their interaction with the environment (Chapter 3 through Chapter 5), summarizes pertinent information related to human health and environmental risk (Chapter 6 and Chapter 7), and identifies and evaluates remedial alternatives to provide protection (Chapter 8 through Chapter 10).

## 6.0 Air Monitoring

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*CJ Perkins, CR Ramos, and DJ Rokkan*

[DOE O 450.1A](#) and [DOE O 5400.5](#), Chg 2, require that environmental monitoring programs be conducted at the Hanford Site to verify protection of the site's environmental and cultural resources, the public, and workers at the site. These monitoring activities support the site's *Safety Management System Policy* ([DOE P 450.4](#)) and its component Environmental Management System ([Section 3](#)). Component systems are tools for achieving site and contractor compliance with environmental, public health, and resource protection laws, regulations, and DOE orders.

The *Environmental Monitoring Plan United States Department of Energy, Richland Operations Office* ([DOE/RL-91-50](#), Rev. 4) provides implementation guidance for Hanford Site monitoring programs and projects. The plan contains the rationale for the required programs and projects, including design criteria, sampling locations and schedules, quality assurance requirements, program and project implementation procedures, analytical procedures, and reporting requirements. The early identification of—and appropriate response to—potentially adverse environmental and resource effects associated with DOE operations are confirmed by the following:

- Pre-operational environmental characterization, assessments, and evaluations
- Effluent and emissions monitoring
- Environmental monitoring and surveillance (as defined in DOE O 5400.5, Chg 2 and in Appendix B of this report, "Glossary")
- Cultural resources monitoring
- Controlling and monitoring of contaminated and undesirable biota.

Objectives of the monitoring programs include the following:

- Detecting, characterizing, and responding to contaminant releases from Hanford Site facilities and operations
- Providing data to assess the human health and ecological impacts of Hanford Site-produced contaminants
- Estimating contaminant dispersal patterns in the environment
- Characterizing pathways of exposure to the public and biota
- Characterizing exposures and doses to individuals, nearby populations, and biota
- Evaluating potential impact to biota (and the Columbia River) in the vicinity of DOE Hanford Site activities
- Verifying that environmental monitoring programs are conducted in an integrated fashion to preclude collecting duplicative environmental data
- Verifying early identification of, and appropriate response to, the potentially adverse environmental impact associated with DOE operations
- Promoting long-term stewardship of Hanford Site natural and cultural resources
- Protecting natural and cultural resources.

Other important reasons for conducting these monitoring activities include the following:

- Complying with and confirming site compliance with DOE orders and local, state, and federal laws and regulations
- Verifying the efficacy of waste management practices at the Hanford Site
- Providing information to reassure the public that Hanford Site facilities and operations are not adversely affecting people or the environment
- Answering questions or providing information to stakeholders, activist organizations, and the public
- Supporting DOE decisions
- Providing information to support DOE in environmental litigations.

## **6.1 Air Emissions**

*DJ Rokkan*

Hanford Site contractors monitor airborne emissions from site facilities to determine compliance with state and federal regulatory requirements as well as to assess the effectiveness of emission control equipment and pollution management practices. Measuring devices quantify most facility emission flows while other emission flows are calculated using process information or fan manufacturers' specifications. Most facility radioactive air emission units are actively ventilated stacks that are sampled either continuously or periodically. Airborne emissions with a potential to contain radioactive materials at prescribed threshold levels are measured for gross alpha and gross beta concentrations and, as warranted, specific radionuclides. Nonradioactive constituents and parameters are monitored directly, sampled and analyzed, or estimated based upon inventory usage.

Emission data are documented in this and other reports, all of which are available to the public. For example, DOE annually submits to EPA and the Washington State Department of Health a report of Hanford Site radionuclide air emissions (e.g., [DOE/RL-2012-19](#) for CY2011) in compliance with 40 CFR 61, Subpart H and with WAC 246-247.

### **6.1.1 Radioactive Airborne Emissions**

Small quantities of particulate and volatilized forms of radionuclides are emitted to the environment through state and federally permitted radioactive emission point sources (i.e., stacks). Tritium (i.e., hydrogen-3), strontium-90, iodine-129, cesium-137, plutonium-238, plutonium-239/240, plutonium-241, and americium-241 are the isotopes most commonly measured in the emissions. Emission points are monitored continuously if they have the potential to exceed 1 percent of the standard for public dose, which is 10 millirem (100 microsievert) per year.

Distinguishing Hanford Site-produced radionuclides in the environment is challenging because concentrations of emissions from site stacks are comparable to widespread background concentrations of radionuclides that originated from historical atmospheric nuclear weapons testing. Gross alpha and gross beta concentrations in stack emissions are on average equivalent to concentrations in the environment, including concentrations at distant locations upwind of the Hanford Site. Radioactive emissions decreased on the Hanford Site largely because the production and processing of nuclear materials ceased.

The continuous monitoring of radioactive emissions from facilities requires analyzing samples collected at points of discharge to the environment, usually a stack. Samples are analyzed for gross alpha and gross beta as

well as for selected radionuclides. Specific radionuclides are selected for sampling, analysis, and reporting based on 1) an evaluation of the hypothetical maximum potential of emissions of known radionuclide inventories in a facility or an outside activity occurring under normal operating conditions with the calculated effect of pollution-abatement equipment removed; 2) the sampling criteria provided in contractor environmental compliance manuals; and 3) the potential of each radionuclide to contribute to the public dose. Continuous air monitoring systems with alarms also are used at selected emission points when the potential exists for radioactive emissions to exceed normal operating ranges to levels that require immediate personnel alert.

Radioactive emission points are located on the Hanford Site in the 100, 200, 300, 400, and 600 Areas. The prime sources of emissions and the number of emission points by operating area in 2011 are as follows:

- In the 100 Areas, three radioactive emission points were active. Emissions originated from cleanup activities at the 100-K West Fuel Storage Basin, which in previous years contained irradiated nuclear fuel, and from the Cold Vacuum Drying Facility.
- In the 200 Areas, 40 radioactive emission points were active. The primary locations of these emission points were the Plutonium Finishing Plant, T Plant, U Plant, B Plant, the Waste Encapsulation and Storage Facility, underground tanks storing high-level radioactive waste, waste evaporators, the Waste Receiving and Processing Facility, and the PUREX Plant.
- In the 300 Area, 10 radioactive emission points were active. The primary sources of these emissions were laboratories and research facilities, including the 324 Waste Technology Engineering Laboratory, 325 Applied Chemistry Laboratory, and 331 Life Sciences Laboratory.
- In the 400 Area, three radioactive emission points were active. The sources of these emissions are three facilities that have been shut down: the Fast Flux Test Facility, the Maintenance and Storage Facility, and the Fuels and Materials Examination Facility.
- In the 600 Area, two radioactive emission points were active at the Waste Sampling and Characterization Facility where low-level radiological and chemical analyses are performed on various types of samples (e.g., particulate air filters, liquids, soil, and vegetation).

Air emissions data collected in 2011 were comparable to those collected in 2010. Table 6.1 summarizes Hanford Site radioactive airborne emissions in 2011.

### **6.1.2 Criteria and Toxic Air Pollutants**

Criteria and toxic air pollutants emitted from chemical-processing and power-generating facilities are monitored when activities at a facility are known to generate potential pollutants of concern. Table 6.2 summarizes the Hanford Site emissions of nonradioactive pollutants discharged to the atmosphere. (Note: the 100 and 400 Areas have no criteria and toxic air pollutants of regulatory concern.)

In previous years, gaseous ammonia has been emitted from the PUREX Plant, 242-A Evaporator, AP Tank Farm, and AW Tank Farm, all located in the 200-East Area. Ammonia emissions are tracked only when activities at these facilities are capable of generating them. Table 6.2 also summarizes the reportable ammonia emissions during 2011, which were produced only in the tank farms located in the 200 Areas.

Onsite diesel-powered electricity-generating plants emitted particulate matter, sulfur oxides, nitrogen oxides, volatile organic compounds, carbon monoxide, and lead. Total annual releases of these constituents are reported in accordance with the air quality standards established in WAC 173-400, *General Regulations for Air Pollution Sources*. Based on the quantities of fossil fuel consumed at Hanford Site power plants, the



resulting emissions were calculated using EPA-approved formulas (AP-42, *Compilation of Air Pollutant Emission Factors*, Volume I: *Stationary Point and Area Sources*).

Release totals are immediately reported to EPA if work activities result in chemical emissions in excess of quantities reportable under CERCLA. If the emissions remain stable at predicted levels, the emissions may be reported annually with EPA approval.

**Table 6.1 Hanford Site Radioactive Airborne Emissions (2011)**

Radionuclide	Half-Life	Release, Ci <sup>(a)</sup>				
		100 Area	200-East Area	200-West Area	300 Area	400 Area
Tritium (as HT)	12.3 yr	NA	NA	NA	$1.7 \times 10^1$	NA
Tritium (as HTO)	12.3 yr	NA	NA	NA	$9.0 \times 10^1$	$1.8 \times 10^{-3(b)}$
Cobalt-60	5.3 yr	ND	ND	ND	$4.3 \times 10^{-7(d)}$	NA
Krypton-85	10.7 yr	NA	NA	NA	$1.1 \times 10^{-5(c)}$	NA
Strontium-90	29.1 yr	$7.3 \times 10^{-6}$	$9.6 \times 10^{-5}$	$2.5 \times 10^{-6}$	$2.0 \times 10^{-7(d)}$	NA
Yttrium-90	1.5 s	NA	NM	NA	$8.7 \times 10^{-5}$	NA
Technetium-99	211,100 yr	NA	NA	NA	$4.2 \times 10^{-6(d)}$	NA
Ruthenium-106	373.6 d	ND	ND	ND	ND	NA
Iodine-129	16,000,000 yr	NA	$1.4 \times 10^{-3}$	NA	NA	NA
Barium-137m	2.6 m	NA	NA	NM	$2.1 \times 10^{-6(d)}$	NA
Cesium-134	2.1 yr	ND	$2.6 \times 10^{-8}$	$1.9 \times 10^{-8}$	ND	NA
Cesium-137	30 yr	$6.0 \times 10^{-6}$	$4.2 \times 10^{-5}$	$1.3 \times 10^{-5}$	$1.1 \times 10^{-8}$	$4.0 \times 10^{-7(e)}$
Samarium-151	90 yr	NM	NM	NM	$1.3 \times 10^{-6(d)}$	NA
Europium-152	13.5 yr	NM	NM	NM	$2.0 \times 10^{-7}$	NA
Europium-154	8.6 yr	$7.5 \times 10^{-8}$	ND	ND	$7.5 \times 10^{-9}$	NA
Europium-155	4.8 yr	$2.1 \times 10^{-8}$	ND	ND	$4.9 \times 10^{-7(d)}$	NA
Gadolinium-153	240.4 d	NA	NA	NA	$2.4 \times 10^{-8}$	NA
Tantalum-183	5.1 d	NA	NA	NA	$6.2 \times 10^{-19(d)}$	NA
Tungstun-188	69.8 d	NA	NA	NA	$1.2 \times 10^{-12(d)}$	NA
Radon-219	4.0 s	NA	NA	NA	$3.9^{(c)}$	NA
Radium-226	1,600 yr	NA	NA	NA	$1.9 \times 10^{-7}$	NA
Actinium-227	21.6 yr	NA	NA	NA	ND	NA
Thorium-228	1.9 yr	NM	NM	NM	$2.2 \times 10^{-10(d)}$	NA
Thorium-232	14.1 billion yr	NA	NA	NA	$1.4 \times 10^{-11(d)}$	NA
Protactinium-231	32,760 yr	NA	ND	NA	NA	NA
Uranium-232	68.9 yr	NA	NA	NA	$5.1 \times 10^{-9(d)}$	NA
Uranium-233	159,200 yr	NA	NA	NA	$2.2 \times 10^{-8(d)}$	NA
Uranium-234	245,500 yr	NA	NA	$2.5 \times 10^{-8}$	$9.6 \times 10^{-10(d)}$	NA
Uranium-235	704,000,000 yr	NA	NA	$9.1 \times 10^{-10}$	$1.3 \times 10^{-09(d)}$	NA
Uranium-236	23,420,000 yr	NA	NA	NA	$2.2 \times 10^{-11(d)}$	NA
Uranium-238	4.7 billion yr	NA	NA	$2.4 \times 10^{-8}$	$1.5 \times 10^{-7(d)}$	NA
Neptunium-237	2,144,000 yr	NA	NA	$6.7 \times 10^{-11}$	$1.3 \times 10^{-7(d)}$	NA
Plutonium-238	87.7 yr	$8.9 \times 10^{-7}$	$3.5 \times 10^{-9}$	$1.2 \times 10^{-8}$	$4.3 \times 10^{-9}$	NA
Plutonium-239/240	24,110 yr	$6.7 \times 10^{-6}$	$4.2 \times 10^{-8}$	$9.5 \times 10^{-6}$	$4.9 \times 10^{-9}$	$9.9 \times 10^{-08(f)}$
Plutonium-241	14.4 yr	$4.2 \times 10^{-5}$	ND	$2.9 \times 10^{-6}$	ND	NA
Plutonium-242	375,000 yr	NA	NA	NA	$8.7 \times 10^{-11(d)}$	NA
Americium-241	432.2 yr	$5.1 \times 10^{-6}$	$7.7 \times 10^{-8}$	$3.4 \times 10^{-6}$	ND	NA
Americium-243	7,380 yr	NA	NA	NA	$5.6 \times 10^{-8(d)}$	NA

**Table 6.1 Hanford Site Radioactive Airborne Emissions (2011)**

Radionuclide	Half-Life	Release, Ci <sup>(a)</sup>				
		100 Area	200-East Area	200-West Area	300 Area	400 Area
Curium-243/244	29.1 yr	NA	NA	NA	ND	NA
Californium-252	2.6 yr	NA	NA	NA	$1.4 \times 10^{-14(d)}$	NA
Gross alpha	NA	$1.2 \times 10^{-5}$	$1.7 \times 10^{-6}$	$2.8 \times 10^{-5}$	$1.1 \times 10^{-7}$	NA
Gross beta	NA	$2.6 \times 10^{-5}$	$2.2 \times 10^{-4}$	$2.4 \times 10^{-5}$	$1.6 \times 10^{-6}$	NA

(a) 1 Ci =  $3.7 \times 10^{10}$  becquerel.

(b) This value is calculated based on the sodium inventory in the primary coolant piping system of the long-deactivated Fast Flux Test Reactor.

(c) This value derives from release records, not actual sampling-analysis measurements.

(d) This value derives from estimated facility inventory and the use of release fractions of the Appendix D method of 40 CFR 61, Subpart H, not from actual sampling-analysis measurements.

(e) This release value derives from data on gross beta emissions from 400 Area stacks.

(f) This release value derives from data on gross alpha emissions from 400 Area stacks.

HT = Elemental tritium.

HTO = Tritiated water vapor.

NA = Not applicable.

ND = Not detected (i.e., either the radionuclide was not detected in any sample during the year or the average of all the measurements for that given radionuclide or type of radioactivity made during the year was below background levels).

NM = Not measured.

**Table 6.2 Hanford Site Criteria and Toxic Air Pollutant Emissions (2011)**

Constituent	Release	
	kg	lb
Particulate matter-total	907	2,000
Particulate matter-10	0	0
Particulate matter-2.5	0	0
Nitrogen oxides	6,165	18,000
Sulfur oxides	907	2,000
Carbon monoxide	6,165	18,000
Lead	0	0
Volatile organic compounds <sup>(a,b)</sup>	6,165	18,000
Ammonia <sup>(c)</sup>	10,886	24,000
<b>Total criteria pollutants<sup>(d)</sup></b>	<b>31,195</b>	<b>82,000</b>

(a) Estimate of volatile organic compounds does not include emissions from certain laboratory operations.

(b) From burning petroleum to produce steam and to power electrical generators; release value also includes calculated estimates from the 200-East and 200-West Areas tank farms, evaporation losses from fuel dispensing, 200 Area Effluent Treatment Facility, Central Waste Complex, T Plant Complex, and Waste Receiving and Processing Facility.

(c) Ammonia releases are calculated estimates from the 200 East and 200 West Areas tank farms and the 200 Area Effluent Treatment Facility; the release value also includes ammonia from burning petroleum to produce steam and to power electrical generators.

(d) Criteria pollutants include particulate matter – total, nitrogen oxides, sulfur oxides, carbon monoxide, lead, and volatile organic compounds.

## 6.2 Ambient-Air Monitoring

*CJ Perkins and CR Ramos*

Atmospheric releases of radioactive materials from Hanford Site facilities and operations to the surrounding region are potential sources of exposure to humans. At the Hanford Site, radioactive constituents in air are monitored onsite near facilities and operations, at site-wide locations away from facilities, and offsite around the site perimeter as well as in nearby and distant communities. Information about these ambient-air monitoring efforts, including detailed descriptions of air-sampling and analysis techniques, is provided in RL's environmental monitoring plan ([DOE/RL-91-50](#), Rev. 4).

Comparing measured radionuclide concentrations from locations on and around the Hanford Site to concentrations measured at upwind locations assumed to be uninfluenced by Hanford Site operations provides an evaluation of the impact of radionuclide air emissions from the Hanford Site on surrounding ambient air.

A 9.0-magnitude earthquake struck northern Japan on March 11, 2011. The epicenter of the powerful earthquake was under the Pacific Ocean, approximately 80 miles east of Sendai, where the Fukushima Daiichi nuclear power plant is located. The plant's automatic earthquake detectors successfully inserted all the control rods into the three reactors that were operating at the time; however, 46 minutes later, a massive tsunami inundated the Fukushima power plant, causing widespread destruction and knocking out the reactors' emergency cooling systems. The reactors overheated, damaging the nuclear fuel and producing chemical explosions which breached the reactor buildings and allowed radioactive elements to escape into the environment.

The Fukushima incident led to trace amounts of radiation, including cesium-134 and cesium-137, being observed around the world. No protective actions were ever needed in the United States or its Pacific Territories and by early May 2011, air monitoring results showed declining levels of radiation in ambient air samples. Cesium-134 and cesium-137 were consistently detected at levels far below levels of public-health concern in composite air samples collected at/near the Hanford Site during the first half of 2011 (Figure 6.1).

During the air sampling period from late-March through early-April 2011, ambient air monitoring stations onsite and offsite showed slight increases in gross beta measurements in the biweekly samples. Gross beta measurements returned to typical levels during the sample period immediately following (Figure 6.2). Peaks in gross beta concentrations during the fall and winter months are the result of a seasonal pattern of natural radioactivity fluctuation.

### 6.2.1 Hanford Site Ambient-Air Monitoring

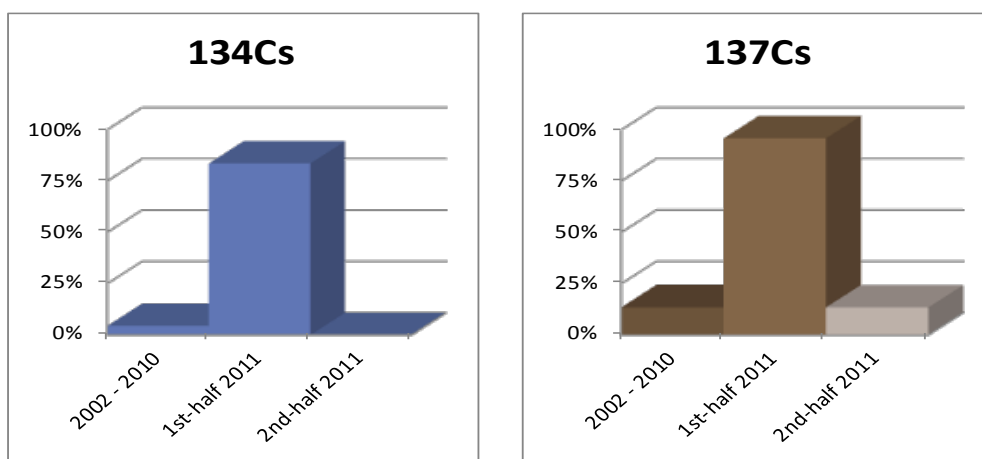
*CJ Perkins*

A network of continuously operating samplers at 84 locations across the Hanford Site was used during 2011 to monitor radioactive materials in air near site facilities and operations (Table 6.3). Most air samplers were located at or within approximately 1,640 feet (500 meters) of sites and facilities having the potential for, or a history of, environmental releases. The samplers were primarily located in the prevailing downwind direction. Samples were collected according to a schedule established before the 2011 monitoring year. Airborne particle samples were collected at each location by drawing air through a cellulose filter. The filters were collected biweekly, field-surveyed for gross radioactivity, held for at least 5 days, and then analyzed for gross alpha and beta activity. A 5-day holding period is necessary to allow for the decay of naturally occurring, short-lived radionuclides that would otherwise obscure the detection of longer-lived radionuclides associated

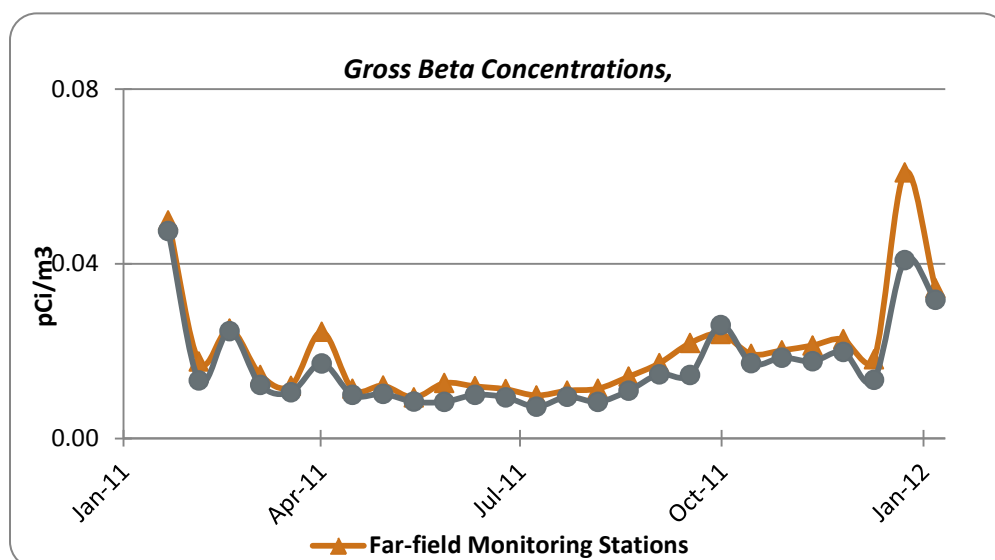
with emissions from nuclear facilities. The gross radioactivity measurements were used to indicate changes in trends in the near-facility environment.

For most specific radionuclide analyses, the amount of radioactive material collected on a single filter during a 2-week period was too small to be measured accurately. The samples were combined into either quarterly or semiannual composite samples for each location to increase the accuracy of the analysis. Composite samples were routinely analyzed for gamma-emitting isotopes, strontium-90, uranium-234, uranium-235, plutonium-238, uranium-238, and plutonium-239/240. Americium-241 and plutonium-241 were analyzed at locations associated with spent nuclear fuel processing. In addition, thorium-228, thorium-230, and thorium-232 were analyzed in composite samples collected at the 100-F Field Remediation Project (Table 6.3).

**Figure 6.1. Detection Percentages for Cesium-134 and Cesium-137 in Ambient Air Samples (Before and after the Fukushima Nuclear Incident)**



**Figure 6.2. Gross Beta Concentrations in Airborne Particulate Samples Collected at Onsite and Offsite Locations (2011)**



**Table 6.3. Hanford Site Near Facilities and Operations Monitoring Locations and Analyses for Ambient-Air Monitoring Samples (2011)**

Site	Samplers	EDP Code (a)	Bi-weekly	Analyses	
				Composite (b)	
100-D Area Field Remediation project <sup>c</sup>	4	N467, N468, N514, N515	Gross	GEA, Sr-90, Pu-iso, U-iso, Am-241	
100-F Area Field Remediation project <sup>c</sup>	3	N519, N520, N521	Gross	GEA, Sr-90, Pu-iso, U-iso, Th-iso	
100-H Area Field Remediation project <sup>c</sup>	4	N508, N509, N510, N574	Gross	GEA, Sr-90, Pu-iso, U-iso	
100-K Basins Closure <sup>c</sup>	6	N403d, N476, N575, N576,	Gross	GEA, Sr-90, Pu-iso, U-iso	
(100-K Area)		N577, N578		Am-241, Pu-241	
118-K-1 Field Remediation projectc (100-K Area)	3	N403, N534, N535	Gross	GEA, Sr-90, Pu-iso, U-iso	
100-N Area D4 project	3	N102, N103, N106	Gross	GEA, Sr-90, Pu-iso, U-iso, Am-241	
200 East Area	17	N019, N158, N498, N499, N957, N967, N968, N969, N970, N972, N973, N976, N977, N978, N984d, N985, N999	Gross	GEA, Sr-90, Pu-iso, U-iso	
BC Controlled Area <sup>c</sup> (600 Area)	4	N572, N573, N957, N978	Gross	GEA, Sr-90, Pu-iso, U-iso, Am-241, Pu-241	
Canister Storage Building (200 East Area)	2	N480, N481	Gross	GEA, Sr-90, Pu-iso, U-iso, Pu-241, Am-241	
Integrated Disposal Facility (200 East Area)	2	N532, N559	Gross	GEA, Sr-90, Pu-iso, U-iso	
200 West Area	25	N155, N161, N165d, N168, N200, N304, N433, N441, N442, N449, N456, N457, N550, N551, N554, N555, N956, N963, N964, N965, N966, N974, N975, N987, N994	Gross	GEA, Sr-90, Pu-iso, U-iso	
200-North Decontamination & Demolition project	4	N563, N564, N567, N568	Gross	GEA, Sr-90, Pu-iso, U-iso	
U Canyon Decontamination & Demolition project (200 West Area)	6	N168, N550, N551, N956, N963, N975	Gross	GEA, Sr-90, Pu-iso, U-iso	
300 Area Decontamination & Demolition and 300-FF-2 Field Remediation projects <sup>c</sup>	2	N557, N130	Gross	GEA, Sr-90, Pu-iso, U-iso	
Environmental Restoration Disposal Facility	5	N482d, N517, N518, N550, N963	Gross	GEA, Sr-90, Pu-iso, U-iso	
600 Area (WYE Barricade)	1	N981d	Gross	GEA, Sr-90, Pu-iso, U-iso	
618-10 Burial Ground	4	N548, N549, N579, N580	Gross	GEA, Sr-90, Pu-iso, U-iso	

(a) EDP Code = Environmental data point (EDP) code = sampler location code.

(b) GEA = Gamma energy analysis; Pu-iso = isotopic plutonium (238Pu, 239/240Pu); U-iso = isotopic uranium (234U, 235U, 238U); Th-iso = isotopic thorium (228Th, 230Th, 232Th).

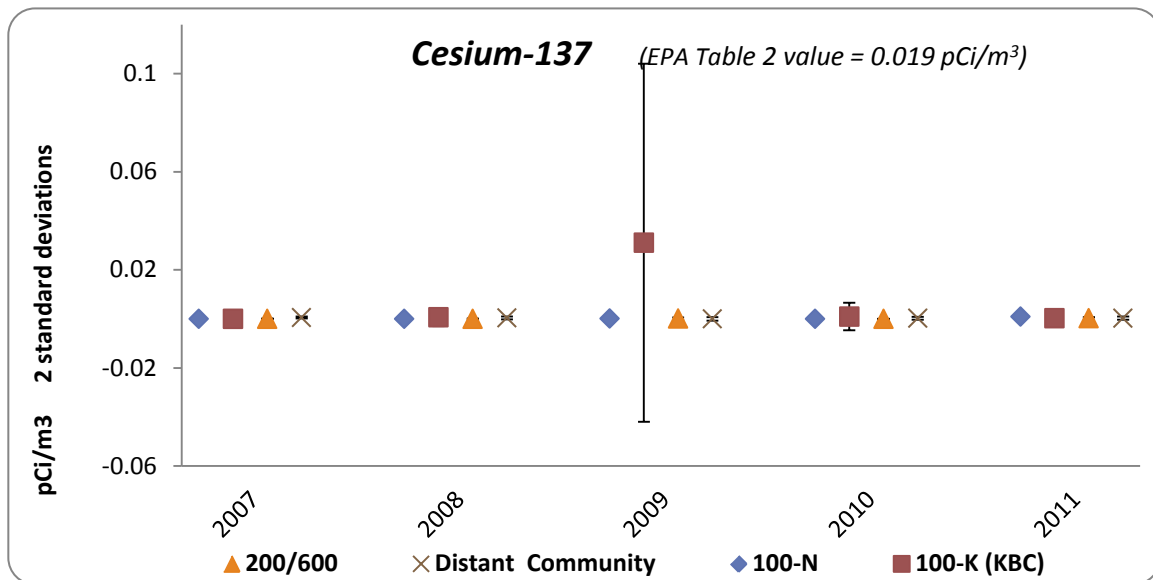
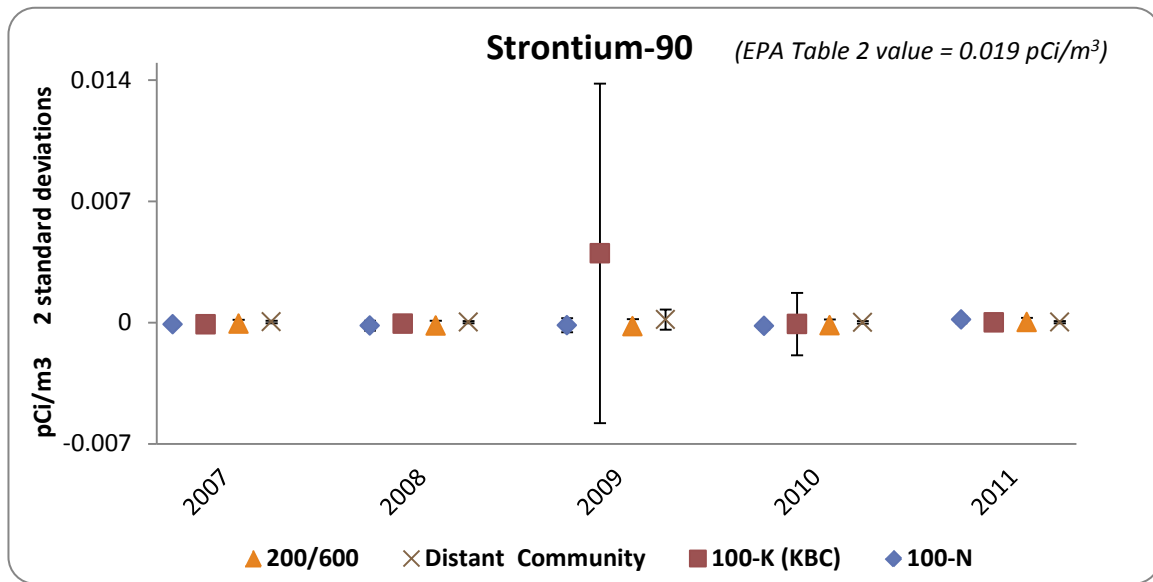
(c) Far-field air sampling station(s) provide supplemental air monitoring data. See Table 8.2.2 for a listing of locations.

(d) Collocated sampling location with Washington State Department of Health.

**Figure 6.3. Hanford Site Near Facilities and Operations Average Concentrations of Selected Radionuclides in Ambient-Air Samples Compared to Samples Collected in Distant Communities (2007 through 2011)**

*As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.*

*KBC = K Basins Closure Project.*

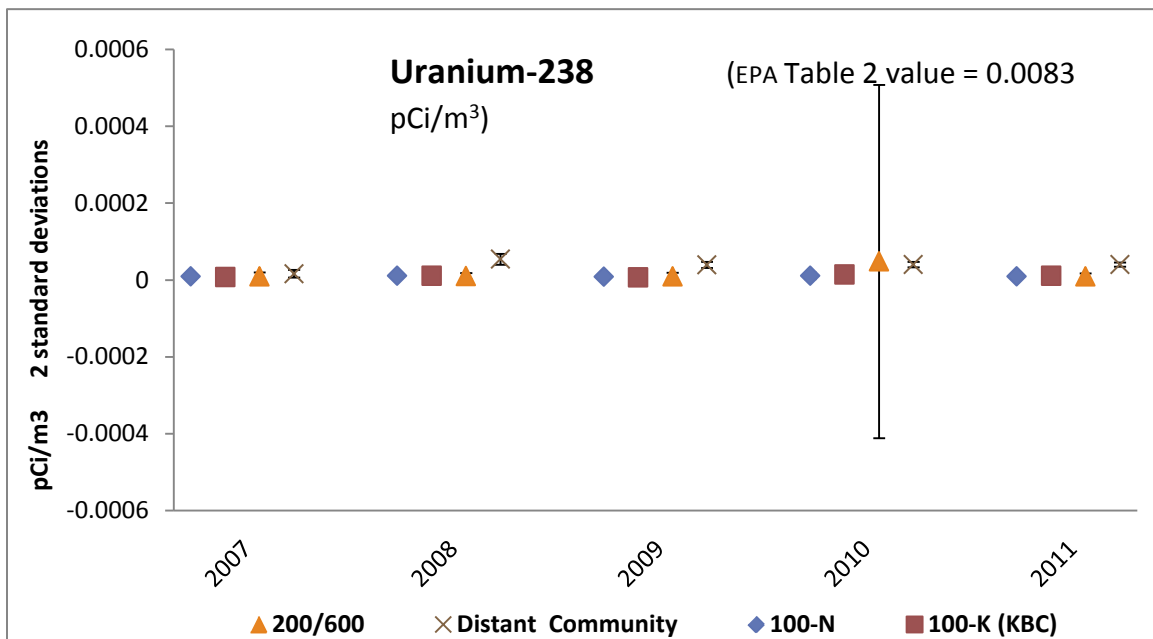
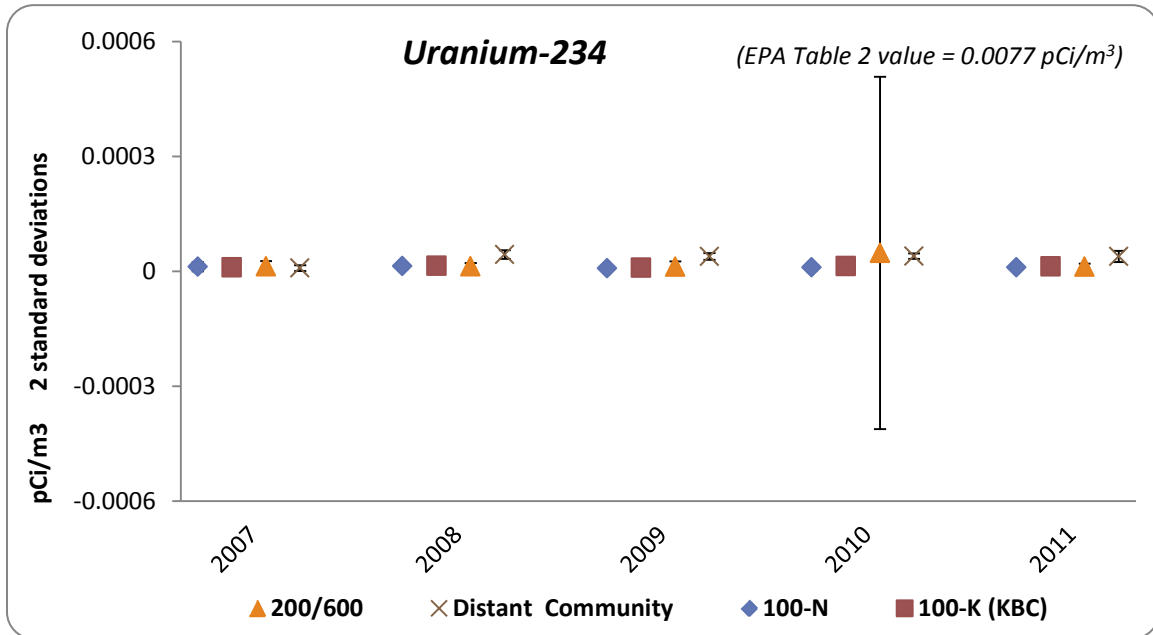




**Figure 6.3. Hanford Site Near Facilities and Operations Average Concentrations of Selected Radionuclides in Ambient-Air Samples Compared to Samples Collected in Distant Communities (2007 through 2011) (Cont.)**

*As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.*

*KBC = K Basins Closure Project.*



**Figure 6.3. Hanford Site Near Facilities and Operations Average Concentrations of Selected Radionuclides in Ambient-Air Samples Compared to Samples Collected in Distant Communities (2007 through 2011) (Cont.)**

*As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.*

*KBC = K Basins Closure Project.*

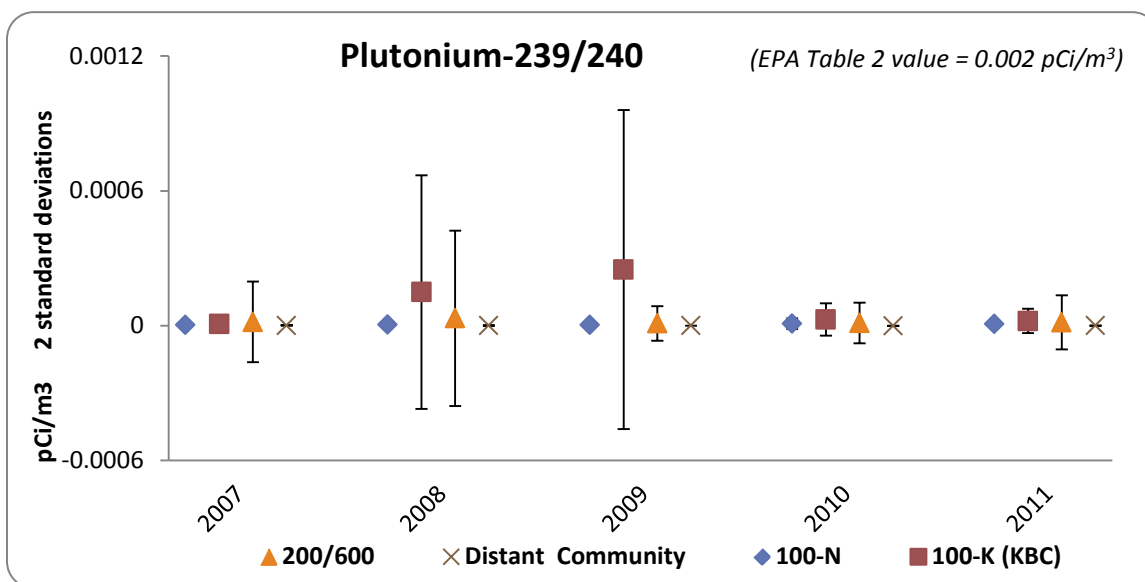


Figure 6.3 shows the annual average air concentrations of selected radionuclides in the 100, 200, and 600 Areas compared to EPA concentration values and air concentrations measured in distant communities. The EPA concentration values for environmental compliance (40 CFR 61, Appendix E, Table 2) are dose-based reference values used as indices of performance. The concentration values are concentrations that would result in a dose of 10 millirem (100 microsievert) per year under conditions of continuous exposure. The 2011 data indicate a large degree of variability by location. Air samples collected from locations at or directly adjacent to Hanford Site facilities had higher radionuclide concentrations than samples collected farther away. In general, analytical results for most radionuclides were at or near Hanford Site background levels, which are much less than EPA concentration values but greater than those measured offsite. The data also show that concentrations of certain radionuclides were higher and widely variable within different onsite operational areas. Naturally occurring radionuclides beryllium-7 and potassium-40 were routinely identified. Appendix C, shows the annual average and maximum concentrations of radionuclides in air samples collected near facilities and operations during 2011.

Air monitoring results from the stations in the 100-D, 100-F, and 100-H Areas, and the 118-K-1 Field Remediation and 100-N deactivation, decommission, decontamination and demolition projects were at or below typical Hanford Site levels in 2011. Uranium-234 and uranium-238 were consistently detected while plutonium-239/240 was detected in approximately 30 percent of the samples and strontium-90 in approximately 15 percent. The presence of americium-241 was analyzed in samples taken at the 100-D, 100-H, 118-K-1, and 100-N Area stations and was detected in approximately 30 percent of those samples. Strontium-90 was detected in approximately 15 percent of the samples. Isotopes of thorium (thorium-228, -230, and -232) were analyzed for in samples collected at the 100-F site and these were

consistently detected at low levels. One air monitoring result from the 100-N Area in 2011 was greater than 10% of EPA's concentration value (40 CFR 61, Appendix E, Table 2) and was reported to EPA and Washington State Department of Health. Cesium-137 at station N106 was elevated during the first-half of the year sample. No contributing cause was specifically identified for this elevated cesium concentration.

Ambient air was monitored in 2011 at 6 locations in the 100-K Area. Uranium-234 and uranium-238 were consistently detected while plutonium-239/240 was detected in approximately 50 percent of the samples. Cesium-137 and americium-241 were detected in approximately 65 percent of the samples.

Air sampling was conducted at 21 locations in the 200-East Area during 2011. Radionuclide levels measured in the 200-East Area ambient-air composite samples in 2011 were similar to those measured in previous years. Uranium-234 and uranium-238 were consistently detected while all other radionuclides were either detected in less than 10 percent of the samples or not at all.

Air sampling was conducted at 25 locations in the 200-West Area during 2011. Generally, radionuclide levels measured in the 200-West Area were similar to results for previous years. Uranium-234 and uranium-238 were detected in approximately 95 percent of the samples. Plutonium-239/240 was detected in approximately 45 percent of the samples. The plutonium-239/240 concentrations at air-sampling location N165 (near the 216-Z-9 Trench) were greater than 10% of the EPA concentration value (40 CFR 61, Appendix E, Table 2) for the composite samples collected during the first- and second-halves of 2011. This elevated plutonium value is believed to originate from the nearby retired 216-ZP-9 Trench that received liquid waste from the Plutonium Finishing Plant until 1995. Also, the plutonium-239/240 concentrations at air-sampling location N441 (near SX/SY Tank Farm) was greater than 10% of the EPA concentration value (40 CFR 61, Appendix E, Table 2) for the composite sample collected during the second-half of 2011. No contributing cause was specifically identified for this elevated plutonium concentration. Required notifications were made to the Washington State Department of Health.

Air monitoring results from the 200-North, U Canyon, and BC Controlled Area decontamination and demolition project stations were at or below typical Hanford Site levels for 2011. Uranium-234 and uranium-238 were consistently detected at each project, while plutonium-239/240 was detected in approximately 50 percent of the samples at the U Canyon site. The BC Controlled Area and the 200-North projects concluded in July and August 2011, respectively.

Air sampling in support of remediation work in the 300-FF-2 Operable Unit (near the 300 Area) and decontamination and decommissioning activities at the 300 Area deactivation, decommission, decontamination and demolition project continued in 2011. Uranium-234 and uranium-238 were detected consistently and at levels similar to those measured in previous years.

Air sampling was conducted at five locations in 2011 at the Environmental Restoration Disposal Facility (200-West Area). Generally, radionuclide levels measured at this site were similar to typical Hanford Site levels. Uranium-234 and uranium-238 were detected in 100 percent of the samples while plutonium-239/240 was detected in approximately 50 percent of the samples.

Beginning in March 2011, air monitoring was conducted at four locations at the 618-10 Burial Ground Project (north of the 300 Area). The analytical results showed that uranium-234, uranium-238, plutonium-239/240, and americium-241 were detected consistently. During the second-half of 2011, two air monitoring results from one station located at the 618-10 Field Remediation project were greater than 10% of EPA's concentration values (40 CFR 61, Appendix E, Table 2) and were reported to EPA and Washington State

Department of Health. Americium-241 and plutonium-239/240 at station N548 were elevated and no contributing cause was specifically identified for these elevated concentrations.

## **6.2.2 Hanford Site and Offsite Ambient-Air Monitoring**

*CR Ramos*

Airborne radionuclide samples were collected in 2011 by 40 continuously operating samplers at or in the vicinity of the Hanford Site. The sampling stations were grouped into four location classifications: 1) onsite (21 stations), 2) perimeter (11 stations), 3) nearby communities (7 stations), and 4) distant community (1 station) (Figure 6.4 and Table 6.4). Onsite air samplers were located primarily around major operational areas to maximize the capability to detect radiological contaminants resulting from site operations. Perimeter samplers were located around the site boundary with emphasis on the prevailing downwind directions to the south and east. Samplers located in Basin City, Benton City, Kennewick, Mattawa, Othello, Pasco, and Richland, Washington, provided data for the nearest population centers. A sampler in Yakima, Washington, provided background data from a community essentially unaffected by Hanford Site operations.

### **6.2.2.1 Hanford Site and Offsite Ambient-Air Samples and Analytes**

Samples were collected and analyzed according to a schedule established prior to the monitoring year ([PNNL-20121](#)). Airborne particle samples were collected biweekly at each location by continuously drawing air through a glass-fiber filter. The filter samples were transported to an analytical laboratory and stored for at least 72 hours to allow for the decay of short-lived, naturally occurring radionuclides (e.g., radon gas decay products) that would otherwise obscure the detection of longer-lived radionuclides potentially present from Hanford Site emissions. The filters were then analyzed for gross beta radiation. Selected filters were analyzed for gross alpha radiation. Historically, for most radionuclides, the amount of radioactive material collected on a filter during a 2-week period has been too small to accurately analyze individual radionuclides of concern. Biweekly samples were combined into quarterly composite samples to increase the sensitivity and accuracy of the analysis. The compositing procedure results in a 12-week average concentration for specific radionuclides present in the atmosphere as particulates. The quarterly composite samples were analyzed for gamma-emitting radionuclides, and most were also analyzed for strontium-90, uranium-234, uranium-235, plutonium-238, uranium-238, and plutonium-239/240.

Atmospheric water vapor was collected for tritium analysis at 20 locations in 2011 by continuously drawing air through multi-column samplers containing adsorbent silica gel. The water-vapor samplers were exchanged every 4 weeks to prevent loss of the sample as a result of breakthrough (i.e., oversaturation). The collection efficiency of the silica gel adsorbent is discussed by Patton et al. (1997). The collected water was distilled from the silica gel and analyzed for its tritium content.

### **6.2.2.2 Hanford Site and Offsite Ambient-Air Monitoring Results**

All sample results in 2011 showed very low radiological concentrations in air. All radionuclide concentrations (Table 6.5) were less than their respective DOE-derived concentration guide (Appendix D, Table D.2). The derived concentration guides are concentrations that would result in a dose of 100 millirem (1 millisievert) per year under conditions of continuous exposure. A more conservative dose standard is the EPA concentration value (40 CFR 61, Appendix E, Table 2) of 10 millirem (100 microsievert) per year from airborne radiological material. Again, all radionuclide concentrations in air samples collected in 2011 were low enough to meet the EPA standard.

Gross alpha concentrations were slightly higher in the air samples collected in 2011 from onsite, perimeter, and nearby communities location classes than from the distant community (Table 6.5). However, the average gross alpha concentration ( $7.33\text{E-}04$  pCi/m<sup>3</sup>) from onsite, perimeter, and nearby communities location classes is less than 4 percent of the DOE-derived value. Also, the maximum gross alpha concentration ( $3.9\text{E-}03$  pCi/m<sup>3</sup>) from all locations is less than 20 percent of the DOE-derived value. There is no EPA concentration value for gross alpha. The average gross alpha concentrations in the air samples collected in 2011 were comparable to the last 5 years.

Gross beta concentrations were comparable in the air samples collected in 2011 from onsite, perimeter, and nearby communities location classes compared to air samples from the distant community (Table 6.5). Gross beta concentrations were slightly higher in the air samples collected from all location classes in 2011 compared to air samples collected in the last 5 years.

Gross beta and gross alpha concentrations in air peaked during the fall and winter months in 2011 (Figure 6.4), repeating a pattern of natural radioactivity fluctuations (Eisenbud 1987). Figure 6.4 shows that this fluctuation is seen in both the onsite and distant locations.

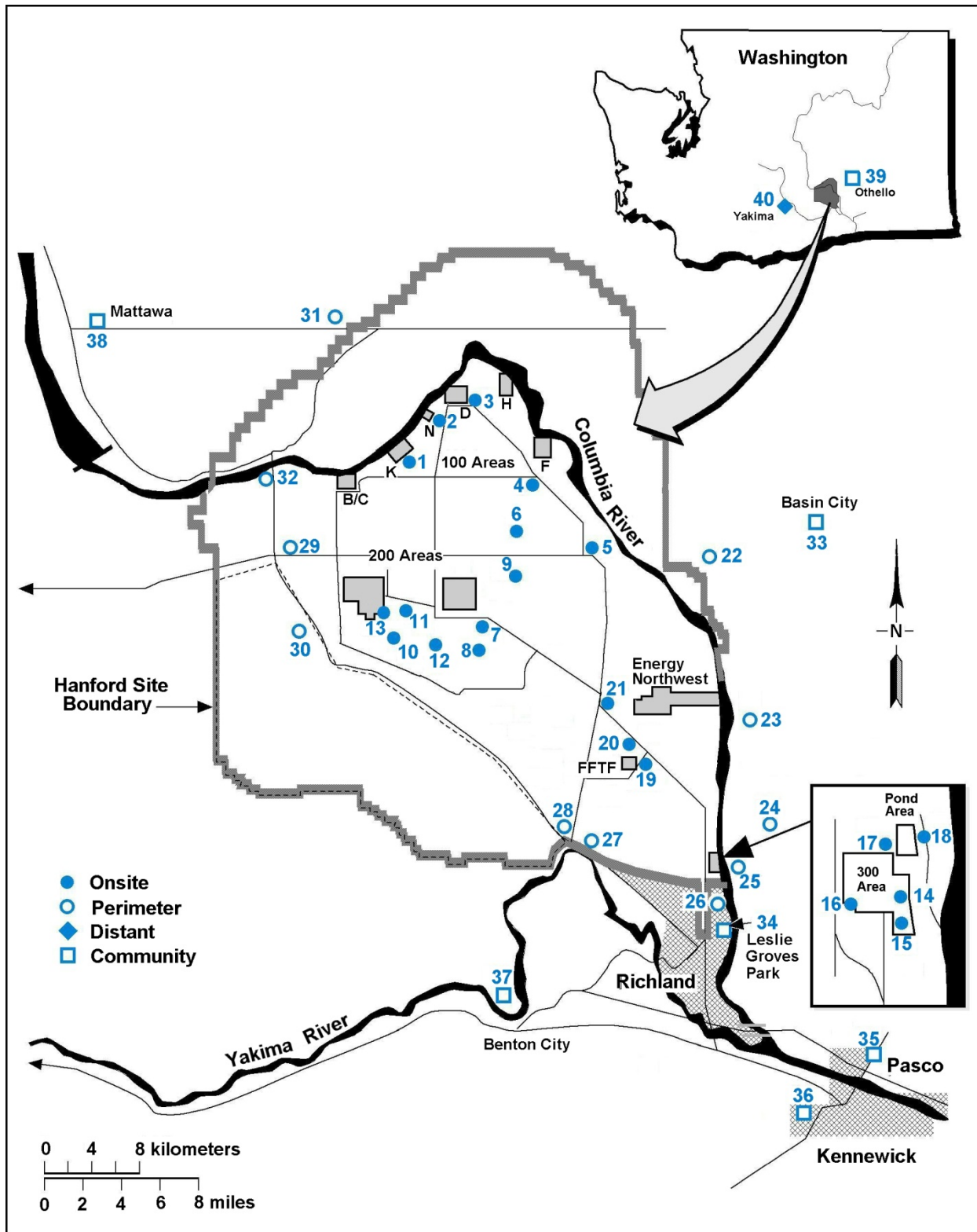
Plutonium-239/240 was detected in 5 out of 75 air samples collected from onsite, perimeter, and nearby communities location classes in 2011 (Table 6.5). There were no detects in the four air samples collected from the distant community location group. The maximum reported plutonium-239/240 concentration was less than 1 percent of the DOE-derived concentration guide the EPA concentration value. Figure 6.4 shows that plutonium-239/240 concentrations in the air samples collected in 2011 are at levels similar to those measured in previous years.

Uranium-234 and uranium-238 were both detected in almost all of the air samples collected in 2011 from all four location classes (Table 6.5). Figure 6.4 shows that uranium-234 and uranium-238 concentrations were at levels similar to those measured in previous years. Figure 6.3 also shows slightly higher in the air samples collected from onsite, perimeter, and nearby communities location classes than the distant community class. However, the maximum concentrations were less than 2 percent of DOE-derived concentration guides and EPA concentration values for both radionuclides.

Uranium-235 was detected in 25 out of 60 air samples collected from onsite, perimeter, and nearby communities location classes in 2011 (Table 6.5). There were one detect in the three air samples collected from the distant community location group. The maximum reported uranium-235 concentration was less than 1 percent of the DOE-derived concentration guide the EPA concentration value.

Cesium-137 and plutonium-238 were both detected in three out of at least 70 air samples collected from onsite, perimeter, and nearby communities location classes in 2011 (Table 6.5). There were no detects in the four air samples collected from the distant community location group. The maximum reported plutonium-238 concentration was less than 1 percent of the DOE-derived concentration guide the EPA concentration value. The maximum reported cesium-137 concentration was 10 percent of the EPA concentration value but less than 1 percent of the DOE-derived concentration guide.

Cobalt-60 and strontium-90 were not detected in any of the samples collected during 2011 (Table 6.5).

**Figure 6.4. Hanford Site and Offsite Ambient-Air Sampling Locations (2011)**

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**Table 6.4. Hanford Site and Offsite Ambient-Air Sampling Locations, Sample Composite Groups, and Analytes (2011)**

Location <sup>(a)</sup>	Sampling Location <sup>(b)</sup>	Analytes <sup>(c)</sup>	Composite Group	Analytes <sup>(d)</sup>
<b>Site-Wide (Onsite)</b>				
1	100 K Area	Alpha, beta, tritium	100 Areas	Gamma, strontium, plutonium
2	100 N-1325 Crib	Alpha, beta, tritium		
3	100 D Area	Alpha, beta		
4	100 F Met Tower	Alpha, beta	Hanford Townsite	Gamma, strontium, plutonium
5	Hanford Townsite	Alpha, beta		
6	Gable Mountain	Alpha, beta	Gable Mountain	Gamma, plutonium, uranium
7	200 ESE	Alpha, beta, tritium	200 E Area	Gamma, strontium, plutonium, uranium
8	S of 200 E	Alpha, beta		
9	B Pond	Alpha, beta	B Pond	Gamma, plutonium, uranium
10	Army Loop Camp	Alpha, beta	200 W South East	Gamma, strontium, plutonium, uranium
11	200 Tel. Exchange	Alpha, beta, tritium		
12	SW of B/C Crib	Alpha, beta		
13	200 W SE	Alpha, beta	200 West	Gamma, plutonium, uranium
14	300 Water Intake	Alpha, beta, tritium	300 Area	Gamma, strontium, plutonium, uranium
15	300 South Gate	Alpha, beta, tritium		
16	300 South West	Alpha, beta, tritium		
17	300 Trench	Alpha, beta, tritium	300 NE	Gamma, strontium, plutonium, uranium
18	300 NE	Alpha, beta, tritium		
19	400 E	Alpha, beta, tritium	400 Area	Gamma, strontium, plutonium
20	400 N	Alpha, beta		
21	Wye Barricade	Alpha, beta	Wye Barricade	Gamma, plutonium, uranium

**Table 6.4. Hanford Site and Offsite Ambient-Air Sampling Locations, Sample Composite Groups, and Analytes (2011)**

Location <sup>(a)</sup>	Sampling Location <sup>(b)</sup>	Analytes <sup>(c)</sup>	Composite Group	Analytes <sup>(d)</sup>
Perimeter				
22	Ringold Met Tower	Alpha, beta, tritium	Ringold Met Tower	Gamma, plutonium
23	W End of Fir Road	Alpha, beta	W End of Fir Road	Gamma, strontium, plutonium, uranium
24	Dogwood Met Tower	Alpha, beta, tritium	Dogwood Met Tower	Gamma, strontium, uranium
25	Byers Landing	Alpha, beta, tritium	Byers Landing	Gamma, strontium, plutonium, uranium
26	Battelle Complex	Alpha, beta, tritium	Battelle Complex	Gamma, uranium
27	Horn Rapids Substation	Alpha, beta	Prosser Barricade	Gamma, strontium, plutonium
28	Prosser Barricade	Alpha, beta, tritium		
29	Yakima Barricade	Alpha, beta	Yakima Barricade	Gamma, strontium, plutonium
30	Rattlesnake Springs	Alpha, beta		
31	Wahluke Slope	Alpha, beta, tritium	Wahluke Slope	Gamma, strontium, plutonium
32	S End Vernita Bridge	Alpha, beta		
Nearby Communities				
33	Basin City School	Alpha, beta, tritium	Basin City School	Gamma, plutonium, uranium
34	Leslie Groves-Richland	Alpha, beta, tritium	Leslie Groves-Richland	Gamma, strontium, plutonium, uranium
35	Pasco	Beta	Tri-Cities	Gamma, strontium, plutonium, uranium
36	Kennewick	Alpha, beta		
37	Benton City	Beta	Benton City	Gamma
38	Mattawa	Beta	Mattawa	Gamma
39	Othello	Beta	Othello	Gamma, uranium
Distant Communities				
40	Yakima	Alpha, beta, tritium	Yakima	Gamma, strontium, plutonium, uranium

(a) Refer to Figure 6.2.

(b) Sampling location names are derived from the Hanford Environmental Information System database.

(c) Alpha (gross) and beta (gross) samples were collected and analyzed every two weeks; tritium samples were collected and analyzed every four weeks.

(d) Gamma spectroscopy, strontium-90, isotopic plutonium (plutonium-238 and plutonium-239/240), and isotopic uranium (uranium-234, uranium-235, and uranium-238) analyses were performed on quarterly composite samples.

Table 6.5. Hanford Site Airborne Radionuclide Concentrations (2011) Compared to Previous Years

Radionuclide (detection limit)	Location Group <sup>(a)</sup>	2011			2006-2010			Derived Concentration Guide <sup>(e)</sup>		
		Detections <sup>(b)</sup>		Maximum <sup>(c)</sup> pCi/m3(f)	Detections <sup>(b)</sup>		Maximum <sup>(d)</sup> pCi/m3(f)			
		Samples	Average <sup>(d)</sup> pCi/m3(f)		Samples	Average <sup>(c)</sup> pCi/m3(f)				
Tritium (1.0 pCi/m <sup>3</sup> )	300 Area	74	45	6.0E+00 ± 2.2E+01	7.7E+01 ± 1.1E+01	302	205	3.9E+00 ± 1.2E+01	6.6E+01 ± 7.2E+00	1.0E+05
	Site-wide	62	36	6.4E+00 ± 2.4E+01	7.7E+01 ± 1.1E+01	257	172	3.8E+00 ± 1.1E+01	6.6E+01 ± 7.2E+00	
	Perimeter	87	51	8.2E+00 ± 2.4E+01	6.7E+01 ± 9.9E+00	446	332	6.8E+00 ± 2.0E+01	7.6E+01 ± 1.3E+01	
	Nearby communities	26	16	8.2E+00 ± 2.1E+01	4.8E+01 ± 1.1E+01	128	97	9.1E+00 ± 3.3E+01	1.6E+02 ± 2.5E+01	
	Distant communities	13	8	1.0E+01 ± 3.7E+01	7.1E+01 ± 1.2E+01	66	41	1.0E+00 ± 4.4E+01	2.2E+01 ± 2.8E+00	
Gross Beta (1.0E-03 pCi/m <sup>3</sup> )	Site-wide	534	534	2.0E-02 ± 2.9E-02	1.3E-01 ± 2.2E-02	2643	2642	1.7E-02 ± 1.9E-02	7.2E-02 ± 1.4E-02	9.0E+00
	Perimeter	277	277	2.0E-02 ± 2.7E-02	7.9E-02 ± 8.9E-03	1404	1404	1.7E-02 ± 1.9E-02	9.4E-02 ± 1.1E-02	
	Nearby communities	176	176	1.9E-02 ± 2.8E-02	8.7E-02 ± 9.7E-03	860	860	1.7E-02 ± 1.8E-02	5.7E-02 ± 1.1E-02	
	Distant communities	26	26	1.8E-02 ± 2.2E-02	5.6E-02 ± 6.5E-03	126	126	1.5E-02 ± 1.4E-02	4.4E-02 ± 4.8E-03	
Gross Alpha (3.5E-04 pCi/m <sup>3</sup> )	Site-wide	532	469	7.4E-04 ± 9.6E-04	3.9E-03 ± 1.5E-03	2639	2257	7.7E-04 ± 9.2E-04	7.2E-03 ± 2.4E-03	2.0E-02
	Perimeter	277	239	7.1E-04 ± 8.6E-04	2.8E-03 ± 7.6E-04	1403	1197	7.8E-04 ± 1.0E-03	8.2E-03 ± 1.6E-03	
	Nearby communities	77	71	7.5E-04 ± 9.9E-04	3.0E-03 ± 8.7E-04	391	335	7.6E-04 ± 1.2E-03	4.8E-03 ± 1.3E-03	
	Distant communities	26	19	5.6E-04 ± 6.0E-04	1.2E-03 ± 4.7E-04	126	103	6.8E-04 ± 7.5E-04	2.0E-03 ± 7.1E-04	
Cobalt-60 (1.1E-03 pCi/m <sup>3</sup> )	Site-wide	44	0	1.2E-05 ± 5.7E-04	8.1E-04 ± 7.1E-04 <sup>(g)</sup>	212	2	5.6E-05 ± 5.7E-04	1.2E-03 ± 1.6E-03 <sup>(g)</sup>	8.0E+01
	Perimeter	32	0	-5.5E-05 ± 8.1E-04	1.2E-03 ± 1.5E-03 <sup>(g)</sup>	156	0	5.2E-05 ± 7.8E-04	1.7E-03 ± 2.2E-03 <sup>(g)</sup>	
	Nearby communities	24	0	4.0E-05 ± 9.4E-04	1.0E-03 ± 9.1E-04 <sup>(g)</sup>	114	0	8.6E-05 ± 9.7E-04	2.2E-03 ± 1.7E-03 <sup>(g)</sup>	
	Distant communities	4	0	2.8E-05 ± 3.2E-04	2.2E-04 ± 6.9E-04 <sup>(g)</sup>	20	0	2.6E-04 ± 6.8E-04	7.0E-04 ± 7.4E-04 <sup>(g)</sup>	
Cesium-137 (1.1E-03 pCi/m <sup>3</sup> )	Site-wide	44	0	1.3E-04 ± 7.0E-04	1.2E-03 ± 1.0E-03 <sup>(g)</sup>	215	1	6.0E-05 ± 5.1E-04	1.0E-03 ± 9.2E-04 <sup>(g)</sup>	4.0E+02
	Perimeter	32	2	2.5E-04 ± 1.2E-03	1.9E-03 ± 1.6E-03	158	1	5.2E-05 ± 1.3E-03	6.9E-03 ± 2.0E-03	
	Nearby communities	24	1	2.5E-04 ± 1.0E-03	1.2E-03 ± 7.0E-04	116	0	5.3E-05 ± 9.5E-04	2.7E-03 ± 2.5E-03 <sup>(g)</sup>	
	Distant communities	4	0	2.9E-04 ± 6.6E-04	7.7E-04 ± 9.1E-04 <sup>(g)</sup>	20	0	3.3E-04 ± 8.0E-04	1.3E-03 ± 1.3E-03 <sup>(g)</sup>	

Table 6.5. Hanford Site Airborne Radionuclide Concentrations (2011) Compared to Previous Years

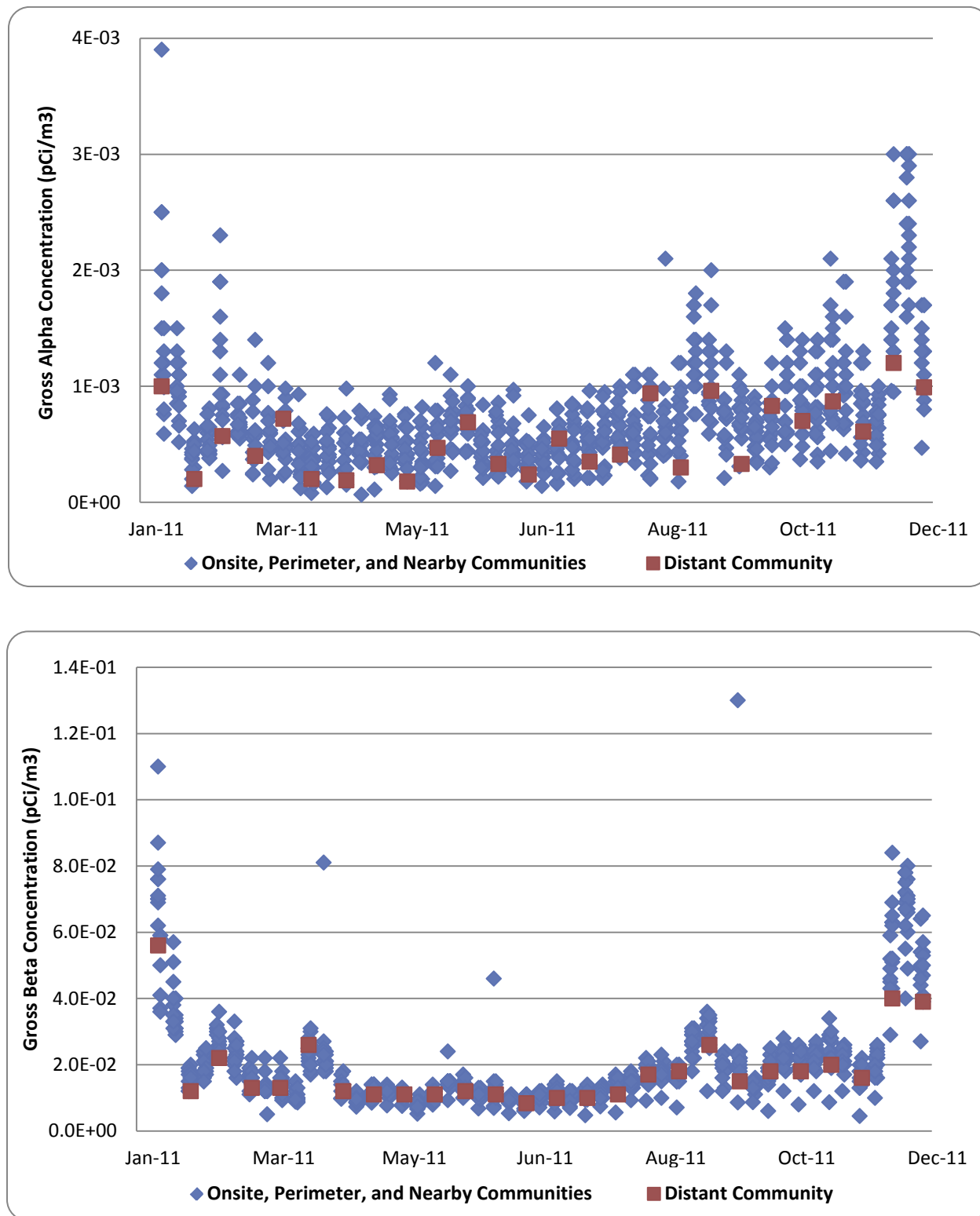
Radionuclide (detection limit)	Location Group <sup>(a)</sup>	2011			2006-2010			Derived Concentration Guide <sup>(e)</sup>		
		Samples	Detections (b)	Maximum <sup>(c)</sup>	Average <sup>(d)</sup>	Samples	Detections (b)		Average <sup>(c)</sup>	Maximum <sup>(d)</sup>
Plutonium-238 (3 aCi/m <sup>3</sup> )	Site-wide	41	1	2.4E-07 ± 2.8E-06	7.0E-06 ± 3.6E-06	181	10	5.6E-07 ± 4.8E-06	3.0E-05 ± 6.9E-06	3.0E-02
	Perimeter	18	1	4.8E-07 ± 2.2E-06	2.2E-06 ± 2.6E-06 <sup>(g)</sup>	103	7	5.3E-07 ± 3.7E-06	1.3E-05 ± 4.2E-06	
	Nearby communities	11	1	1.1E-06 ± 3.0E-06	4.5E-06 ± 2.4E-06	54	6	5.1E-07 ± 2.8E-06	5.7E-06 ± 3.2E-06	
	Distant communities	3	0	6.4E-07 ± 4.4E-07	8.8E-07 ± 1.7E-06 <sup>(g)</sup>	16	3	1.0E-06 ± 3.6E-06	7.5E-06 ± 4.8E-06	
Plutonium-239/240 (3.0E-06 pCi/m <sup>3</sup> )	Site-wide	41	2	7.4E-07 ± 2.4E-06	5.0E-06 ± 3.2E-06	182	30	1.2E-06 ± 5.1E-06	2.1E-05 ± 7.0E-06	2.0E-02
	Perimeter	24	1	6.3E-07 ± 2.1E-06	3.0E-06 ± 2.0E-06	107	9	1.2E-06 ± 1.1E-05	5.5E-05 ± 1.3E-05	
	Nearby communities	12	2	1.4E-06 ± 5.4E-06	1.0E-05 ± 3.7E-06	53	5	5.8E-07 ± 4.8E-06	1.6E-05 ± 4.6E-06	
	Distant communities	4	0	2.2E-07 ± 1.2E-06	8.8E-07 ± 2.1E-06 <sup>(g)</sup>	18	0	4.0E-07 ± 1.7E-06	1.9E-06 ± 3.6E-06 <sup>(g)</sup>	
Strontium-90 (1.0E-04 pCi/m <sup>3</sup> )	Site-wide	28	0	-4.7E-06 ± 4.5E-05	3.1E-05 ± 2.6E-05 <sup>(g)</sup>	149	2	1.4E-05 ± 5.9E-05	1.6E-04 ± 5.2E-05	9.0E+00
	Perimeter	24	0	3.6E-06 ± 6.9E-05	7.7E-05 ± 6.4E-05 <sup>(g)</sup>	129	4	7.2E-06 ± 9.3E-05	3.1E-04 ± 1.0E-04	
	Nearby communities	8	0	3.1E-06 ± 5.7E-05	6.5E-05 ± 5.4E-05 <sup>(g)</sup>	51	1	2.5E-05 ± 2.8E-04	7.2E-04 ± 1.9E-04	
	Distant communities	4	0	2.3E-05 ± 6.9E-05	6.9E-05 ± 5.4E-05 <sup>(g)</sup>	19	0	6.1E-05 ± 3.0E-04	6.7E-04 ± 8.0E-04 <sup>(g)</sup>	
Uranium-234 (1.0E-05 pCi/m <sup>3</sup> )	Site-wide	32	31	4.2E-05 ± 2.7E-05	6.8E-05 ± 1.6E-05	140	86	2.9E-05 ± 4.8E-05	8.8E-05 ± 2.1E-05	9.0E-02
	Perimeter	16	16	5.3E-05 ± 2.7E-05	8.3E-05 ± 1.8E-05	79	49	3.3E-05 ± 6.7E-05	9.4E-05 ± 3.1E-05	
	Nearby communities	16	13	5.2E-05 ± 3.4E-05	8.7E-05 ± 1.9E-05	60	44	3.5E-05 ± 5.8E-05	1.0E-04 ± 3.0E-05	
	Distant communities	4	4	3.9E-05 ± 1.5E-05	5.1E-05 ± 2.9E-05	19	11	3.1E-05 ± 2.9E-05	5.0E-05 ± 1.8E-05	
Uranium-235 (1.0E-05 pCi/m <sup>3</sup> )	Site-wide	31	9	1.7E-06 ± 1.0E-05	5.8E-06 ± 3.1E-06	135	18	2.6E-06 ± 8.9E-06	3.6E-05 ± 4.1E-05 <sup>(g)</sup>	1.0E-01
	Perimeter	15	7	3.6E-06 ± 4.7E-06	1.0E-05 ± 1.1E-05 <sup>(g)</sup>	76	8	2.1E-06 ± 7.4E-06	1.9E-05 ± 1.3E-05	
	Nearby communities	14	9	6.6E-06 ± 1.2E-05	2.2E-05 ± 3.4E-05 <sup>(g)</sup>	56	12	2.4E-06 ± 7.1E-06	1.4E-05 ± 1.1E-05	
	Distant communities	3	1	5.6E-06 ± 4.2E-06	8.5E-06 ± 1.2E-05 <sup>(g)</sup>	17	1	2.7E-06 ± 4.6E-06	1.0E-05 ± 8.2E-06 <sup>(g)</sup>	

Table 6.5. Hanford Site Airborne Radionuclide Concentrations (2011) Compared to Previous Years

Radionuclide (detection limit)	Location Group <sup>(a)</sup>	2011				2006-2010				Derived Concentration Guide <sup>(e)</sup>
		Samples	Detections <sup>(b)</sup>	Maximum <sup>(c)</sup>	Average <sup>(d)</sup>	Samples	Detections <sup>(b)</sup>	Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	
Uranium-238 (1.0E-05 pCi/m <sup>3</sup> )	Site-wide	32	31	4.4E-05 ± 2.1E-05	6.8E-05 ± 1.6E-05	140	130	3.4E-05 ± 3.6E-05	8.7E-05 ± 5.9E-05	
	Perimeter	16	16	4.9E-05 ± 3.6E-05	9.4E-05 ± 2.0E-05	79	79	4.2E-05 ± 4.4E-05	9.6E-05 ± 5.6E-05	
	Nearby communities	16	16	5.7E-05 ± 1.8E-05	7.8E-05 ± 1.8E-05	60	58	4.4E-05 ± 4.1E-05	9.5E-05 ± 3.2E-05	1.0E-01
	Distant communities	4	4	4.0E-05 ± 5.6E-06	4.4E-05 ± 1.2E-05	19	16	3.1E-05 ± 3.6E-05	5.8E-05 ± 1.9E-05	

(a) Location groups are identified in Table 6.4.  
(b) Detection is defined as a value reported above the minimum detectable activity and above the total propagated analytical uncertainty.  
(c) Average of all samples ± 2 times the standard deviation.  
(d) Maximum single sample result ± total analytical uncertainty. Negative concentration values are explained in Appendix A.  
(e) DOE-derived concentration guide (Appendix D, Table D.2).  
(f) 1 pCi = 0.037 Bq  
(g) 1 million attocuries (aCi) = 1 picocurie (pCi).

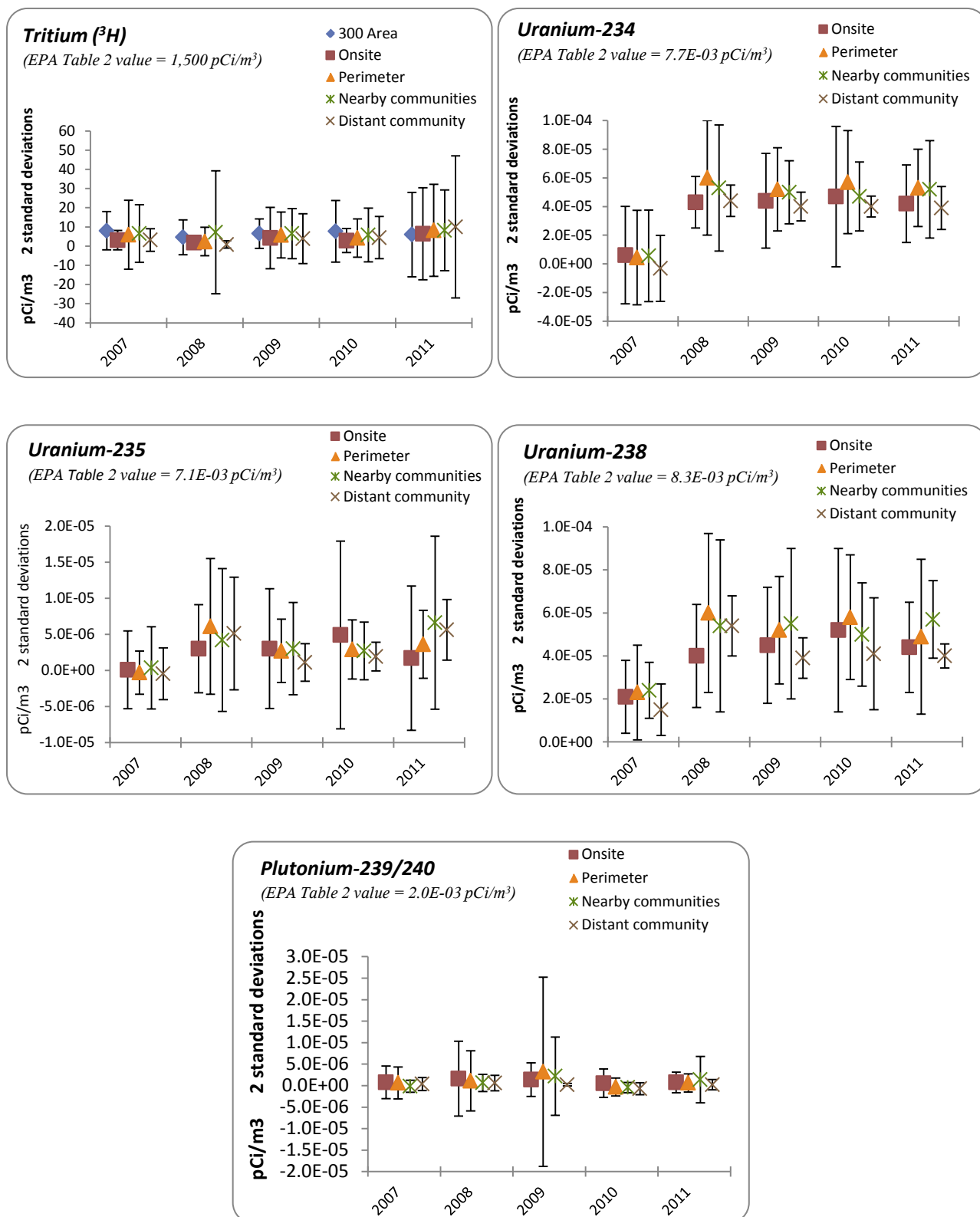
**Figure 6.5. Hanford Site and Distant Locations Gross Alpha and Gross Beta Concentrations in Airborne Particulate Samples Collected (2011)**  
(1 pCi = 0.037 Bq)





**Figure 6.6. Hanford Site Average Concentrations of Selected Radionuclides in Ambient-Air Samples Compared to Samples Collected in Nearby and Distant Communities (2007 through 2011)**

(1 pCi = 0.037 Bq).



## 7.0 Water Monitoring

### 7.1 Drinking Water Systems

*LE Bisping and LM Kelly*

Nine DOE-owned, contractor-operated, public water systems supplied drinking water during 2011 to DOE facilities on the Hanford Site (Table 7.1). Drinking water for the 200-East Area is supplied from the 200-West Area facility. Eight of the nine systems used water from the Columbia River. The 400 Area system used groundwater from the unconfined aquifer beneath the site. MSA operated six of the public water systems; WCH operated one system; and CHPRC operated two systems. The city of Richland supplied water for the 300 Area. In addition to the 300 Area, the city of Richland provided drinking water to the Richland North Area and HAMMER.

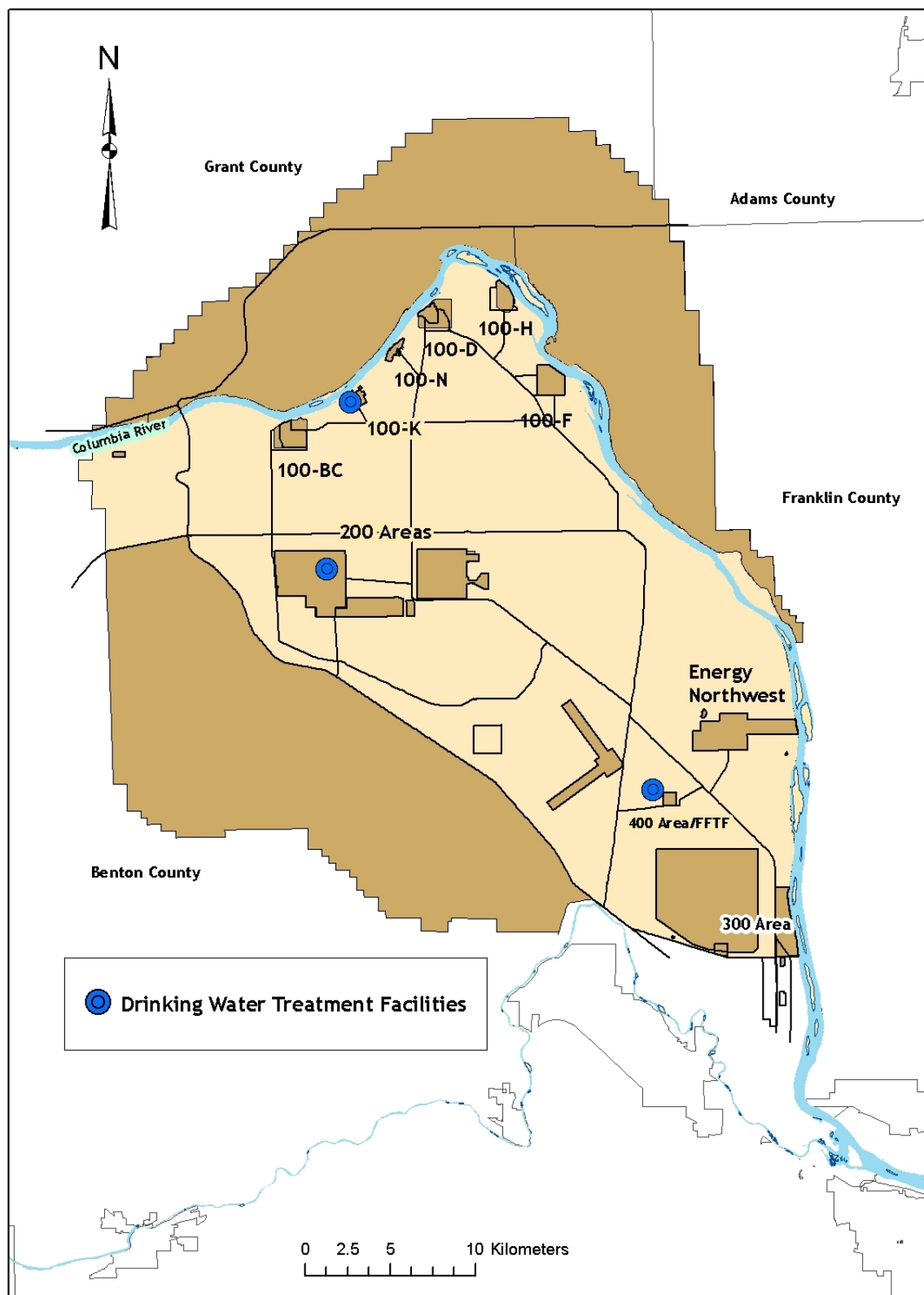
**Table 7.1 Drinking Water Systems**

Public Water Systems	Water Source	Operator
100-K Area	Columbia River	CHPRC
200-East Area	Columbia River	MSA
200-West Area	Columbia River	MSA
251 Substation	Columbia River	MSA
Wye Barricade	Columbia River	MSA
Yakima Barricade	Columbia River	MSA
300 Area	Columbia River and wells	WCH
400 Area	400 Area groundwater wells	CHPRC
609 Fire Station	Columbia River	MSA

#### 7.1.1 Drinking Water Treatment Facilities

*LE Bisping and LM Kelly*

Raw water was treated at three DOE-owned water treatment facilities in the 100-K, 200-West, and 400 Areas (Figure 7.1). Water for the 100-K Area and 200-West Area facilities was obtained from the Columbia River. In support of deactivation, decommission, decontamination, and demolition activities in 100-K East Area, the existing 100-K Area water treatment plant was shut down permanently in February 2011 and replaced with a new membrane alternative filtration technology plant located near the western portion of the 100-K Area. The plant and modified distribution system was placed in operation in April 2011. The 400 Area source of supply was groundwater provided from one of three wells. The 400 Area primary supply well 499-S1-8J (P-16) was the source of drinking water for all of CY2011. Emergency backup wells 499-S0-8 (P-14) and 499-S0-7 (P-15) did not supply water to 400 Area consumers during 2011.

**Figure 7.1. Drinking Water Treatment Facilities and Sampling Locations (2011)**

## 7.1.2 Monitoring Results

### *LE Bisping and LM Kelly*

Samples at all three drinking water treatment facilities were collected monthly and analyzed quarterly or annually for radiological contaminants. All were samples of treated water collected before the water was distributed for general use. Drinking water in the 300 Area, Richland North Area, and HAMMER was not routinely monitored for radiological contaminants by DOE contractor personnel. However, between January and April 2011, personnel from PNNL's Surface Environmental Surveillance Project routinely collected water samples from the Columbia River at the city of Richland river water intake. It became the responsibility of MSA, Public Safety, and Resource Protection in May 2011 for sampling at the city of Richland river water intake. The Columbia River is a major source of the city of Richland's drinking water. The radiological analytical results for these river water samples are summarized in this section and tabulated in Appendix D. The city of Richland monitors its water for radiological and chemical contaminants as well as for general water quality. Because it is a community water system, city officials are required to annually report monitoring results and characterize the risks (if any) from exposure to contaminants in the water in what is known as a Consumer Confidence Report. The annual water quality report is mailed to all utility consumers as an insert with a monthly utility bill. The water quality report is also available on the city of Richland website at <http://www.ci.richland.wa.us/DocumentView.aspx?DID=2489>.

## 7.1.3 Radiological Results

PNNL scientists conducted radiological monitoring of drinking water at one DOE-owned pump and three water treatment facilities during 2011. MSA, the site water-compliance organization, conducted routine chemical, physical, and microbiological monitoring of onsite drinking water. Individual water systems operated by MSA, CHPRC, and WCH performed process monitoring (including chemical and physical sampling) at the water treatment plants and distribution systems to determine compliance with applicable regulations.

*Group A Public Water Supplies* (WAC 246-290) requires that all drinking water analytical results be reported routinely to the Washington State Department of Health. Radiological results for Hanford Site drinking water samples are reported to the state through this annual environmental report. Process monitoring reports are provided directly to the state each month by the contractor responsible for operating the water system. Chemical, physical, and microbiological data are reported to the state directly by the state-accredited laboratory performing the analyses, as well as to MSA, but are not published.

All DOE-owned Hanford Site drinking water systems were in compliance with drinking water standards for radiological, chemical, and microbiological contaminant levels during 2011. Contaminant concentrations measured during the year were similar to those observed in recent years ([PNNL-20548](#); [PNNL-19455](#)).

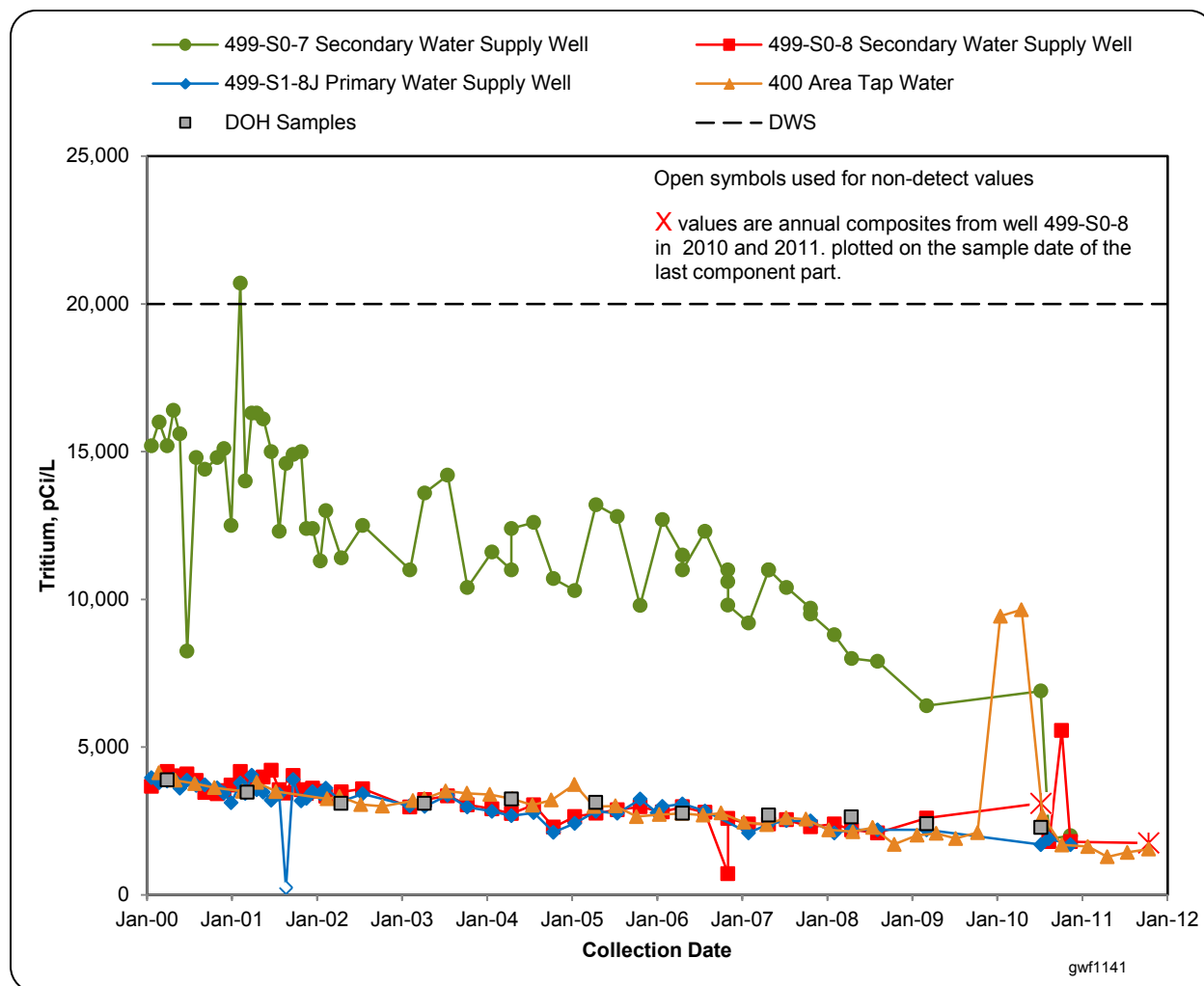
Drinking water samples collected by PNNL for radiological analysis in 2011 were analyzed for gross alpha, gross beta, tritium, and strontium-90 (Table 7.2). The maximum amount of beta-gamma radiation from manmade radionuclides allowed in drinking water by Washington State and EPA is an annual average concentration that will not produce an annual dose equivalent to the whole body or any internal organ greater than 4 millirem (0.04 millisievert). Maximum contaminant levels for gross alpha (excluding radon and uranium) are 15 pCi/L (0.56 Bq/L). The maximum allowable annual average limit for tritium is 20,000 pCi/L (740 Bq/L) (40 CFR 141; WAC 246-290). These concentrations are assumed to produce a total body or organ dose of 4 millirem (0.04 millisievert) per year. If two or more radionuclides are present, the sum of their annual dose equivalent to the total body or to any internal organ must not exceed 4 millirem (0.04 millisievert).

Annual average concentrations of all monitored radionuclides in Hanford Site drinking water in 2011 were below state and federal maximum allowable contaminant levels. The gross alpha, gross beta, tritium, and strontium-90 results from the two facilities where drinking water was obtained from the Columbia River were all below their minimum detectable concentrations (i.e., concentrations were too low to measure). The 400 Area source of drinking water for 2011 was well 499-S1-8J (P-16). Gross beta and tritium were found in all 400 Area water samples, but still below the maximum allowable contaminant level. Gross alpha and strontium-90 were not detected in 400 Area water samples (Table 7.2).

A tritium plume originating in the 200-East Area and extending under the 400 Area historically has affected tritium concentrations in all of the 400 Area drinking water wells (Figure 7.2). In previous years, the Soil and Groundwater Remediation Project personnel would collect and analyze raw (untreated) water samples from all three 400 Area drinking water wells (one primary well and two backup wells); however, this sampling did not occur in 2011. PNNL scientists collected raw (untreated) water samples in 2011 from backup well 499-S0-8 (P1-14). Samples were collected quarterly, composited for a single annual tritium analysis ( $1760 \pm 528$  pCi/L), and fell below the 20,000-pCi/L (740-Bq/L) state and federal annual average drinking water standard.

**Figure 7.2. 400 Area Tritium Concentrations in Drinking Water (2000 through 2011)**

(Multiply pCi/L by 0.037 to convert to Bq/L)



**Table 7.2 Drinking Water Annual Average Concentrations of Selected Radiological Constituents (2011)**(pCi/L)<sup>(a)</sup>

Constituent	Systems	Samples Analyzed from		Annual Average <sup>(b)</sup>	Standard
		Each Location			
Gross alpha <sup>(c,d)</sup>	100 K Area <sup>(e)</sup>	1		-0.134 ± 0.974	15 <sup>(f,g)</sup>
	100-K Area <sup>(h)</sup>	3		0.013 ± 0.910	
	200-West Area	4		0.051 ± 0.368	
	400 Area	4		0.575 ± 0.768	
Gross beta <sup>(c)</sup>	100 K Area <sup>(e)</sup>	1		1.41 ± 1.99 <sup>(d)</sup>	50 <sup>(g)</sup>
	100-K Area <sup>(h)</sup>	3		1.643 ± 1.251 <sup>(d)</sup>	
	200-West Area	4		0.715 ± 2.663 <sup>(d)</sup>	
	400 Area	4		7.385 ± 2.94	
Tritium <sup>(i)</sup>	100 K Area <sup>(e)</sup>	1		98.5 ± 303 <sup>(d)</sup>	20,000 <sup>(g)</sup>
	100-K Area <sup>(h)</sup>	1		331 ± 325 <sup>(d)</sup>	
	200-West Area	1		159 ± 310 <sup>(d)</sup>	
	400 Area	4		1480 ± 301.55	
Strontium-90 <sup>(d,i)</sup>	100-K Area <sup>(h)</sup>	1		0.018 ± 0.96	8 <sup>(f,g)</sup>
	200-West Area	1		1.14 ± 0.863	
	400 Area	1		0.182 ± 0.642	

(a) Multiply pCi/L by 0.037 to convert to Bq/L.

(b) For locations with more than one sample analyzed, the annual average is ±2 times the standard deviation.

(c) Gross alpha samples were collected and analyzed quarterly. Gross beta samples were collected monthly, composited, and analyzed quarterly. The exception was the 100-K Area which was a single grab sample.

(d) Analytical results for all samples were below the detection limit.

(e) 100-K Area water system permanently shut down in February 2011.

(f) WAC 246-290.

(g) 40 CFR 141.

(h) April 2011 a new membrane alternative filtration technology plant went online, referred to as 100-K Area.

(i) Samples were collected quarterly, composited, and analyzed annually, with the exception of the 400 Area, where tritium was collected and analyzed quarterly.

## 7.2 Columbia River Surface Water

*ME Hoefer and ZL Simmons*

Samples of surface water and sediment on and near the Hanford Site were collected and analyzed to determine the concentrations of radiological and chemical contaminants in the aquatic environment attributed to the Hanford Site. Surface-water bodies monitored included the Columbia River, onsite ponds, and offsite irrigation sources (Figure 7.3). Aquatic sediment monitoring was conducted for the Columbia River and one onsite pond. Tables 7.3 and 7.4 summarize the sampling locations, types, and frequencies, as well as sample analyses included in surface-water and sediment monitoring during 2011. This section describes the monitoring efforts and summarizes the results for these aquatic environments.

The Columbia River is one of the largest rivers in the continental United States in terms of total flow and is the dominant surface-water body at the Hanford Site. The original selection of the Hanford Site for plutonium production was based partly on the abundant water supply offered by the river. The river flows through the northern portion of the Hanford Site and forms part of the eastern boundary of the site. The river is used as a source of drinking water for onsite facilities and communities downstream from the Hanford Site. Water removed from the river immediately downstream of the Hanford Site is also used for crop irrigation in Benton and Franklin Counties. In addition, the Hanford Reach of the Columbia River is used for a variety of recreational activities including hunting, fishing, boating, waterskiing, and swimming.

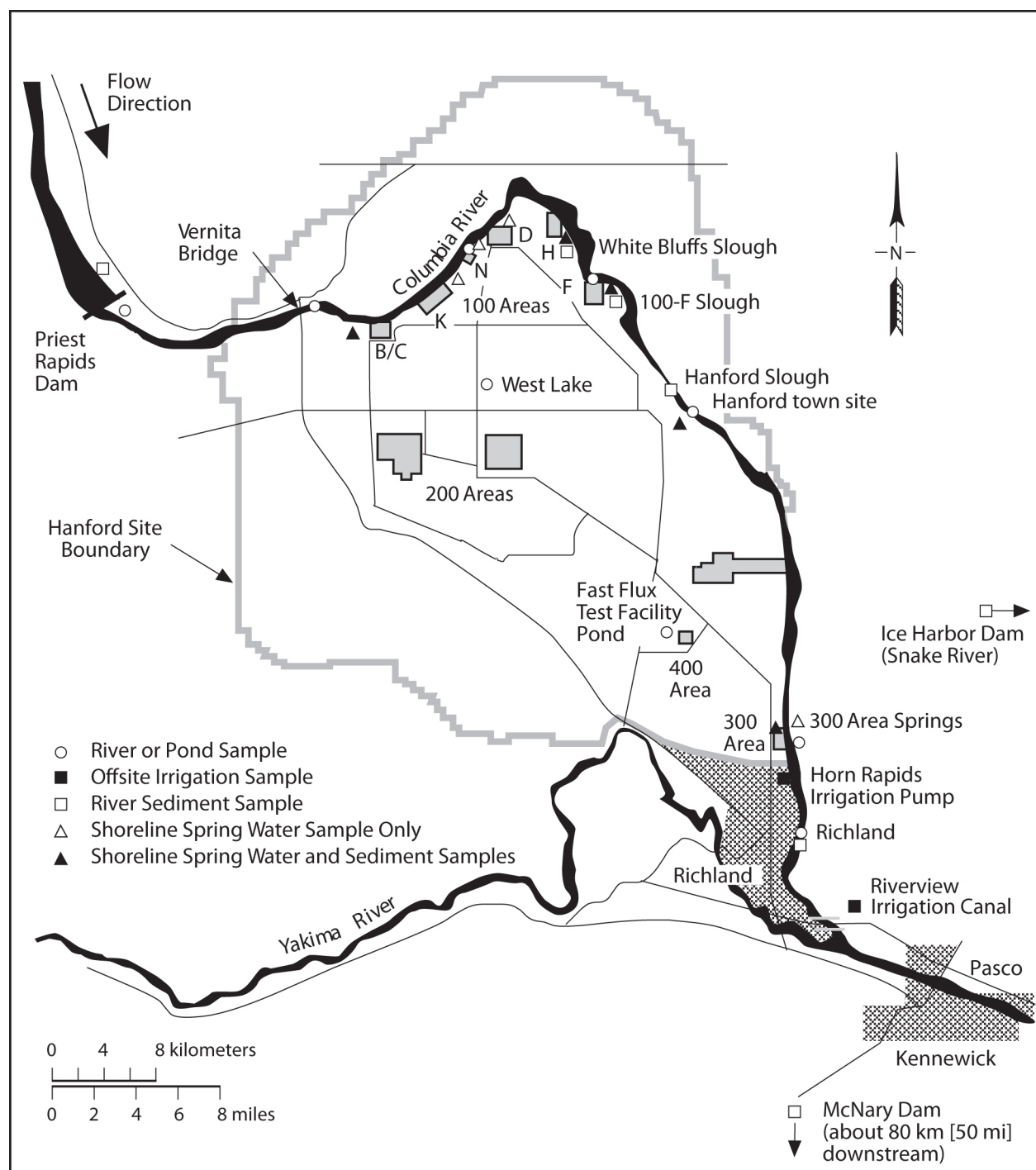
Originating in the Rocky Mountains of eastern British Columbia, the Columbia River and its tributaries drain an area of approximately 260,000 square miles (670,000 square kilometers) before discharging to the Pacific Ocean. Three dams in Canada and 11 dams in the United States regulate the flow of the river; four of these dams are downstream of the Hanford Site. Priest Rapids Dam is the nearest upstream dam, and McNary Dam is the nearest downstream dam to the Hanford Site.

The Hanford Reach of the Columbia River extends from Priest Rapids Dam downstream to the head of Lake Wallula, created by McNary Dam, near the city of Richland, Washington. The Hanford Reach is the last stretch of the Columbia River in the United States upstream of Bonneville Dam (the first dam upstream from the ocean) that remains un-impounded.

River flow through the Hanford Reach fluctuates significantly and is controlled primarily by operations at upstream dams. The annual average flow of the Columbia River downstream of Priest Rapids Dam is approximately 120,000 cubic feet (3,400 cubic meters) per second (WA-94-1). The Columbia River had above normal flows in 2011; the average daily flow rate downstream of Priest Rapids Dam was 150,950 cubic feet (4,275 cubic meters) per second. The peak monthly average flow rate occurred during June (295,100 cubic feet [8,360 cubic meters] per second) (Figure 7.4). The lowest monthly average flow rate occurred during September (77,330 cubic feet [2,190 cubic meters] per second), based on mean daily flows. Daily average flow rates varied from 40,960 to 334,390 cubic feet (1,160 to 9,470 cubic meters) per second during 2011. As a result of fluctuation in discharges, the depth of the river varies significantly over time. The river stage (river water surface elevation) may change along the Hanford Reach by up to 10 feet (3 meters) within a few hours. Seasonal changes of approximately the same magnitude are also observed. River-stage fluctuations measured at the 300 Area are approximately one-half the magnitude of those measured near the 100 Areas because of the effect of the pool behind McNary Dam and the relative distance of each area from Priest Rapids Dam. The width of the river varies from approximately 980 to 3,300 feet (300 to 1,000 meters) as it passes through the Hanford Site.

Pollutants from multiple sources are present in the Columbia River as it passes through the Hanford Reach. These sources include upstream industry, atmospheric fallout that collects in the river's drainage basin, runoff from agricultural operations, and discharge from the aquifers on either side of the river. Hanford Site pollutants, both radiological and chemical, enter the Columbia River along the Hanford Reach. Effluent from each direct discharge point is monitored routinely and reported by the responsible operating contractor. Direct discharges are identified and regulated for non-radiological constituents under NPDES (40 CFR 122) in compliance with the *Clean Water Act of 1977*. In addition to permitted direct discharges of liquid effluent from Hanford Site facilities, groundwater contaminants from past operational releases to the ground discharge into the Columbia River ([DOE/RL-92-12](#)). In general, groundwater discharges are considered to be the dominant pathway for Hanford Site contaminants to enter the Columbia River.



**Figure 7.3. Surface-Water and Sediment Sampling Locations (2011)**

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**Table 7.3 Surface-Water Surveillance (2011)**

Location	Sample Type	Frequency	Analyses
<b>Columbia River - Radiological</b>			
Priest Rapids Dam, and Richland Pump House	Cumulative	M Comp(a)	Alpha, beta, low tritium,(b) strontium-90, technetium-99, isotopic uranium(c)
	Particulate (filter)	M Cont(d) Q Cont(e)	Gamma energy analysis Isotopic plutonium(f)
	Soluble (resin)	M Cont	Gamma energy analysis
		Q Cont	Isotopic plutonium
Vernita Bridge	Grab (transects)	2/year	Low tritium, strontium-90, isotopic uranium
Richland	Grab (transects)	3/year	Low tritium, strontium-90, isotopic uranium
100-N and 300 Areas and Hanford town site	Grab (transects)	Annually	Low tritium, strontium-90, isotopic uranium
<b>Columbia River - Chemical</b>			
Vernita Bridge	Grab (transects)	2/year	Temperature, pH, anions, specific conductance, chromium, nitrate + nitrite
	Grab (transects)	Annually	Metals (filtered and unfiltered), volatile organic compounds
Richland	Grab (transects)	3/year	Temperature, pH, anions, specific conductance, chromium, nitrate + nitrite
	Grab (transects)	Annually	Metals (filtered and unfiltered), volatile organic compounds
100-N Area, 300 Area, and Hanford Town Site	Grab (transects)	Annually	Metals (filtered and unfiltered), anions
<b>Onsite Ponds</b>			
West Lake	Grab	Quarterly(g)	Tritium, isotopic uranium
Fast Flux Test Facility Pond	Grab	Quarterly	Alpha, beta, tritium, gamma energy analysis
<b>Offsite Irrigation Water</b>			
Riverview Irrigation Canal	Grab	3/year	Alpha, beta, tritium, strontium-90, isotopic uranium, gamma energy analysis
Horn Rapids	Grab	3/year	Alpha, beta, tritium, strontium-90, isotopic uranium, gamma energy analysis

**Table 7.3 Surface-Water Surveillance (2011)**

- (a) M Comp indicates river water was collected hourly and composited monthly for analysis.
- (b) Low tritium = Low-level tritium analysis (10-pCi/L detection limit), which includes an electrolytic preconcentration.
- (c) Isotopic uranium (uranium-234, uranium-235, and uranium-238).
- (d) M Cont = River water was sampled for 2 weeks by continuous flow through a filter and resin column, and multiple samples were composited monthly for analysis.
- (e) Q Cont = River water was sampled for 2 weeks by continuous flow through a filter and resin column, and multiple samples were composited quarterly for analysis.
- (f) Isotopic plutonium (plutonium-238 and plutonium-239/240).
- (g) West Lake was not sampled during the first quarter of 2011.

Comp = Composite

Cont = Continuous

M = Monthly

Q = Quarterly.

**Table 7.4 Columbia River Sediment Surveillance (2011)**

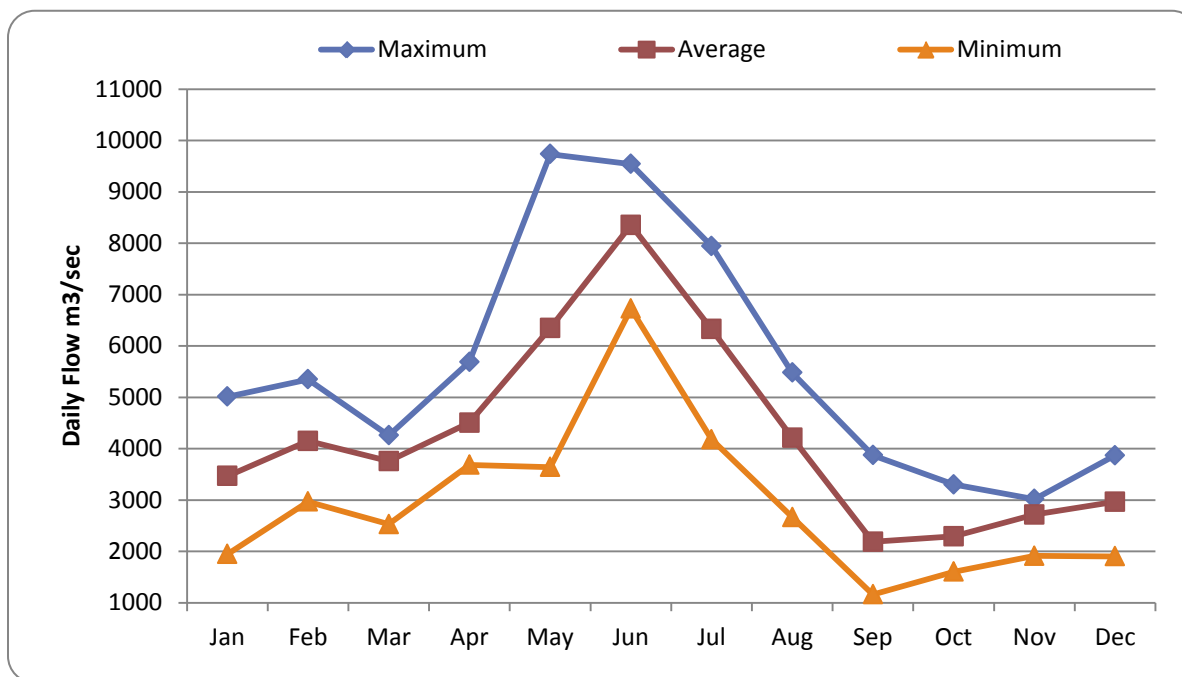
Location <sup>(a)</sup>	Frequency	Analyses
Priest Rapids Dam (Two locations near the dam):	Annually	Gamma energy analysis, strontium-90, isotopic uranium, <sup>(b)</sup> isotopic plutonium, <sup>(c)</sup> metals, mercury, and total organic carbon
White Bluffs Slough	Annually	Gamma energy analysis, strontium-90, isotopic uranium, <sup>(b)</sup> isotopic plutonium, <sup>(c)</sup> metals, mercury, and total organic carbon
McNary Dam (Two locations near the dam)	Annually	Gamma energy analysis, strontium-90, isotopic uranium, <sup>(b)</sup> isotopic plutonium, <sup>(c)</sup> metals, mercury, and total organic carbon

(a) Refer to Figure 7.3.

(b) Isotopic uranium (uranium-234, uranium-235, and uranium-238) analyzed by alpha spectrometry (alpha energy analysis).

(c) Isotopic plutonium (plutonium-238 and plutonium-239/240).

The Washington State Legislature (WAC 173-201A-602) has classified the general water-use and water quality criteria for the Columbia River downstream from Grand Coulee Dam with an aquatic-life designation of 'salmonid spawning, rearing, and migration', which provides for the protection of spawning, rearing, and migration of salmon and trout as well as other associated aquatic life. The recreational uses designation for the Columbia River downstream from Grand Coulee Dam is 'primary contact', which provides for activities that may involve complete submersion by the participant. The entire Columbia River is designated as suitable for all water supply and miscellaneous uses by Washington State.

**Figure 7.4. Columbia River Flow Rates at Priest Rapids Dam, Washington (2011)***(multiply  $m^3/sec$  by 35.31 to obtain  $ft^3/sec$ )*

### 7.2.1 Monitoring Results

Columbia River water samples were collected from fixed-location monitoring stations at Priest Rapids Dam and the city of Richland in 2011 and analyzed for radionuclides. Cross-river transects and near-shore locations near Vernita Bridge, 100-N Area, Hanford town site, 300 Area, and the city of Richland were analyzed for both radionuclides and chemicals (Figure 7.3). Samples were collected upstream from the Hanford Site at Priest Rapids Dam and Vernita Bridge to provide data from locations unaffected by site operations. Samples were collected from all other locations, including a municipal drinking water supply and points of withdrawal for irrigation water downstream of the Hanford Site, to identify any increase in contaminant concentrations attributable to the site. The sampling of irrigation water systems is discussed in [Section 7.6](#).

The fixed-location monitoring stations at Priest Rapids Dam and the city of Richland consist of an automated sampler and a continuous flow system. The automated sampler at Priest Rapids Dam was used to obtain hourly unfiltered samples of Columbia River water (cumulative samples), which were composited for a period of 7 days. The automated sampler at the city of Richland experienced technical problems, so weekly grab samples were obtained. These weekly samples were combined into monthly and quarterly composite samples for radiological analyses (Table 7.3). The continuous flow system was used to collect particulate and soluble constituents in Columbia River water by passing water through a filter and then through a resin column. Filter and resin samples were exchanged approximately every 14 days and were combined into quarterly composite samples for radiological analyses. The river sampling locations and the methods used for sample collection are discussed in [DOE/RL-91-50](#).

Radionuclides of interest were selected for analysis based on the following criteria:

- Their presence in effluent discharged from Hanford Site facilities or in near-river groundwater underlying the site

- Their importance in determining water quality, verifying facility effluent controls and monitoring systems, and determining compliance with applicable water quality standards.

Constituents of interest in Columbia River water samples collected at Priest Rapids Dam and the city of Richland included gamma-emitting radionuclides, tritium, strontium-90, technetium-99, uranium-234, uranium-235, plutonium-238, uranium-238, and plutonium-239/240. Gross alpha and gross beta measurements were made as indicators of the general radiological quality of the river and provided a timely indication of change. Gamma-energy analysis provides the capability to detect numerous specific radionuclides. Analytical detection levels (defined as the laboratory-reported minimum detectable concentration) for all radionuclides were less than or equal to 10 percent of their respective Washington State water quality criteria levels (Appendix C). Unless otherwise noted in this section, the statistical tests for differences are paired sample comparisons and two-tailed t-tests, with alpha at a 5 percent significance level.

Transect sampling (i.e., multiple samples collected along a line across the Columbia River) was initiated as a result of findings of a special study conducted during 1987 and 1988. That study concluded that, under certain flow conditions, contaminants entering the Columbia River from the Hanford Site are not completely mixed when sampled at routine monitoring stations located downriver. Incomplete mixing results in a slightly conservative (high) bias in the data generated using the routine, single-point, sampling system at the city of Richland drinking water intake. During 1999, the transect sampling strategy was modified; some of the mid-river sampling points were shifted to near-shore locations in the vicinity of the transect. For example, at the 100-N Area, instead of 10 evenly spaced cross-river transect samples, only 6 cross-river samples were collected, and the other 4 samples were obtained at near-shore locations (typically less than 16 feet [5 meters] from shore). This sampling pattern was used during 2011 and allowed the cross-river concentration profile to be determined and also provided information over a larger portion of the Hanford Site shoreline where the highest contaminant concentrations would be expected. City of Richland transects and near-shore locations were sampled quarterly during 2011. Vernita Bridge transects and near-shore locations were sampled during the first, third, and fourth quarters of 2011. Vernita Bridge transects and near-shore locations were not sampled during the second quarter due to safety concerns with extremely high river flows. Annual transect and near-shore sampling were conducted at the 100-N Area, Hanford town site, and 300 Area locations in late summer when river flows were low, which provides the highest probability of detecting Hanford Site contaminants carried by groundwater to the Columbia River.

Columbia River transect water samples collected during 2011 were analyzed for both radiological and chemical contaminants (Table 7.3). Specific metals and anions were selected for analysis following reviews of existing surface-water and groundwater data, various RI/FS work plans, and preliminary Hanford Site risk assessments ([DOE/RL-92-67](#), [WCH-380](#)). Grab samples of water collected along transects were radiologically and chemically analyzed. Metals analyses included both unfiltered and filtered samples.

### 7.2.1.1 Radiological Results

**Fixed-Location Samples.** Results of radiological analyses of Columbia River water samples collected at Priest Rapids Dam and the city of Richland in 2011 and for the previous 5 years are summarized in Appendix C. All individual radiological contaminant concentrations measured in Columbia River water during 2011 were less than 1/25 of the concentrations comparable to the DOE-derived concentration guides (Appendix D). The DOE-derived concentration guides are based on a 100-millirem (1-milliseivert) per year standard; dividing by 25 allows for more direct comparison to the 4-millirem (0.04-milliseivert) per year drinking water standard and Washington State ambient surface-water quality criteria (40 CFR 141; WAC 173-201A; Appendix D). Significant results are discussed in the following paragraphs, and comparisons to previous years are provided.

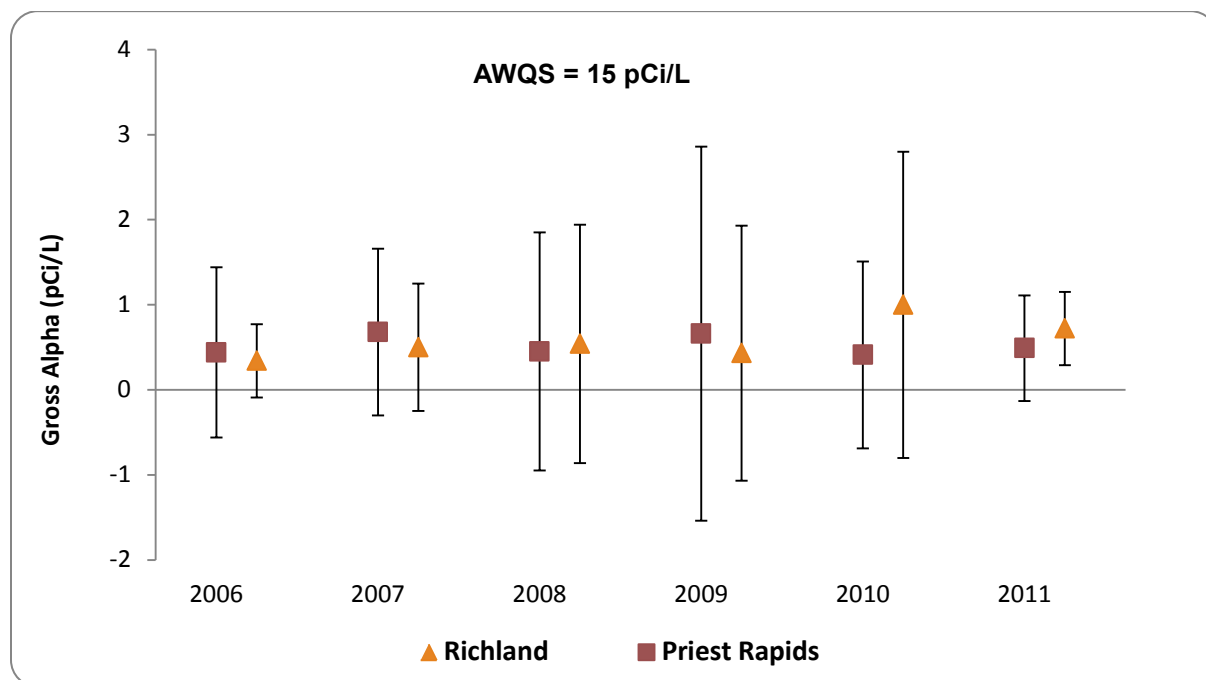
Radionuclide concentrations monitored in Columbia River water were low throughout 2011. Tritium, uranium-234, uranium-238, and naturally occurring beryllium-7 and potassium-40 were measured consistently in river water at levels greater than their reported minimum detectable concentrations. Strontium-90, uranium-235, plutonium-238, and plutonium-239/240 were occasionally detected, but all values were near the minimum detectable concentrations. Concentrations of all other radionuclides were typically less than the minimum detectable concentrations. Tritium, strontium-90, and plutonium exist in worldwide nuclear fallout as well as in effluent from Hanford Site facilities. Tritium and uranium occur naturally in the environment in addition to being present in Hanford Site effluent.

The 2011 average gross alpha and gross beta concentrations measured upstream and downstream of the Hanford Site were similar to those observed during recent years (Figures 7.5 and 7.6). Statistical comparisons for gross alpha and gross beta concentrations at Priest Rapids Dam and the city of Richland were not performed because most of the concentrations were less than the 1- and 3-pCi/L (0.037- and 0.11-Bq/L) minimum detectable concentrations, respectively. All gross alpha and gross beta concentrations in Columbia River water at the city of Richland during 2011 were less than the Washington State ambient surface-water quality criteria of 15 and 50 pCi/L (0.56 and 1.9 Bq/L), respectively.

The 2011 annual average tritium concentrations measured upstream and downstream of the Hanford Site were similar to concentrations measured in recent years. Statistical analyses indicated that monthly tritium concentrations in river water samples at the city of Richland were higher than concentrations in samples from Priest Rapids Dam (Figure 7.7). However, 2011 average tritium concentrations in Columbia River water collected at the city of Richland were only 0.19 percent of the Washington State ambient surface-water quality criterion of 20,000 pCi/L (740 Bq/L). The onsite source of tritium entering the river is groundwater seepage. Although representative of river water used by the city of Richland for drinking water (first municipal water source downstream from the Hanford Site), tritium concentrations measured at the Richland shoreline tend to be elevated when compared to average tritium concentrations across the river at this location. This bias is attributable to a groundwater plume (originating from the 200-East Area entering the river along the portion of shoreline extending from the Hanford town site downstream to downstream of the 300 Area), which is relatively close to the city of Richland water intake. This plume is not completely mixed within the Columbia River at the city of Richland. Sampling along cross-river transects at the city of Richland during 2011 confirmed the existence of a concentration gradient in the river under certain flow conditions and is discussed subsequently in this section. The extent to which samples taken at the city of Richland drinking water intake overestimate the average tritium concentrations in the Columbia River at this location is variable and appears to be related to the flow rate of the river just before and during sample collection.

**Figure 7.5. Gross Alpha Annual Average Concentrations Columbia River Water Upstream and Downstream of the Hanford Site (2006 through 2011)**

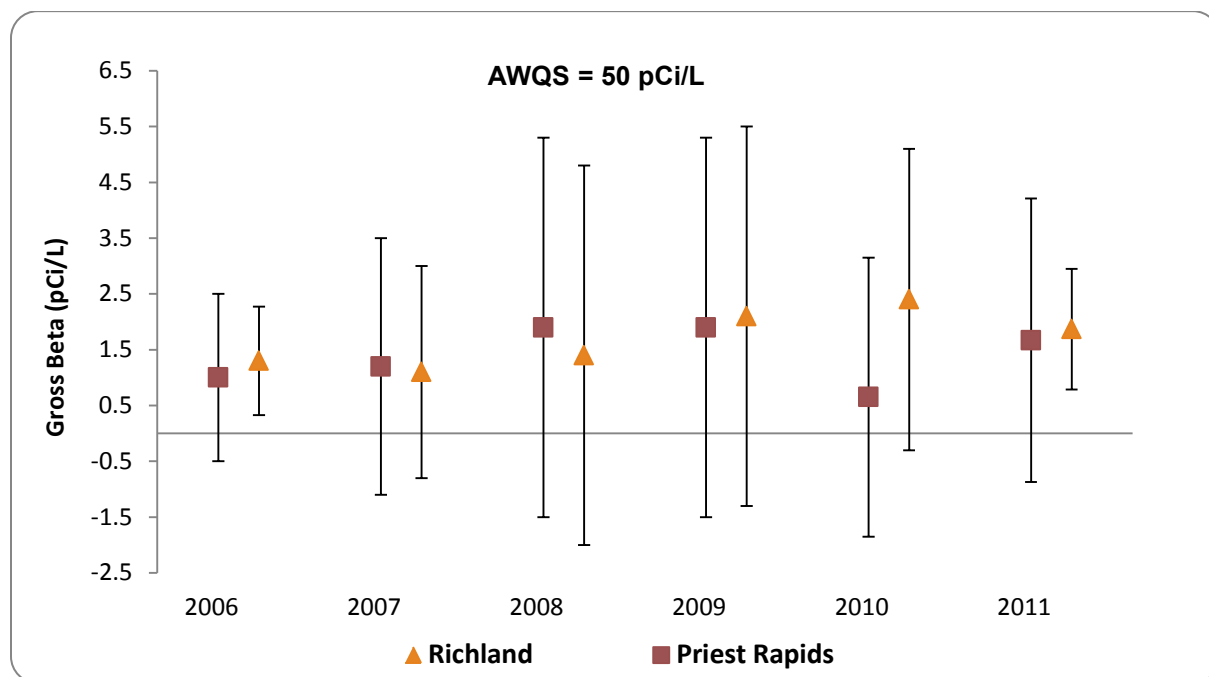
( $\pm 1$  standard deviation, AWQS = ambient water quality standard)





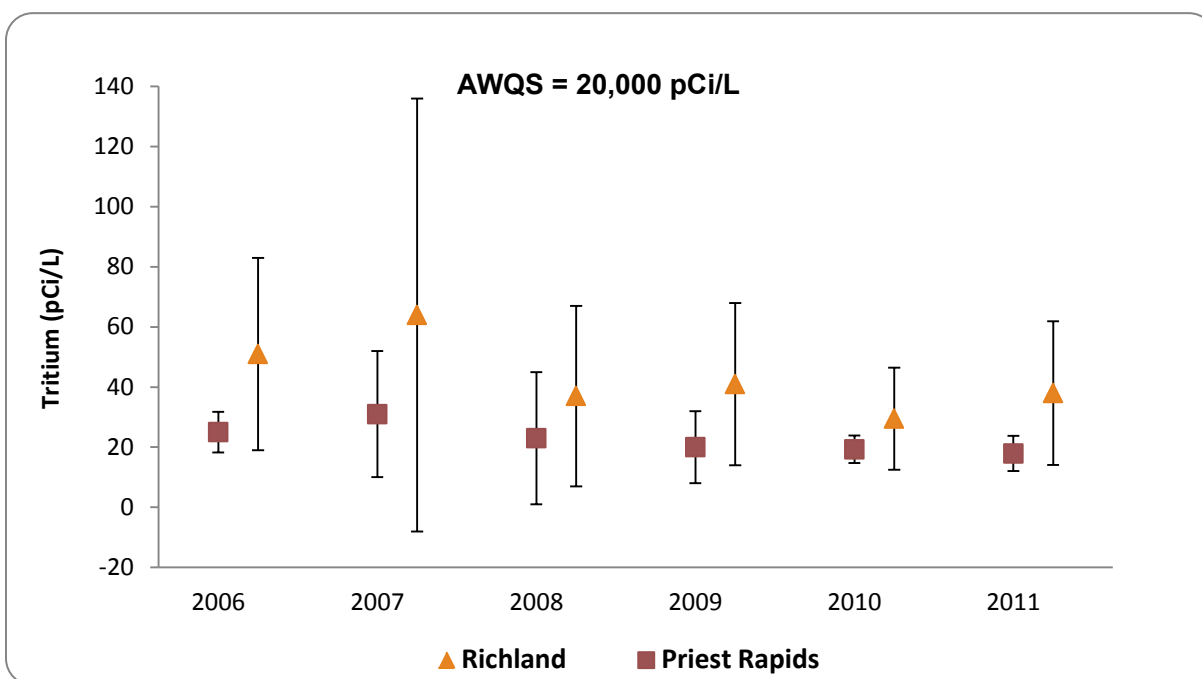
**Figure 7.6. Gross Beta Annual Average Concentrations Columbia River Water Upstream and Downstream of the Hanford Site (2006 through 2011)**

( $\pm 1$  standard deviation, AWQS = ambient water quality standard)



**Figure 7.7. Tritium Annual Average Concentrations Columbia River Water Upstream and Downstream of the Hanford Site (2006 through 2011)**

( $\pm 1$  standard deviation, AWQS = ambient water quality standard)



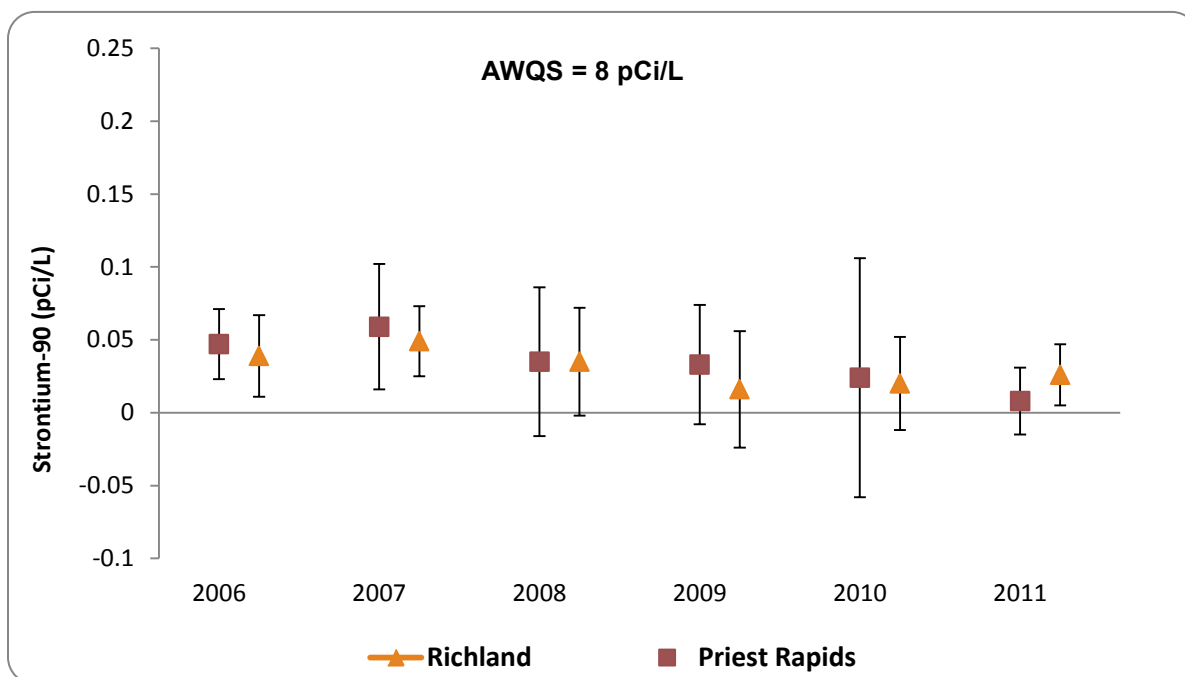
Average strontium-90 levels measured in Columbia River water collected upstream and downstream of the Hanford Site during 2011 were similar to those reported previously (Figure 7.8). Groundwater plumes containing strontium-90 enter the Columbia River throughout the 100 Areas. Some of the highest strontium-90 levels that have been found in onsite groundwater are the result of past discharges to the 100-N Area liquid waste disposal facilities. Strontium-90 concentrations at Priest Rapids Dam were not statistically compared with the city of Richland because most of the concentrations were less than the minimum detectable concentration. Average strontium-90 concentrations in Columbia River water at the city of Richland were less than 0.33 percent of the Washington State ambient surface-water quality criterion (8 pCi/L [0.30 Bq/L]).

Annual average total uranium concentrations (i.e., the sum of uranium-234, uranium-235, and uranium-238) observed in water samples collected upstream and downstream of the Hanford Site in 2011 were similar to those observed during recent years (Figure 7.9). Monthly total uranium concentrations measured at the city of Richland in 2011 were significantly higher than those measured at Priest Rapids Dam. Uranium is present in the groundwater beneath the 300 Area as a result of past Hanford Site operations and has been detected at elevated levels in shoreline springs at the 300 Area in the past ([Section 7.4](#); [PNNL-13692](#); [PNNL-16805](#)). Elevated uranium concentrations were measured in the effluent discharged into the Columbia River from the aquaculture lab at the Battelle complex in the 300 Area. Uranium from non-Hanford Site sources, such as fertilizer use, also is known to enter the Columbia River across from the Hanford Site via irrigation return water and groundwater seepage associated with extensive irrigation north and east of the river. Most phosphate fertilizers contain trace amounts of naturally occurring uranium. There is no Washington State ambient surface-water quality criterion directly applicable to uranium; however, total uranium levels in the river during 2011 were well below the EPA drinking water standard of 30 µg/L (approximately 20 pCi/L [0.74 Bq/L], Appendix D).

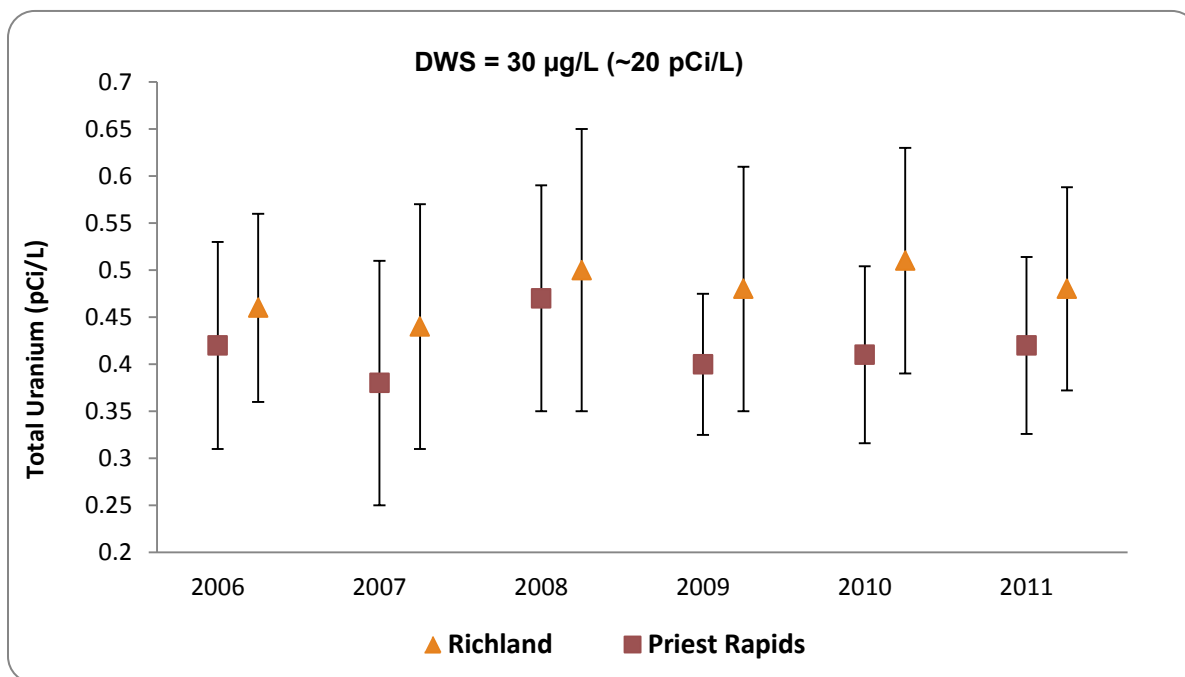
Columbia River water samples were not collected for iodine-129 analysis in 2011 because the unique instrument for this assay was not operational, and an alternative for this ultra-trace measurement capability was not available. The onsite source of iodine-129 to the Columbia River is the discharge of contaminated groundwater along the portion of shoreline downstream of the Hanford town site ([Section 8.0](#), Groundwater Monitoring). The iodine-129 plume originated in the 200 Areas from past waste disposal practices. In previous years, quarterly iodine-129 concentrations in Columbia River water at the city of Richland were significantly higher than those at Priest Rapids Dam, indicating a Hanford Site source of iodine-129. Past results have shown that iodine-129 values at Priest Rapids Dam are largely unaffected by river stages; however, the concentrations measured for river water at the city of Richland are inversely proportional to the river stage (i.e., during lower flow, the concentrations of iodine-129 are higher and vice versa).

Plutonium-239/240 concentrations for river water samples at the city of Richland in 2011 were extremely low. All plutonium concentrations for the particulate and dissolved fractions of water samples were reported as undetected by the analytical laboratory. All concentrations and detection limits were well below the DOE-derived concentration guide of 30 pCi/L (1.1 Bq/L). No Washington State ambient surface-water quality criterion exists for plutonium-239/240. Plutonium concentrations at Priest Rapids Dam were not statistically compared with the city of Richland because most of the concentrations were less than the reported minimum detectable concentrations.

**Figure 7.8. Strontium-90 Annual Average Concentrations Columbia River Water Upstream and Downstream of the Hanford Site (2006 through 2011)**  
( $\pm 1$  standard deviation, AWQS = ambient water quality standard)



**Figure 7.9. Uranium Annual Average Concentrations Columbia River Water Upstream and Downstream of the Hanford Site (2006 through 2011)**  
( $\pm 1$  standard deviation, DWS = drinking water standard)

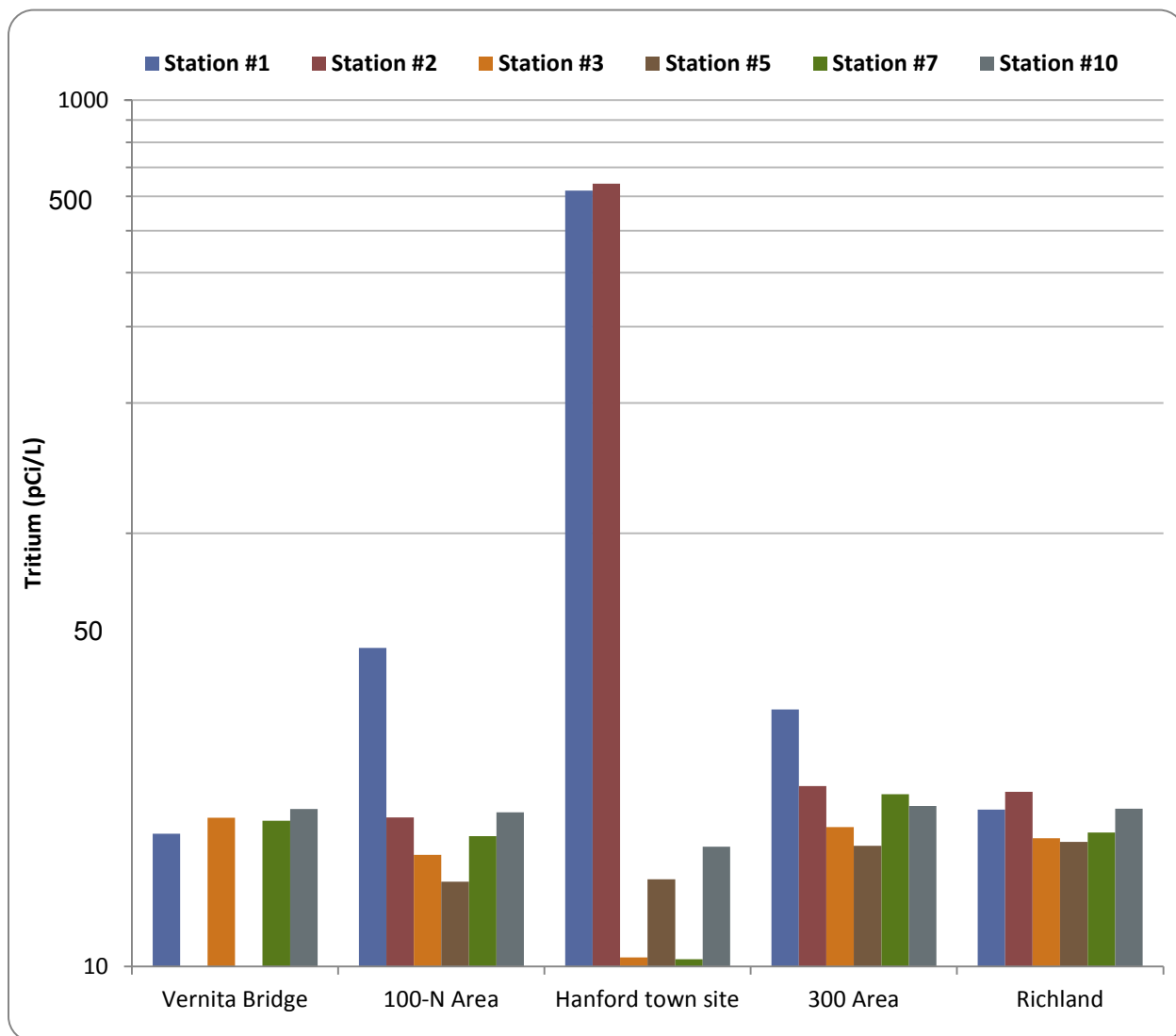


**Columbia River Transect and Near-Shore Samples.** Radiological results from samples collected along Columbia River transects and at near-shore locations near Vernita Bridge, 100-N Area, Hanford town site, 300 Area, and the city of Richland are presented in Appendix C. Sampling locations were documented using a global positioning system receiver. Radionuclides consistently measured at concentrations greater than the minimum detectable activity included tritium, uranium-234, and uranium-238. Strontium-90 and uranium-235 were occasionally detected, and most values were near the minimum detectable concentrations. All measured concentrations of these radionuclides were less than the applicable Washington State ambient surface-water quality criteria and the EPA drinking water standards.

Tritium concentrations measured along Columbia River transects at Vernita Bridge, 100-N Area, Hanford town site, 300 Area, and the city of Richland Pumphouse during June, August, September, and November 2011 are depicted in Figure 7.10. The transect at Vernita Bridge is the most upstream location. Stations 1 and 10 are located along the Benton County and Grant-Franklin County shorelines, respectively. The 100-N Area, Hanford town site, 300 Area, and the city of Richland transects have higher tritium concentrations near the Hanford Site shore (Benton County) relative to the opposite shore. The presence of a tritium concentration gradient in the Columbia River at the city of Richland supports previous studies showing that contaminants in the 200 Areas groundwater plume entering the river at, and upstream of, the 300 Area are not completely mixed in the river at the city of Richland. The gradient is most pronounced during periods of relatively low river flow. Since transect sampling began in 1987, the average tritium concentration measured along the city of Richland transect has been less than that measured in monthly composited samples from the fixed-location monitoring station in the city of Richland, illustrating the conservative bias (i.e., overestimate) of the fixed-location monitoring station. For samples collected in 2011, the highest tritium concentration measured in cross-river transect water was  $642 \pm 275$  pCi/L ( $23.8 \pm 10.2$  Bq/L) at the Hanford town site. The highest tritium concentration measured in near-shore water samples was  $3,160 \pm 663$  pCi/L ( $117 \pm 25$  Bq/L) from a sample collected at the 300 Area. The highest tritium concentrations for transect and near-shore samples were measured at the 300 Area. Specific conductivity results for the 2011 transect and near-shore water samples collected at the 300 Area indicate there was only limited mixing of groundwater into the river at the time of sample collection.

Strontium-90 concentrations in Hanford Reach river water for both transect and near-shore samples collected in 2011 were similar to reference concentrations for most locations. The maximum strontium-90 concentration was  $0.0506 \pm 0.033$  pCi/L ( $0.0019 \pm 0.0012$  Bq/L) for a near-shore water sample collected along the 100-N Area shoreline. The average strontium-90 concentration found during transect sampling at the city of Richland was similar to those measured in monthly composite samples at the Richland Pumphouse and at Priest Rapids Dam.

Uranium was monitored in transect and near-shore water samples collected in 2011 from the Vernita Bridge, city of Richland, 100-N Area, and 300 Area (Figure 7.3). Uranium concentrations were elevated in near-shore water samples collected from two 300 Area locations. The highest total uranium level was found to be  $16 \pm 2.4$  pCi/L [ $0.59 \pm 0.09$  Bq/L or approximately  $24 \pm 3.5$  µg/L], which was collected at 300 Area Spring 42-2. The total uranium concentration in this near-shore grab sample was below the EPA drinking water standard of 30 µg/L (approximately 20 pCi/L [ $0.74$  Bq/L]). Elevated uranium concentrations exist in the unconfined aquifer beneath the 300 Area in the vicinity of former uranium fuel fabrication facilities and inactive waste sites. Gross alpha and gross beta concentrations in 300 Area shoreline spring water from 2005 through 2010 parallel uranium concentrations and are likely associated with its presence.

**Figure 7.10. Tritium Concentrations in Cross-River Transect Water Samples from the Hanford Reach of the Columbia River (2011)***[Washington State ambient water quality standard for tritium is 20,000 pCi/L (740 Bq/L)]*

### 7.2.1.2 Chemical and Physical Results

Chemical and physical water quality data was compiled in 2011 for the Columbia River. A number of the parameters measured have no regulatory limits, but they are useful as indicators of water quality and contaminants of Hanford Site origin. Potential sources of pollutants not associated with the Hanford Site include irrigation return water; groundwater seepage associated with extensive irrigation north and east of the Columbia River; and industrial, agricultural, and mining effluent introduced upstream of the Hanford Site.

The concentrations of metals and anions observed in river water during 2011 were similar to those observed in the past and remain below regulatory limits. Metals and anions were detected in Columbia River transect samples both upstream and downstream of the Hanford Site. Arsenic, antimony, chromium, lead, selenium, and zinc were detected in several samples. Beryllium and silver were not detected in any Columbia River water samples. Washington State ambient surface-water quality criteria for cadmium, copper, lead, nickel,

silver, and zinc are total-hardness dependent (WAC 173-201A). Increased water hardness (i.e., primarily higher concentrations of calcium and magnesium ions) can reduce the toxicity of some metals by limiting their absorption into aquatic organisms. Criteria for Columbia River water were calculated using a total hardness of 47 mg/L as calcium carbonate, the lowest value based on U.S. Geological Survey monitoring of Columbia River water near Vernita Bridge and the city of Richland in recent years. All metal and anion concentrations in river water were less than the Washington State ambient surface-water quality criteria for the protection of aquatic life (Appendix C, Table C.7). Arsenic concentrations at the 100-N Area exceeded the EPA standard for the protection of human health for the consumption of water and organisms. However, this EPA value is approximately 10,500 times lower than the Washington State chronic toxicity value.

For samples collected on the cross-river transects, concentrations of nitrate, chloride, and sulfate were slightly elevated along the Grant-Franklin County shoreline near the city of Richland. Nitrate concentrations were slightly elevated along the Benton County shoreline at the Hanford town site and the 300 Area. Chloride concentrations were slightly elevated along the Grant-Franklin County shoreline at the 100-N Area and at the city of Richland. Sulfate concentrations were slightly elevated along the Grant-Franklin County shoreline at the 100-N Area, 300 Area, and at the city of Richland. Sulfate concentrations were slightly elevated along the Benton County shoreline at the Hanford town site. In many cases, the highest anion concentrations were for samples collected along the Franklin County shoreline. These elevated results likely resulted from groundwater seepage associated with extensive irrigation north and east of the Columbia River. Nitrate contamination of some Franklin County groundwater has been documented by the 1995 U.S. Geological Survey and is associated with high fertilizer and water usage in agricultural areas. Numerous wells in western Franklin County exceed the EPA maximum contaminant level for nitrate (40 CFR 141; U.S. Geological Survey Circular 1144). Average quarterly concentrations of chloride, nitrate, and sulfate were higher at the city of Richland transect than in the Vernita Bridge transect. The concentrations of volatile organic compounds in Columbia River water samples (e.g., chlorinated solvents and hydrocarbons) were below the analytical laboratory's contractually required detection limits for all samples, with no indication of a Hanford Site source.

Concentrations of hexavalent chromium (reported as chromium in Appendix C) in the Hanford Reach are of interest because groundwater contaminated with chromium above the ambient water quality criterion intersects the Columbia River at several Hanford Site locations. All river transect and near-shore filtered water samples for 2011 had chromium concentrations below the ambient water quality criterion. One near-shore water sample collected at the 300 Area had slightly elevated chromium levels compared to upstream samples at Vernita Bridge.

### **7.3 Columbia River Sediment**

#### *Z. Simmons*

During peak operating years at the Hanford Site, large amounts of effluents associated with reactor operations were discharged to the Columbia River. Some constituents in these effluents may have become associated with particulate matter that accumulated in riverbed sediment, particularly in slack-water areas and in the reservoirs behind the dams located downstream of the Hanford Site. The majority of short-lived radioactive constituents have decayed away, but some longer-lived radionuclides, such as isotopes of cesium, plutonium, strontium, and uranium, are still detectable. Fluctuations in the river flow from the operation of upriver hydroelectric dams, annual spring high river flows, and occasional floods have resulted in resuspension, relocation, and subsequent re-deposition of sediment. Upper-layer sediment in the Columbia River

downstream of the Hanford Site contains low concentrations of radionuclides, metals of Hanford Site origin, and radionuclides from world-wide atmospheric fallout as well as metals and other nonradioactive contaminants from mining and agricultural activities ([PNNL-13417](#); [PNNL-16990](#)). Periodic sediment sampling confirms that concentrations are low and that no significant changes in concentrations have occurred. The accumulation of radioactive materials in sediment can lead to human exposure from ingestion of aquatic organisms associated with the sediment or sediment resuspension into drinking water supplies. Sediment with accumulated radioactive materials can be an external radiation source, irradiating people who are fishing, wading, swimming, sunbathing, or participating in other recreational activities associated with the river or shoreline ([DOE/EH-0173T](#)).

Since the shutdown of the last single-pass reactor at the Hanford Site in 1971, the contaminant concentrations in Columbia River surface sediment near and downstream of the Hanford Site have been decreasing. This decrease is a result of radioactive decay and the deposition of uncontaminated material on top of the older sediment, which occurs in the reservoirs of the dams downstream of the Hanford Site. However, discharges of some pollutants from the Hanford Site to the Columbia River occurred through March 2011 at a permit-regulated liquid effluent discharge at the 100-K Area and through contaminated groundwater .

Several studies have been conducted to investigate the difference in sediment grain-size composition and total organic carbon content at routine Columbia River monitoring sites and the effect of grain size and organic content in measured contaminant concentrations ([PNNL-13417](#)). Physical and chemical sediment characteristics were found to be highly variable among monitoring sites along the Columbia River. Samples containing the highest percentage of silts, clays, and total organic carbon were generally collected from the reservoir behind Priest Rapids dam upstream of the site and from the White Bluffs Slough on the Hanford Reach.

### **7.3.1 Monitoring Results**

Samples of the surface layer of Columbia River sediment were collected in 2011 at depths of 0 to 6.3 inches (0 to 16 centimeters) from six river locations that were permanently submerged (some Hanford Reach sampling locations may not be submerged during an extremely low river stage). Sampling locations were documented using a global positioning system receiver. Surface sediment was collected with a dredge sampler, capturing several years of integrated deposits, including both sediment grains and associated pore water. Estimated average sediment deposition rates of 0.28 inch (0.723 centimeter) per year for Priest Rapids Dam and 0.89 inch (2.25 centimeters) per year for McNary Dam (Gibbons 2000). Assuming a maximum sediment sampling depth of 6.3 inches (16 centimeters) with the dredge, the samples would integrate up to approximately 22 years at Priest Rapids Dam and 7 years at McNary Dam. Sediment deposition rates have not been estimated for Hanford Reach locations.

Samples were collected upstream of Hanford Site facilities from the Priest Rapids Dam reservoir (the nearest upstream impoundment) to provide data from an area unaffected by site operations. Samples were collected downstream of the Hanford Site above McNary Dam (the nearest downstream impoundment) to identify any increase in contaminant concentrations. Any increases in contaminant concentrations found in sediment above McNary Dam compared to those found above Priest Rapids Dam do not necessarily reflect a Hanford Site source. The confluences of the Columbia River with the Yakima, Snake, and Walla Walla Rivers lie between the Hanford Site and McNary Dam. Several towns, irrigation water returns, and factories in these drainages, as well as atmospheric nuclear fallout, may also contribute to the contaminant load found in McNary Dam sediment. Thus, sediment samples are taken periodically in the reservoir above Ice Harbor Dam (the first dam



on the Snake River upstream of the river mouth) to assess Snake River input. Sediment samples were also collected at the White Bluffs Slough along the Hanford Reach of the Columbia River, from slack-water areas where fine-grained material is known to deposit.

Monitoring sites in the reservoirs behind McNary and Priest Rapids dams consisted of two stations spaced approximately equidistant on a transect line crossing the Columbia River; the samples were collected near the boat-exclusion buoys immediately upstream of each dam. The White Bluffs Slough monitoring site consisted of a single sampling location. Samples were collected using a clam-shell style sediment dredge; this sampling method is discussed in [PNNL-16744](#). All sediment samples were analyzed for gamma-emitting radionuclides, strontium-90, uranium-234, uranium-235, plutonium-238, uranium-238, plutonium-239/240, metals, mercury, and total organic carbon ([DOE/RL-91-50](#)). The specific analytes selected for sediment samples were based on findings of previous Columbia River sediment investigations, reviews of past and present effluent contaminants discharged from site facilities, and reviews of contaminant concentrations observed in Hanford Site groundwater monitoring wells near the Columbia River.

### 7.3.2 Radiological Results

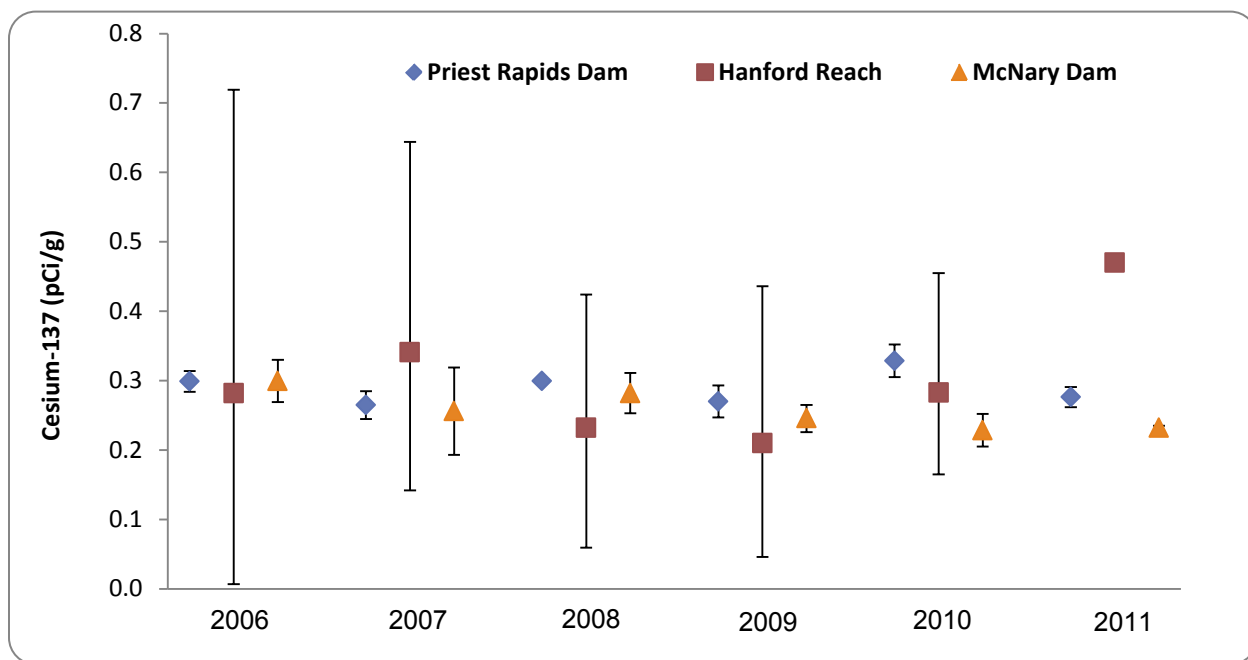
Radionuclides consistently detected in river sediment adjacent to and downstream of the Hanford Site during 2011 included beryllium-7, potassium-40, cesium-137, uranium-234, uranium-235, uranium-238, plutonium-239/240, and decay products from naturally occurring radionuclides. The concentrations of all other radionuclides, including strontium-90, were below the reported minimum detectable concentrations for most samples. Cesium-137 and plutonium isotopes exist in worldwide fallout as well as in effluent from Hanford Site facilities. Beryllium-7, potassium-40, and uranium isotopes occur naturally in the environment, and uranium isotopes are also present in Hanford Site effluent. No federal or state freshwater sediment criteria are available to assess the sediment quality of the Columbia River ([EPA 822-R-96-001](#)). Uranium concentrations were slightly elevated at the White Bluffs Slough and McNary Dam locations as compared to values measured in 2006 through 2010. Other radionuclide concentrations reported in river sediment during 2011 were similar to those reported for previous years, with the exception of cesium-137 (Appendix D), and there were no obvious differences between locations. The 2011 values for cesium-137 at the White Bluffs Slough were slightly elevated compared to Priest Rapids Dam but lower than elevated values measured in 2004 through 2007. Previous studies of soils from the White Bluffs Slough detected elevated concentrations of cesium-137. Average, maximum, and minimum concentrations of selected radionuclides measured in Columbia River sediment (2006 through 2011) are presented in Figures 7.11, 7.12 and 7.13.

### 7.3.3 Chemical Results

Detectable amounts of most metals were found in all river sediment samples (Figure 7.14). Maximum and average concentrations of most metals were higher for sediment collected in the reservoir upstream of Priest Rapids Dam than in sediment from either the Hanford Reach or McNary Dam. The concentrations of cadmium, copper, nickel, and zinc differed the most between locations, which may be associated with upstream mining activities. Currently, there are no Washington State freshwater sediment quality criteria to compare with the measured values.

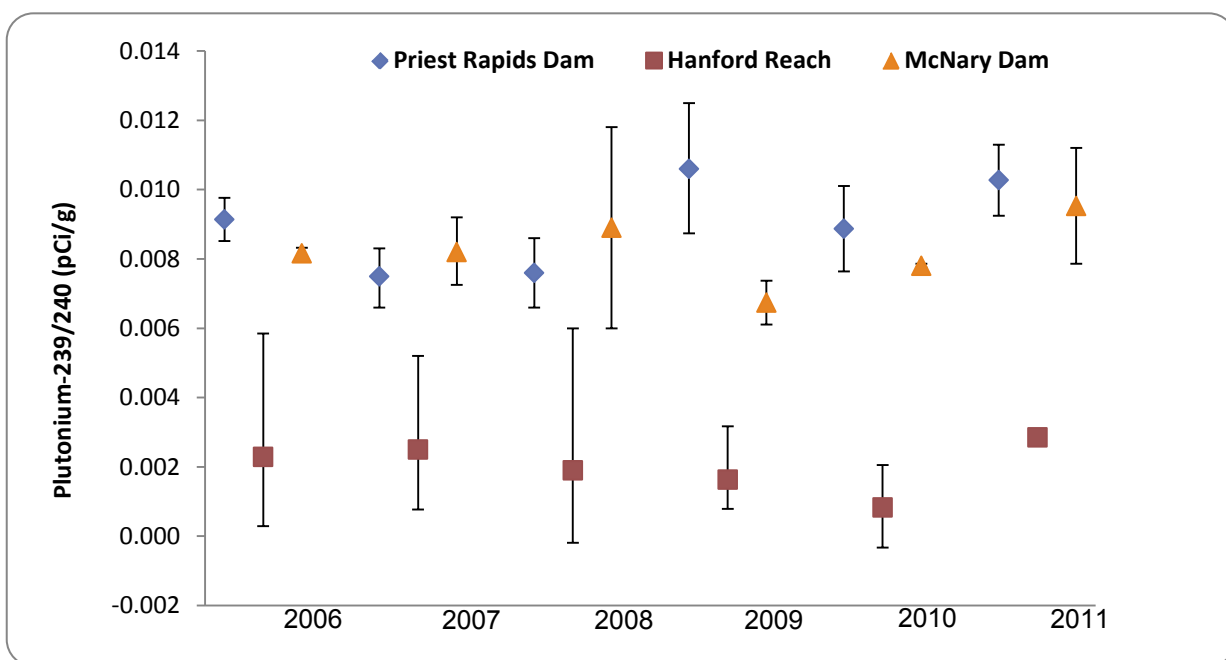
**Figure 7.11. Cesium-137 Average, Maximum, and Minimum Concentrations Measured in Columbia River Sediment (2006 through 2011)**

*(Upper and lower bars represent maximum and minimum values; these values may be similar to the average and may not be visible in the Figure.)*



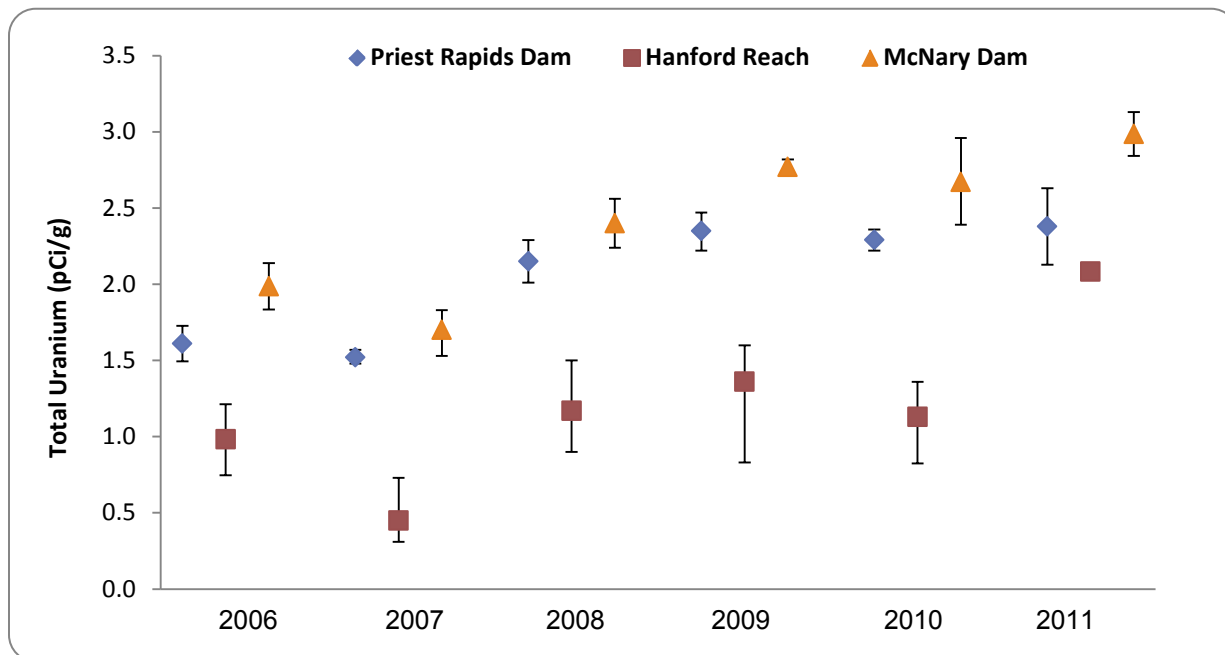
**Figure 7.12. Plutonium 239/240 Average, Maximum, and Minimum Concentrations Measured in Columbia River Sediment (2006 through 2011)**

*(Upper and lower bars represent maximum and minimum values; these values may be similar to the average and may not be visible in the Figure.)*



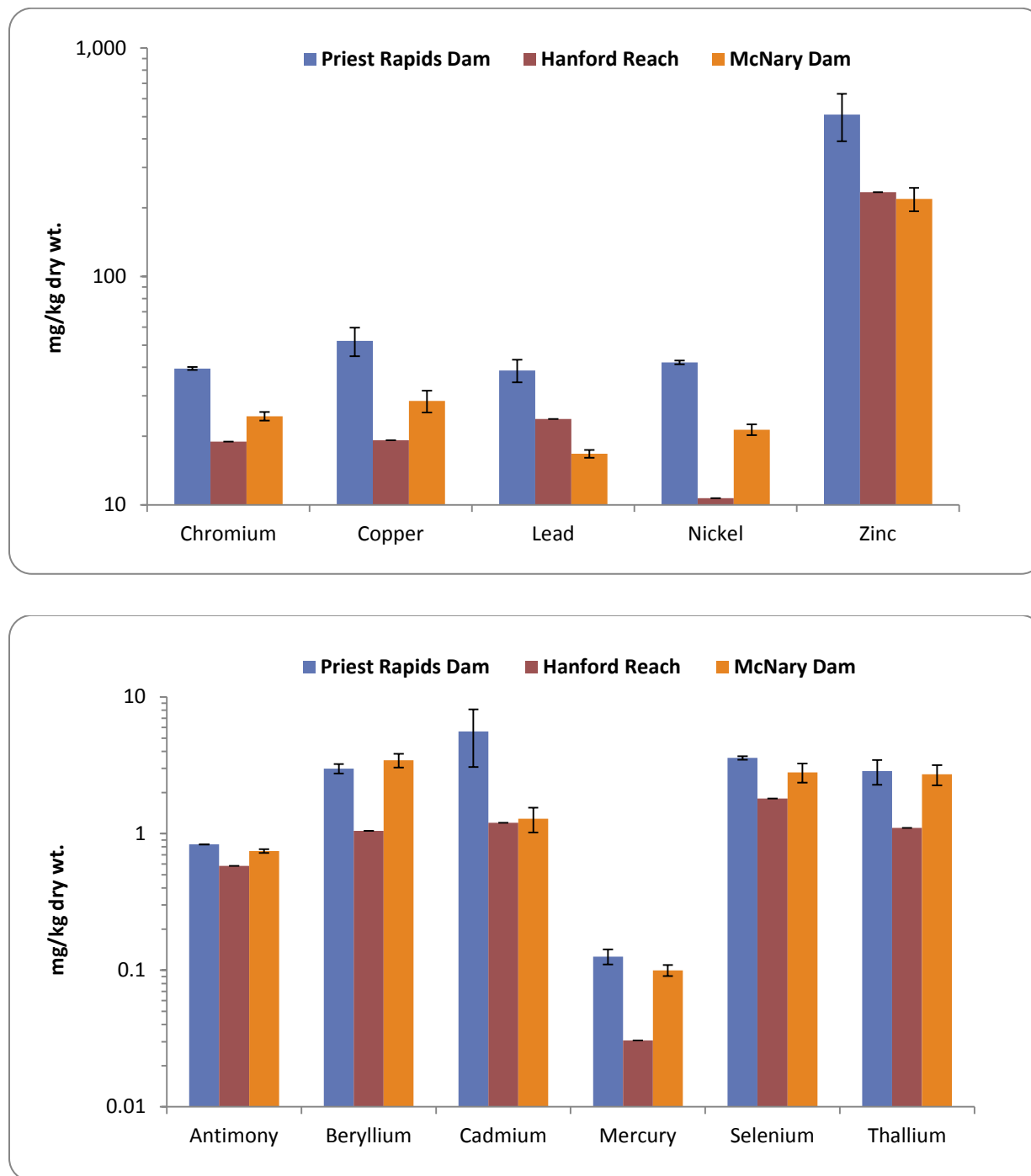
**Figure 7.13. Uranium Average, Maximum, and Minimum Concentrations Measured in Columbia River Sediment (2006 through 2011)**

*(Upper and lower bars represent maximum and minimum values; these values may be similar to the average and may not be visible in the Figure.)*



**Figure 7.14. Selected Metals Average, Maximum, and Minimum Concentrations Measured in Columbia River Sediment (Washington and Oregon, 2011)**

*(Upper and lower bars represent maximum and minimum values; these values may be similar to the average and may not be visible in the Figure.)*



## 7.4 Columbia River Riverbank

*ZL Simmons*

Samples of Columbia River riverbank seep water and associated sediment were collected along the Hanford Reach (Figure 7.3) and analyzed to determine the potential impact of radiological and chemical contaminants from the Hanford Site on the public and the aquatic environment.

### 7.4.1 Seep Water Monitoring

The Columbia River is the discharge area for the unconfined aquifer underlying the Hanford Site. Groundwater provides a means for transporting Hanford Site-associated contaminants that have leached into groundwater from past waste disposal practices to the Columbia River ([DOE/RL-92-12](#), Rev. 1; [PNL-5289](#); [PNL-7500](#); [WHC-SD-EN-TI-006](#)). Contaminated groundwater enters the Columbia River via surface and subsurface discharge. Discharge zones, located above the water level of the river, are identified in this report as riverbank seeps. Routine monitoring of riverbank seeps offers the opportunity to characterize the quality of groundwater being discharged to the river and assess the potential human and ecological risk associated with the seep water. In addition, contaminants in groundwater near the Columbia River are monitored using shoreline groundwater-sampling tubes (aquifer tubes) ([Section 7.5](#); [BHL-01153](#), Rev. 0; [PNNL 14444](#); [PNNL-16805](#); [PNNL-16894](#); [SGW-41497](#), Rev. 0).

Riverbank Seeps were documented along the Hanford Reach long before Hanford Site operations began during World War II (Jenkins 1922). During the early 1980s, researchers walked a 41-mile (66-kilometer) stretch of the Benton County shoreline of the Hanford Reach and identified 115 springs ([PNL-5289](#)). These researchers reported that the predominant areas of riverbank springs at that time were in the vicinity of the 100-N Area, Hanford town site, and the 300 Area. In recent years, it has become increasingly difficult to locate riverbank seeps in the 100-N Area. Declining water table elevations, a consequence of the end of N Reactor operations, have reduced discharge from the 100-N Area springs.

The presence of riverbank seeps also varies with river stage (river-water surface elevation). The water table near the Hanford Reach is strongly influenced by river-stage fluctuations. The river stage in the Hanford Reach is controlled by upriver conditions and operations at upriver dams. As river water levels fluctuate, groundwater levels change, which causes the presence of riverbank seeps in the Hanford Reach to vary. At the 300 Area, the river stage is also influenced by the elevation of the McNary Dam pool. Columbia River water moves into the Hanford Site aquifer as the river stage rises (bank storage) and then discharges from the aquifer in the form of riverbank seeps as the river stage falls. Following an extended period of low river flow, groundwater discharge zones above the water level of the river may cease to exist when the level of the aquifer comes into equilibrium with the river level. Thus, springs are most readily identified immediately following a decline in river stage.

Bank storage of river water affects the contaminant concentration of the seeps. Riverbank seep water discharged immediately following a river stage decline generally consists of river water or a mixture of river water and groundwater. The percentage of groundwater in the spring water discharge increases over time following a drop in river stage. Measuring the specific conductance of the seep water discharge provides an indicator of the extent of bank storage because Hanford Site groundwater has a higher specific conductance than Columbia River water.

The effect of bank storage on groundwater discharges and contaminant concentration variations in aquifer thickness, porosity, and plume concentrations makes it difficult to accurately estimate the volume of

contaminated groundwater discharging via springs to the Columbia River within the Hanford Reach. Studies of riverbank seeps conducted during 1983 ([PNL-5289](#)), 1988 ([PNL-7500](#)), and 1991 ([DOE/RL-92-12](#), Rev. 1; [WHC-EP-0609](#)) and results of near-shore studies in 1997 ([PNNL-11933](#)) and 2001 (PNNL-13692) noted that discharges from the springs had only localized effects on Columbia River contaminant concentrations.

#### 7.4.1.1 Monitoring Results

Routine monitoring of selected riverbank seeps was initiated during 1988. Currently, riverbank seep water samples are collected for contaminant monitoring and to support groundwater operable unit investigations ([DOE/RL-91-50](#)). Tables 7.5 and 7.6 summarize the sampling locations and frequencies, as well as sample types and analyses included in riverbank seeps monitoring during 2011. This section describes the monitoring efforts and summarizes the results for these aquatic environments. Detailed analytical results are available upon request (see Preface for contact information). Analytes of interest for samples from riverbank seeps were selected based on findings of previous investigations, reviews of contaminant concentrations observed in nearby groundwater monitoring wells, and results of preliminary risk assessments. Sampling is conducted annually when river flows are low, typically in early fall.

All samples collected during 2011 were analyzed for gamma-emitting radionuclides, gross alpha, gross beta, tritium, strontium-90, metals, mercury, and anions. Samples from selected springs were analyzed for technetium-99, uranium-234, uranium-235, uranium-238, and volatile organic compounds. Only unfiltered samples were analyzed, except for metals analyses, in which case both filtered and unfiltered samples were analyzed (Table 7.5).

**Table 7.5 Columbia River Riverbank Seep Water Monitoring (2011)**

Spring Location <sup>(a)</sup>	Sample Type	Sampling Frequency	Analyses
100-B Area	Grab	Annually	Alpha, beta, tritium, strontium-90, technetium-99, gamma energy analysis, metals (filtered and unfiltered), anions, mercury, VOA <sup>(b)</sup>
100-K Area	Grab	Annually	Alpha, beta, tritium, strontium-90, gamma energy analysis, metals (filtered and unfiltered), anions, mercury, VOA <sup>(b)</sup>
100-N Area	Grab	Annually	Alpha, beta, tritium, strontium-90, gamma energy analysis, metals (filtered and unfiltered), anions, mercury
100-D Area	Grab	Annually	Alpha, beta, tritium, strontium-90, gamma energy analysis, metals (filtered and unfiltered), anions, mercury
100-H Area	Grab	Annually	Alpha, beta, tritium, strontium-90, technetium-99, isotopic uranium, <sup>(c)</sup> gamma energy analysis, metals (filtered and unfiltered), anions, mercury

(a) Refer to Figure 7.8.

(b) VOA = Volatile organic compounds analyses.

(c) Isotopic uranium-234, uranium-235, and uranium-238 analyzed by alpha spectrometry (alpha energy analysis).

**Table 7.6 Hanford Reach Riverbank Seeps Sediment Monitoring (2011)**

Spring Location <sup>(a)</sup>	Sampling Frequency	Analyses
100-B Area	Annually	Gamma energy analysis, strontium-90 isotopic uranium, <sup>(b)</sup> metals, mercury
100-K Area	Annually	Gamma energy analysis, strontium-90, isotopic uranium, <sup>(b)</sup> metals, mercury
100-H Area	Annually	Gamma energy analysis, strontium-90, isotopic uranium, <sup>(b)</sup> metals, mercury

(a) Refer to Figure 7.8.

(b) Isotopic uranium (uranium-234, uranium-235, and uranium-238) analyzed by alpha spectrometry (alpha energy analysis).

#### 7.4.1.2 Radiological Results

Contaminants of Hanford Site origin continued to be detected in 2011 in water from riverbank seeps entering the Columbia River along the Hanford Site. Gross alpha, gross beta, tritium, strontium-90, technetium-99, and total uranium (uranium-234, uranium-235, and uranium-238) were detected in spring water. All radiological contaminant concentrations measured in riverbank seeps during 2011 were less than applicable DOE-derived concentration guides, but exceeded the Washington State ambient water quality criteria for gross alpha at some locations for tritium ([DOE O 5400.5](#), Chg 2; Appendix D, Table D.2).

Gross beta concentrations in riverbank seep water at locations in the 100 Areas were elevated in 2011 compared to gross beta concentrations in Columbia River water at Priest Rapids Dam, but were below the Washington State ambient water quality criterion. The highest gross beta concentration measured in riverbank seeps was at 100-K Area ( $9 \pm 3.1$  pCi/L [ $0.333 \pm 0.061$  Bq/L]), which was 18 percent of the Washington State ambient surface water quality criterion of 50 pCi/L (1.85 Bq/L) (WAC 173-201A; 40 CFR 141).

Tritium concentrations varied widely with location. The highest tritium concentration measured in riverbank seeps was at 100-D Area ( $1840 \pm 415$  pCi/L [ $68 \pm 9.8$  Bq/L]), which was 9 percent of the Washington State ambient surface water quality criterion of 20,000 pCi/L (740 Bq/L) (WAC 173-201A; 40 CFR 141). Tritium concentrations in most riverbank seep water samples were elevated compared to the 2011 Columbia River water concentrations at Priest Rapids Dam.

All water samples from riverbank seeps were analyzed in 2011 for strontium-90. The highest strontium-90 concentration detected in shoreline spring water in 2011 was at the 100-B Area ( $0.0301 \pm 0.0282$  pCi/L [ $0.001 \pm 0.001$  Bq/L]), followed by  $0.0227 \pm 0.0353$  pCi/L ( $0.0008 \pm 0.001$  Bq/L) at the 100-N Area. These values were well below the Washington State ambient surface water quality criterion of 8 pCi/L (0.30 Bq/L). Groundwater at the 100-N Area historically has had the highest strontium-90 concentrations. However, since 1997 no visible riverbank seeps have been observed along the 100-N Area shoreline where strontium-90 concentrations in groundwater have been most elevated.

Water samples from riverbank seeps in the 100-B Area and 100-H Area were analyzed for technetium-99. All results for technetium-99 were below the EPA drinking water standard of 900 pCi/L (33 Bq/L) (Appendix D). The highest technetium-99 concentration was found in shoreline spring water from the 100-B Area ( $2.37 \pm 0.898$  pCi/L [ $0.088 \pm 0.033$  Bq/L]).

Water samples from riverbank seeps at the Hanford town site and the 300 Area were collected in 2005 and submitted to a laboratory for iodine-129 analyses using a method capable of detecting extremely low concentrations. However, since 2005, the unique instrument used for this assay has not been operational, and an alternative for this ultra-trace measurement capability is not available. The highest concentrations were



measured in water samples from the Hanford town site seeps in 2005, with all values below the Washington State surface water quality criterion of 1 pCi/L (0.037 Bq/L) (Appendix D). Riverbank seep water samples were analyzed for iodine-129 in 2007 to 2010 with traditional gamma spectrometry, which has a higher detection limit than the ultra-trace method. All samples analyzed for iodine-129 in 2007 to 2010 were below the detection limit of 1 pCi/L (0.037 Bq/L).

Uranium was monitored in riverbank seep water samples in 2011 from the 100-H Area. The riverbank seep in the 300 Area that has been reported in previous years to have elevated gross alpha, gross beta, and uranium concentrations had no observed flow during multiple attempts in 2011 to collect the sample. The highest total uranium level was found to be  $5 \pm 1$  pCi/L [ $0.185 \pm 0.037$  Bq/L or approximately  $7 \pm 1.5$  µg/L, which was collected at 100-H Spring 145-1. The total uranium concentration in this spring was below the EPA drinking water standard of 30 µg/L (approximately 20 pCi/L [ $0.74$  Bq/L]).

#### 7.4.1.3 Chemical Results

Chemical contaminants originating from the Hanford Site continued to be detected in water from riverbank seeps entering the Columbia River. Metals and anions of interest (chloride, nitrate, and sulfate) were detected in seep water. Concentrations of volatile organic compounds were near or below the analytical laboratory's required detection limits in all samples. Trace amounts of trichloroethene—a chlorinated organic compound—were detected for Spring 38-3 in the 100-B Area. Trichloroethene has been consistently detected at trace concentrations in 300 Area shoreline spring water, which is a result of contaminated groundwater in the shallowest part of the unconfined aquifer near the Columbia River. Relatively high concentrations recently discovered at depth in the unconfined aquifer, which greatly exceeded regulatory standards ([PNNL-16435](#)), were not observed in the riverbank seeps.

Table 7.7 presents concentration ranges of selected chemicals measured in riverbank seep water during 2006 through 2011. For most locations, the 2011 chemical sample results were similar to those previously reported ([PNNL-14687](#)). Nitrate concentrations for 2006 through 2011 were highest in seep water samples from the 100-F Area. Dissolved chromium concentrations in riverbank seeps for 2006 through 2011 were highest in the 100-K Area. Hanford Site groundwater monitoring results for 2011 indicated similar contaminant concentrations at shoreline areas near the discharge locations for the springs ([Section 8.0](#), Groundwater Monitoring).

The Washington State ambient surface water quality criteria for cadmium, copper, lead, nickel, silver, and zinc are total-hardness dependent (WAC 173-201A; Appendix D). For comparison purposes, riverbank seep water criteria were calculated using the same 47-mg/L calcium carbonate hardness listed in Appendix D. Concentrations of most metals measured in water collected from seeps along the Hanford Site shoreline during 2006 through 2011 were below Washington State ambient surface water chronic toxicity levels (WAC 173-201A). However, for 2006 through 2011, the maximum concentrations of dissolved chromium in riverbank seep water from the 100-B, 100-K, 100-D, and 100-H Areas were above the Washington State ambient surface water chronic and acute toxicity levels; concentrations from the 100-N Area were above the Washington State ambient surface water chronic toxicity levels only (Appendix D, standards). Dissolved chromium was at or above the Washington State ambient surface water level in 2011 for chronic and acute toxicity levels at the 100-B, 100-D, and 100-K Areas. The riverbank seep in the 100-D Area, which is adjacent to the location with the highest chromium concentrations in near-shore groundwater, had no observed flow during multiple attempts in 2011 to collect the sample. Arsenic concentrations in riverbank seep water were well below the Washington State ambient surface water chronic toxicity level, but concentrations in all

samples (including upriver Columbia River water samples) exceeded the EPA limit for the protection of human health for the consumption of water and organisms. Nevertheless, this EPA value is more than 10,500 times lower than the Washington State chronic toxicity standard (40 CFR 141; Appendix D). Nitrate concentrations at all riverbank seep locations were below the drinking water standard (Appendix D).

### 7.4.2 Sediment Monitoring

Beginning in the 1990s, periodic studies were conducted to collect and analyze sediment from riverbank seeps in the 100 Areas and the 300 Area (DOE/RL-92-12, Rev. 1; WHC-EP-0609; WHC-SD-EN-TI-125, Rev. 0; WHC-SD-EN-TI-198). Routine sampling of sediment from riverbank seeps began during 1993 at the Hanford town site and the 300 Area. Sampling of riverbank seeps sediment in the 100-B, 100-K, and 100-F Areas began during 1995 and in 2004 in the 100-H Area. Substrates at the riverbank seeps in the 100-N and 100-D Areas consist predominantly of large cobble, which is unsuitable for sampling. Sediment samples were collected in 2011 at riverbank seeps in the 100-B, 100-H, and 100-K Areas.

**Table 7.7. Columbia River Riverbank Seeps Concentration Ranges for Selected Chemicals in Water Monitoring Samples, Hanford Site (2006 through 2011)**

Ambient-Water Quality Criterion						
Level <sup>(a)</sup>		100-BC Area	100-K Area	100-N Area	100-D Area	100-H Area
<b>Dissolved Metals (µg/L)</b>						
<b>Number of Samples</b>		<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>
Antimony <sup>(b)</sup>	NA	3.5	3.5	3.5	3.5	3.5
Arsenic	190	5 <sup>(b)</sup>	6.2 - 7.1	6.5 - 7.6	7.2 - 7.4	5.0 - 5.5
Cadmium <sup>(b)</sup>	0.59	1.0	1.0	1.0	1.0	1.0
Chromium	10	4.9 - 24.2	31.4 - 31.9	1 - 3.5	22.4 - 23.2	5.7 - 5.8
Copper	6.0	3.0 - 7.7	3.0 - 3.84	3.0 - 3.8	3.0 <sup>(b)</sup>	3.0 <sup>(b)</sup>
Lead	1.1	3.3 - 3.6	3.3 <sup>(b)</sup>	3.3 <sup>(b)</sup>	3.3 <sup>(b)</sup>	3.3 <sup>(b)</sup>
Nickel	83	1.5 - 7.9	1.5 <sup>(b)</sup>	1.5 - 2.5	1.5 - 1.8	1.5 <sup>(b)</sup>
Silver <sup>(b)</sup>	0.94 <sup>(c)</sup>	1.0	1.0	1.0	1.0	1.0
Thallium <sup>(b)</sup>	NA	5.0	5.0	5.0	5.0	5.0
Zinc	55	6.6 - 35.1	3.3 - 6.8	3.3 - 20.4	3.3 - 10.7	3.3 <sup>(b)</sup>
<b>Total Recoverable Metals (µg/L)</b>						
<b>Number of Samples</b>		<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>
Chromium	96	4.9 - 24.2	31.4 - 31.9	1.0 - 3.5	22.4 - 23.2	5.7 - 5.8
Mercury <sup>(b)</sup>	0.012	0.066	0.066	0.066	0.066	0.066
Selenium	5.0	6.0 <sup>(b)</sup>	6.0 <sup>(b)</sup>	6.0 <sup>(b)</sup>	6.0 - 6.51	6.0 <sup>(b)</sup>
<b>Anions (mg/L)</b>						
<b>Number of Samples</b>		<b>1</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>1</b>
Nitrate <sup>(d)</sup>	10	3.3	3.3 - 10.5	2.4	13.8	3.8

(a) Ambient water quality criteria values (WAC 173-201A-240) for chronic toxicity unless otherwise noted.

(b) Not detected at laboratory reporting limit.

(c) Value for acute toxicity; chronic value not available.

(d) Nitrate as NO<sub>3</sub><sup>-</sup> ion. Drinking water standard (WAC 246-290).

NA = Not available.

### 7.4.2.1 Radiological Results

Results for 2011 riverbank seep sediment samples were similar to those observed for previous years. Potassium-40, cesium-137, and uranium isotopes were the only radionuclides reported above the minimum detectable concentrations. Radionuclide concentrations in riverbank seep sediment in 2011 were similar to those observed in Columbia River sediment.

### 7.4.2.2 Chemical Results

Concentrations of metals in riverbank seep sediment samples collected in 2011 were similar to concentrations in Hanford Reach Columbia River sediment samples. Lead, mercury, cadmium and arsenic concentrations in riverbank seep sediment were slightly elevated at the 100-H Area, and chromium levels were slightly elevated at the 100-B Area. Currently, there are no Washington State freshwater sediment quality criteria to compare with the measured values.

## 7.5 Pond Water and Sediment

### *Z. Simmons*

Two onsite ponds, West Lake and the Fast Flux Test Facility Pond (Figure 7.3), located near facilities in various stages of remediation, were sampled periodically during 2011. The ponds are accessible to migratory waterfowl, deer, and other wildlife, creating a potential biological pathway for the dispersion of contaminants. The Fast Flux Test Facility Pond is a disposal site for process water, primarily cooling water drawn from 400 Area groundwater wells. West Lake, the only naturally occurring pond on the site, is located north of the 200-East Area ([ARH-CD-775](#)). West Lake has not received direct effluent discharges from Hanford Site facilities, but it is influenced by precipitation and changing water table elevations that are related to the discharge of water to the ground in the 200 Areas. The water level in West Lake fluctuates, and the lake changes from standing water in winter and spring to dry or nearly dry in summer and fall.

### 7.5.1 Monitoring Results

Grab samples were collected quarterly in 2011 from the Fast Flux Test Facility Pond (water) and from West Lake [water (3 collections) and biannual sediment]. All water samples were analyzed for tritium. Water samples from the Fast Flux Test Facility Pond were analyzed for gross alpha and gross beta concentrations as well as gamma-emitting radionuclides. The groundwater table in the 200-East Area has dropped in recent years ([Section 8.0](#), Groundwater Monitoring), decreasing the size of West Lake and causing the suspended sediment loading to increase. Since 2002, West Lake water samples have not been analyzed for gross alpha, gross beta, strontium-90, technetium-99, uranium-234, uranium-235, and uranium-238 because of the high sediment load. A special study conducted in 2000 ([PNNL-13487](#)) indicated that uranium is present in a soluble form in West Lake water. As a result, analysis of West Lake water samples for uranium-234, uranium-235, and uranium-238 was resumed in 2011. West Lake sediment samples were analyzed for gross alpha, gross beta, strontium-90, technetium-99, uranium-234, uranium-235, uranium-238, and gamma-emitting radionuclides. Radionuclides were chosen for analysis based on their presence in local groundwater and their potential to contribute to the overall radiation dose to biota that frequent the ponds.

### 7.5.2 Radiological Results

With the exceptions of uranium-234 and uranium-238 concentrations in samples from West Lake, radionuclide concentrations in onsite pond water samples were less than applicable DOE-derived concentration guides (DOE O 5400.5, Chg 2; Appendix D) and Washington State ambient surface-water quality criteria (WAC 173-201A; 40 CFR 141; Appendix D).

Figure 7.15 shows the annual average gross beta and tritium concentrations in Fast Flux Test Facility Pond water from 2006 through 2011. Average levels of both constituents decreased in 2011 as compared to 2010. The average tritium concentration in Fast Flux Test Facility Pond water during 2011 was 8 percent of the Washington State ambient surface-water quality criterion of 20,000 pCi/L (740 Bq/L). The sources of contaminants in the pond water are groundwater contaminant plumes from the 200 Areas that have migrated to wells in the 400 Area that supply water to facility operations.

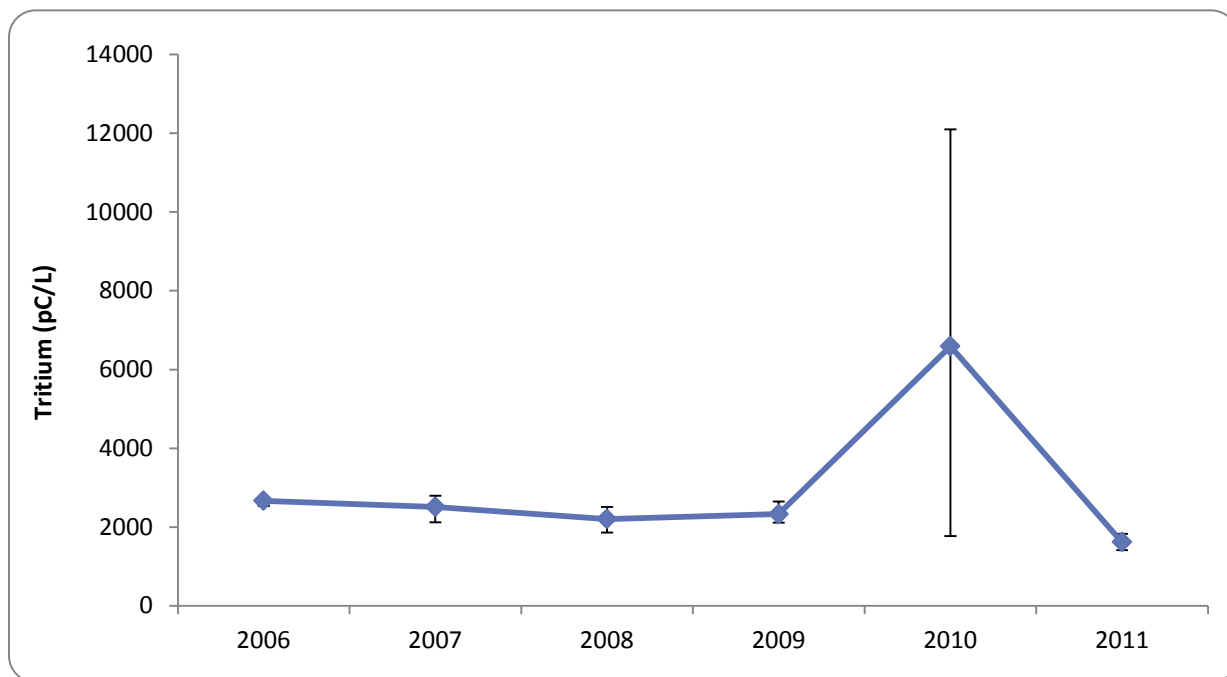
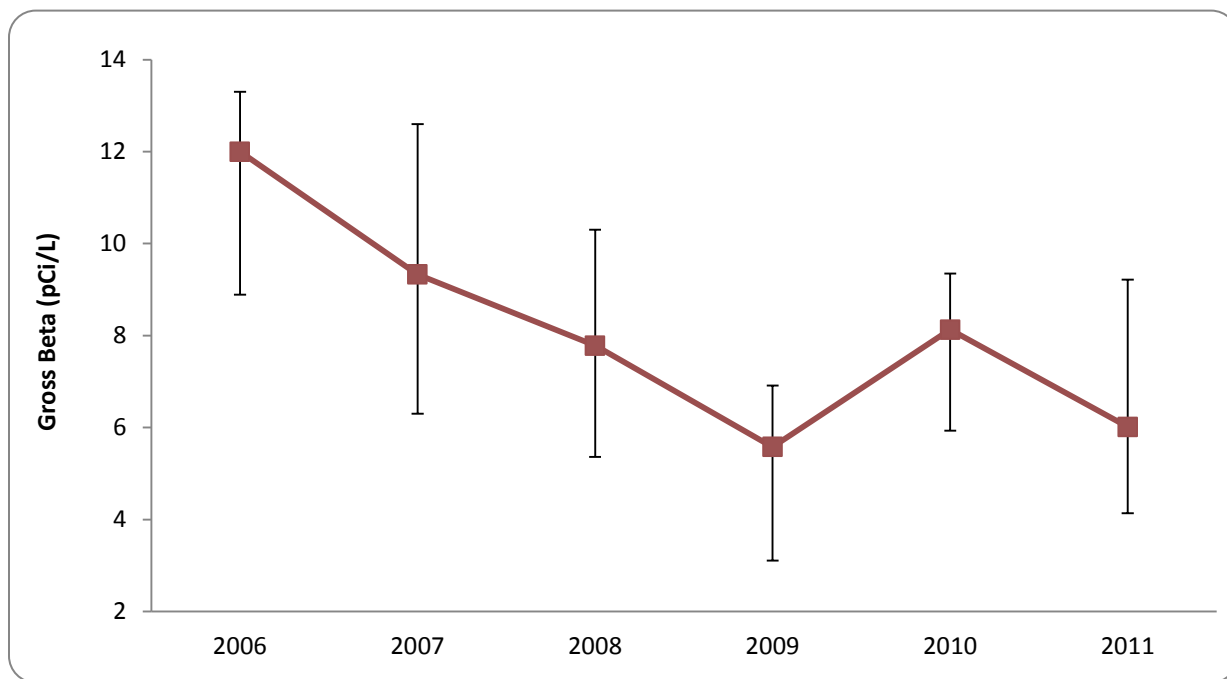
Tritium concentrations in West Lake water in 2011 were similar to those observed in the past and were below the laboratory-reported detection limit. Figure 7.16 shows the annual average total uranium concentrations in West Lake Pond water from 2006 through 2011.

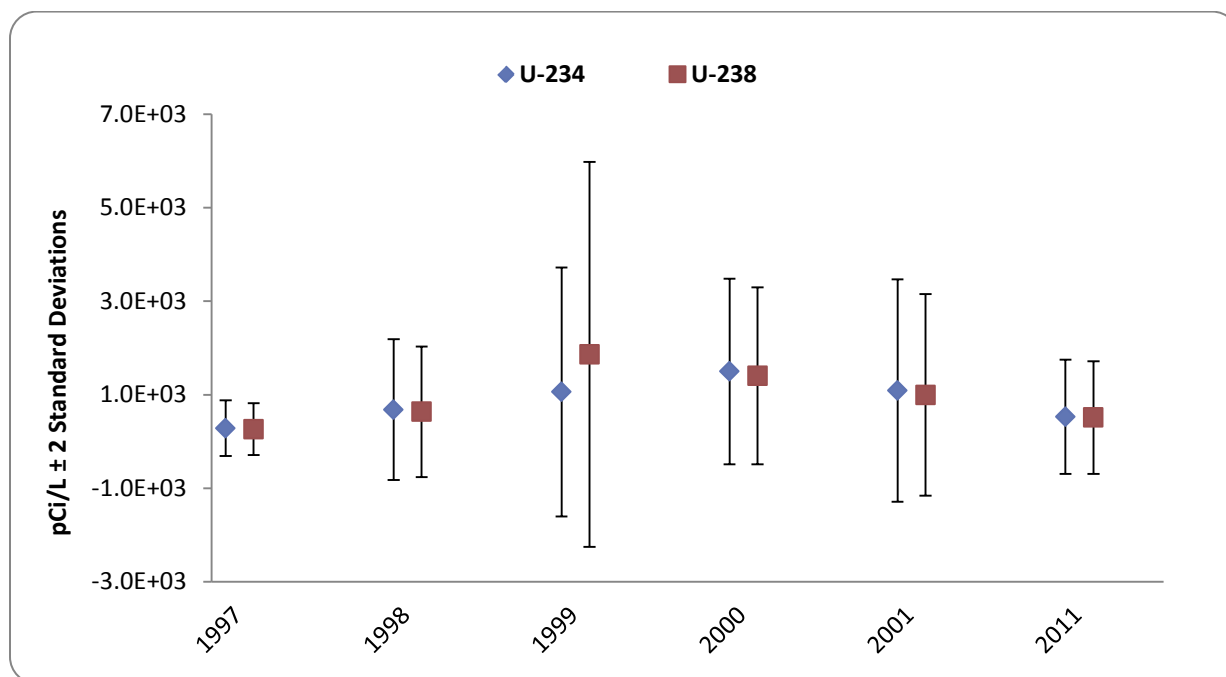
Samples of West Lake upper-layer sediment in 2011 had the following values:

- Gross alpha— $10.4 \pm 2.57$  pCi/g ( $0.39 \pm 0.09$  Bq/g)
- Gross beta— $27.4 \pm 3.0$  pCi/g ( $1.01 \pm 0.11$  Bq/g)
- Potassium-40— $17 \pm 1.9$  pCi/g ( $0.63 \pm 0.069$  Bq/g)
- Strontium-90— $0.27 \pm 0.068$  pCi/g ( $0.010 \pm 0.0025$  Bq/g)
- Cesium-137— $0.96 \pm 0.09$  pCi/g ( $0.036 \pm 0.0034$  Bq/g)
- Uranium-234— $2.1 \pm 0.41$  pCi/g ( $0.0788 \pm 0.0152$  Bq/g)
- Uranium-235— $0.126 \pm 0.063$  pCi/g ( $0.0047 \pm 0.00232$  Bq/g)
- Uranium-238— $2.0 \pm 0.39$  pCi/g ( $0.075 \pm 0.0146$  Bq/g).

West Lake sediment samples were collected with a hand-scoop near the shoreline as grab samples of upper-layer material. Radionuclide levels in West Lake surface sediments are similar to previous measurements reported. Uranium concentrations are most likely from naturally occurring uranium in the surrounding soil ([BNWL-1979](#)).

**Figure 7.15. Gross Beta and Tritium Average, Maximum, and Minimum Concentrations in Water Samples from the Fast Flux Test Facility Pond, 2006 through 2011**



**Figure 7.16. Average Uranium Concentrations in Water Samples from West Lake at the Hanford Site (1997 through 2011)**

## 7.6 Offsite Irrigation Water

*M. Hoefer*

As a result of public concern about the potential for Hanford Site-associated contaminants in offsite water, sampling was conducted in 2011 to document the levels of radionuclides in water used by the public. The consumption of vegetation irrigated with Columbia River water downstream of the site has been identified as one of the primary pathways contributing to the potential dose to the hypothetical, maximally exposed individual and any other member of the public ([Section 4.2.1](#)).

**Offsite Irrigation Water Monitoring.** Water samples were collected in 2011 from an irrigation canal located east of the Columbia River and downstream from the Hanford Site at Riverview. Samples of the water supply from the Horn Rapids irrigation pumping station (Figure 7.3) were collected from the irrigation valve at the Battelle sporting complex. Each location was sampled three times during the 2011 irrigation season. Unfiltered samples were analyzed for gross alpha, gross beta, gamma emitters, tritium, strontium-90, uranium-234, uranium-235, and uranium-238.

**Sample Results.** Most radionuclide concentrations measured in irrigation water in 2011 were at the same levels detected in Columbia River water samples collected upstream of the Hanford Site. At the Horn Rapids irrigation pumping station, the tritium results were slightly higher than Columbia River water samples collected upstream of the Hanford Site. All radionuclide concentrations were less than their respective DOE-derived concentration guides and Washington State ambient surface-water quality criteria (DOE O 5400.5, Chg 2; WAC 173-201A; 40 CFR 141).

## 7.7 Liquid Effluent

DJ Rokkan

Liquid effluents were discharged from a few facilities in 2011 at the Hanford Site. Effluent streams are sampled for gross alpha and gross beta concentrations, as well as for concentrations of selected radionuclides and nonradioactive hazardous materials.

Contaminant data from liquid effluent sampling and analyses are reported to DOE annually in an environmental release report (e.g., HNF-EP-0527-20). The report includes summaries of monitoring results on liquid effluents discharged to the Columbia River, which are regulated by NPDES (40 CFR 122) permit and reported to EPA, and liquid effluent discharges to the soil, which are regulated by WAC 173-216 and reported to Ecology.

### 7.7.1 Radionuclide Results

Facilities in the 200 Areas discharged radioactive liquid effluent to the ground at a single location in 2011, the 616-A Crib, also known as the State-Approved Land Disposal Site. Table 7.8 summarizes this effluent discharge.

Table 7.9 summarizes the liquid effluent discharged in the 100 Areas. Generally, this effluent consists of secondary cooling water discharged from the 100-K Area to the Columbia River via the NPDES-permitted 1908-K Outfall, which permanently ceased operation in March 2011.

**Table 7.8. Radionuclides in 200 Areas Liquid Effluent Discharged to the State-Approved Land Disposal Site (2011)**

Radionuclide	Half-Life	Release, Ci <sup>(a)</sup>
Tritium	12.35 years	1.5

(a) 1 Ci =  $3.7 \times 10^{10}$  Bq.

**Table 7.9. Radionuclides in Liquid Effluent from the 100-K Area Discharged to the Columbia River (2011)**

Radionuclide	Half-Life	Release, Ci <sup>(a)</sup>
Plutonium-239/240	24,110/6,564 years	$1.1 \times 10^{-6}$

(a) 1 Ci =  $3.7 \times 10^{10}$  Bq.

### 7.7.2 Nonradioactive Hazardous Materials Results

Nonradioactive hazardous materials in liquid effluents are monitored in the 100, 200, and 400 Areas for selected nonradioactive hazardous materials. These effluents are discharged to the State-Approved Land Disposal Site and to the Columbia River; the single remaining discharge point to the Columbia permanently ceased operation in March 2011. Effluent entering the environment at designated discharge points is sampled and analyzed to determine compliance with the NPDES (40 CFR 122) and state waste discharge permits (WAC 173-216) for the Hanford Site. The release totals are immediately reported to EPA if chemicals in liquid effluents exceed quantities reportable under CERCLA. If chemicals in effluents remain stable at predicted levels, these levels may be reported annually if EPA has approved this practice. [Section 2.4.1](#) provides a brief description of the NPDES and state waste discharge permits.



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## 8.0 Groundwater Monitoring

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*MJ Hartman and KA Ivarson*

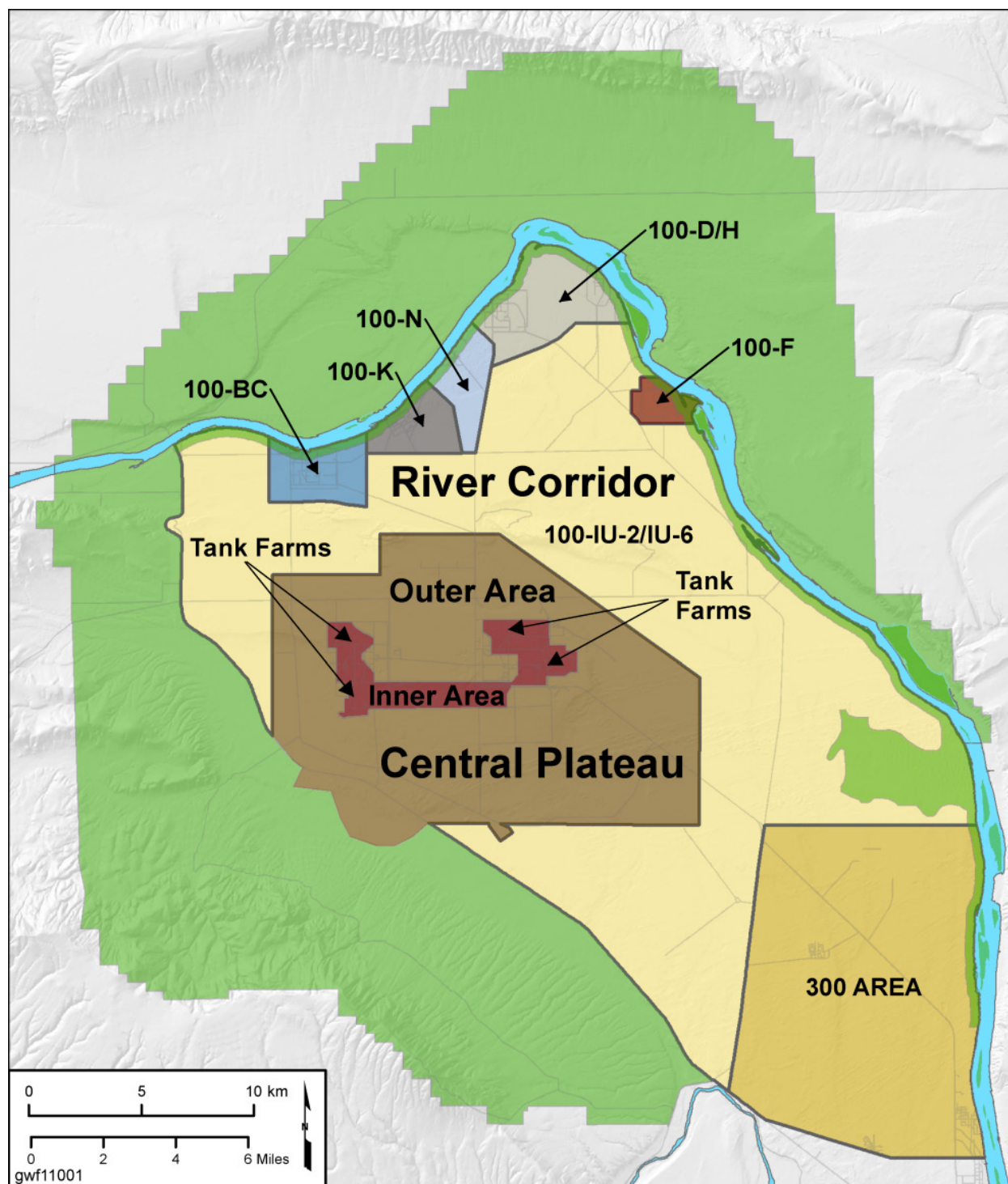
The Hanford Site, part of the DOE nuclear weapons complex, encompasses 586 square miles (1,524 square kilometers) northwest of the city of Richland along the Columbia River in southeastern Washington State. As part of the top secret Manhattan Project, the federal government took possession of the site in 1943 to build the world's first large-scale plutonium production reactor, the B Reactor. This reactor was used to make the plutonium for the Trinity Test and the bomb that was dropped on Nagasaki, Japan in 1945. During the Cold War period (1945 to 1991), the government built a total of nine reactors along the Columbia River for the production of weapons-grade plutonium.

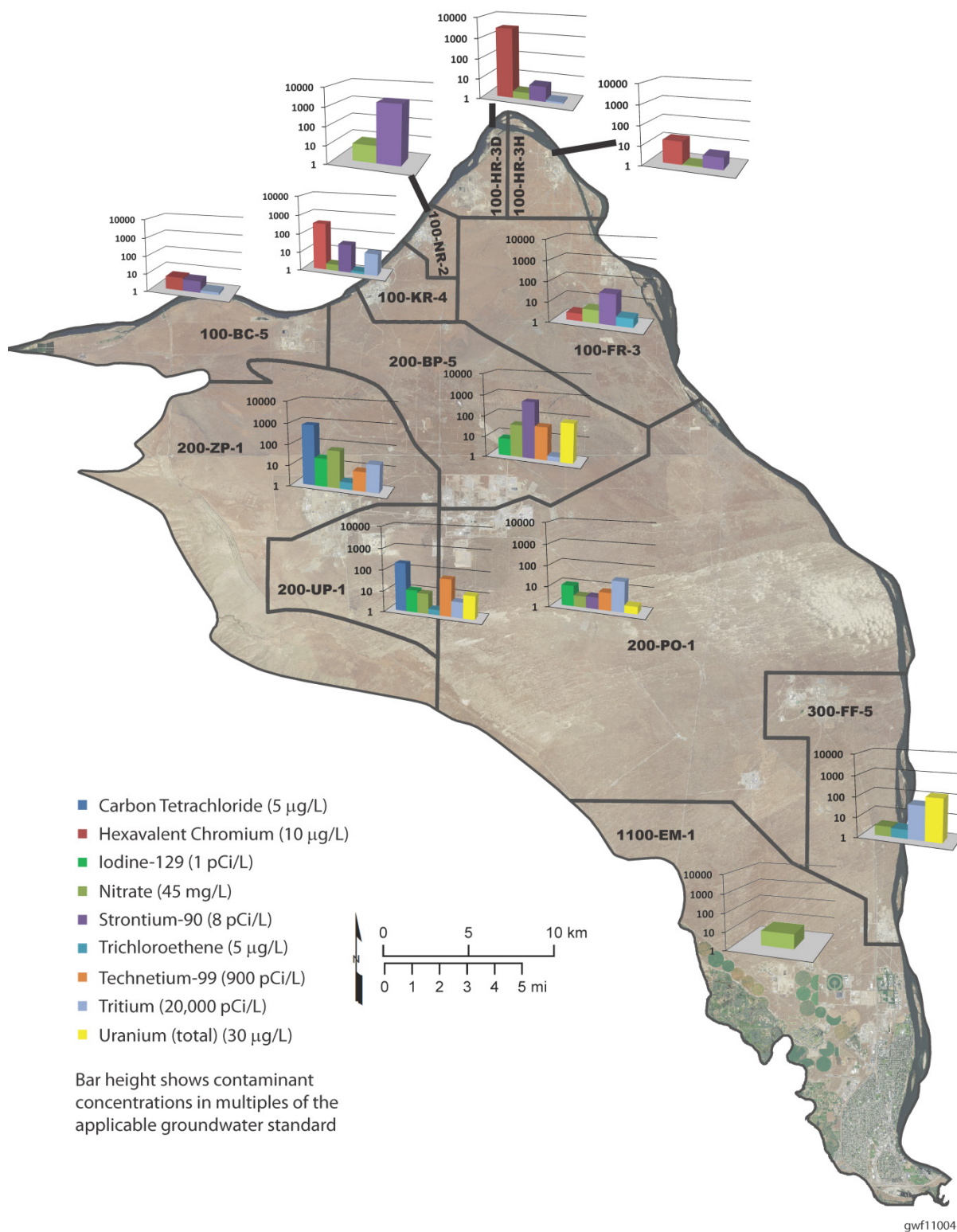
During reactor operations, chemical and radioactive waste was released into the environment and contaminated the soil and groundwater beneath portions of the Hanford Site. Groundwater flows to the Columbia River and is the primary exposure route for contaminants to reach human, environmental, and ecological receptors.

The River Corridor (Figure 8.1) includes the 100 Area, where nine nuclear reactors formerly operated, and the 300 Area, where nuclear fuel assemblies were made. The Central Plateau includes the 200 Area, where chemical processing of nuclear fuel occurred.

Figure 8.2 shows the 2011 maximum concentrations of groundwater contaminants in each groundwater interest area. The heights of the bars represent multiples of the applicable water quality standards. For example, if the maximum strontium-90 concentration was 80 pCi/L, the bar is 10 units high because the drinking water standard is 8 pCi/L.

Since the 1990s, DOE has worked to characterize, remove, treat, and dispose of contamination from past operations. DOE developed a plan to address groundwater and vadose (unsaturated) zone contamination in consultation with the EPA and Ecology. Key elements associated with managing the Hanford Site's groundwater and vadose zone contamination are to: 1) Protect the Columbia River and groundwater, 2) Develop a cleanup decision process, and 3) Achieve final cleanup.

**Figure 8.1. Hanford Site River Corridor and Central Plateau**

**Figure 8.2. Maximum Concentrations of Groundwater Contaminants in each Groundwater Interest Area (2011)**

This section describes monitoring results for RCRA TSD units, for CERCLA groundwater operable units, where no active remediation is currently taking place, and for the *Atomic Energy Act of 1954* (AEA), as required by DOE orders. This report provides a summary of vadose zone monitoring, investigations, and results, as well as well installation, remediation, and decommissioning activities. DOE publishes details on CERCLA remediation activities (e.g., pump-and-treat operations) in separate reports that are summarized and referenced in this report. The data presented in this report—and information on well locations, construction, and screened intervals—can be found through the DOE’s Environmental Dashboard Application at <http://environet.hanford.gov/EDA/>.

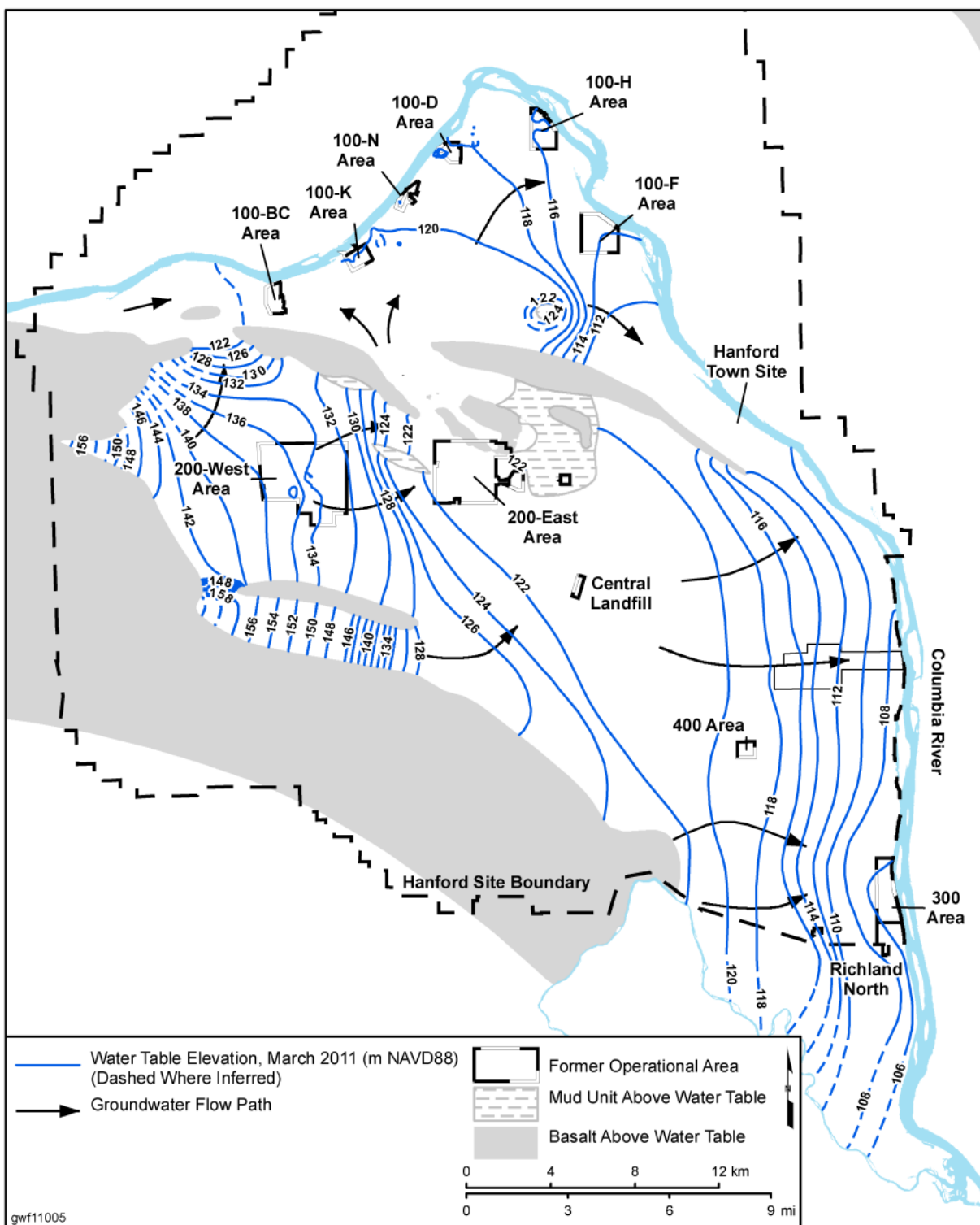
On the Hanford Site, groundwater in the unconfined aquifer flows from areas where the water table is high to where it is lower, and eventually discharges to the Columbia River (Figure 8.3). RCRA regulates the management of solid waste, hazardous waste, and certain underground storage tanks. It applies to active or recently-active TSD units. Monitoring is required at some units to determine if they are affecting groundwater quality in the uppermost aquifer. The uppermost aquifer is the unconfined aquifer beneath most of the Hanford Site. Groundwater monitoring requirements for the Hanford Site’s RCRA units fall into one of two broad categories: interim status or final status. A permitted RCRA unit requires final status monitoring, as specified in [WAC 173-303-645](#), *Dangerous Waste Regulations, Releases from Regulated Units*. The RCRA units not currently incorporated into a permit require interim status monitoring, as specified in [WAC 173-303-400](#), *Dangerous Waste Regulations, Interim Status Facility Standards* (based on 40 CFR 265, *Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities*). Although the single-shell tank farms and inactive units are listed in the Hanford Facility Part A Dangerous Waste Permit (WA7890008967), they are operated under interim status requirements until an approved operating permit for each unit is issued.

RCRA groundwater monitoring is conducted under one of three possible phases: 1) Contaminant indicator evaluation (or detection) monitoring, 2) Groundwater quality assessment (or compliance) monitoring, or 3) Corrective action monitoring. In the interim-status contaminant indicator evaluation monitoring, four indicator parameters (pH, specific conductivity, total organic carbon, and total organic halides) are monitored and evaluated against statistically derived threshold values calculated from upgradient wells. In final status detection monitoring, site-specific indicators are evaluated using statistical methods identified in the respective permit. Groundwater quality assessment (interim status) or compliance (final status) monitoring occurs when a facility appears to have impacted groundwater quality. The objective of the monitoring program shifts from detection to assessing the nature and extent of the problem. Under corrective action monitoring, Ecology has stipulated some form of groundwater remediation. The goal of a corrective action groundwater monitoring program is to determine if the corrective action is effective.

CERCLA is the federal government’s program to clean up the nation’s uncontrolled hazardous and radioactive waste sites. Cleanup decisions are based on the results of environmental investigations that include the vadose zone and groundwater. CERCLA groundwater monitoring on the Hanford Site includes monitoring of contaminants and water levels, and monitoring the effectiveness of groundwater remedial actions, such as pump-and-treat systems.

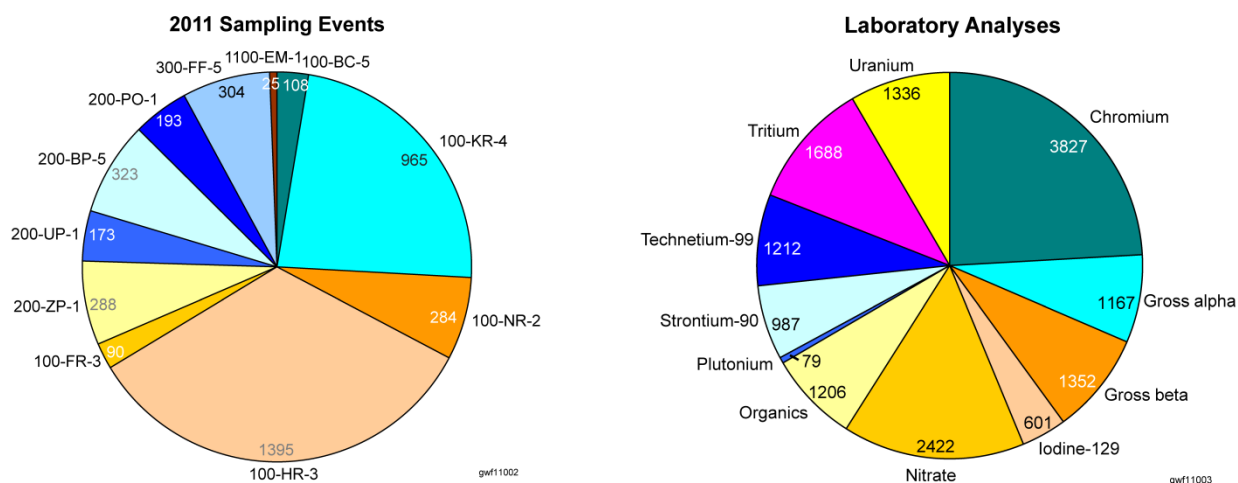
DOE orders implement requirements of the AEA at DOE sites. These requirements include groundwater monitoring to detect, characterize, and respond to releases of radionuclides. This AEA monitoring is integrated with CERCLA and RCRA monitoring on the Hanford Site.



**Figure 8.3 Hanford Site Water Table and Groundwater Flow**

DOE sampled 931 wells and 285 shoreline aquifer tubes in 2011. Many of the wells were sampled multiple times, for a total of 4,147 sampling events. Figure 8.4 shows the number of sampling events (left) and laboratory analyses run on Hanford Site groundwater samples for the most common constituents (right) in 2011.

**Figure 8.4. 2011 Sampling Events and Groundwater Analyses**



## 8.1 River Corridor

The Columbia River flows through the northern portion of the Hanford Site before turning south toward the city of Richland. The region of the Hanford Site along the shoreline is known as the River Corridor. Hanford Site groundwater flows toward the Columbia River, so groundwater is the primary exposure route for contaminants to reach human and environmental receptors. Daily, monthly, and seasonal changes in river stage, controlled by operation of Priest Rapids Dam, affect the flow of nearby groundwater. During periods of high river stage, the river temporarily recharges the adjacent aquifer, whereas during periods of low or moderate river stage, groundwater discharges from the aquifer to the river. River stage changes cause a mixing zone to occur in the aquifer near the shore.

Table 8.1 summarizes information about the River Corridor. In the 100 Area groundwater contamination is related to past disposal of waste associated with water-cooled nuclear reactors. The primary groundwater contaminants in the River Corridor are hexavalent chromium, strontium-90, nitrate, and tritium in the 100 Area, and uranium and tritium in 300-FF-5 (Figure 8.5). Other contaminants of concern in the 100 Area include carbon-14 and trichloroethene. The primary sources of hexavalent chromium contamination were the routine disposal of reactor cooling water, which contained the corrosion inhibitor sodium dichromate and unplanned spills and leaks of the high-concentration sodium dichromate stock solution.

***DOE conducted intensive field studies in the River Corridor in 2010 and 2011. Results will be used to select methods for final remediation of soil and groundwater.***

More than 60 percent the waste sites near the river have been remediated or are classified as not requiring remediation under interim records of decision. Cleanup of the remaining sites is underway. Removal of contaminated soil reduces the potential for future groundwater contamination. Groundwater remediation

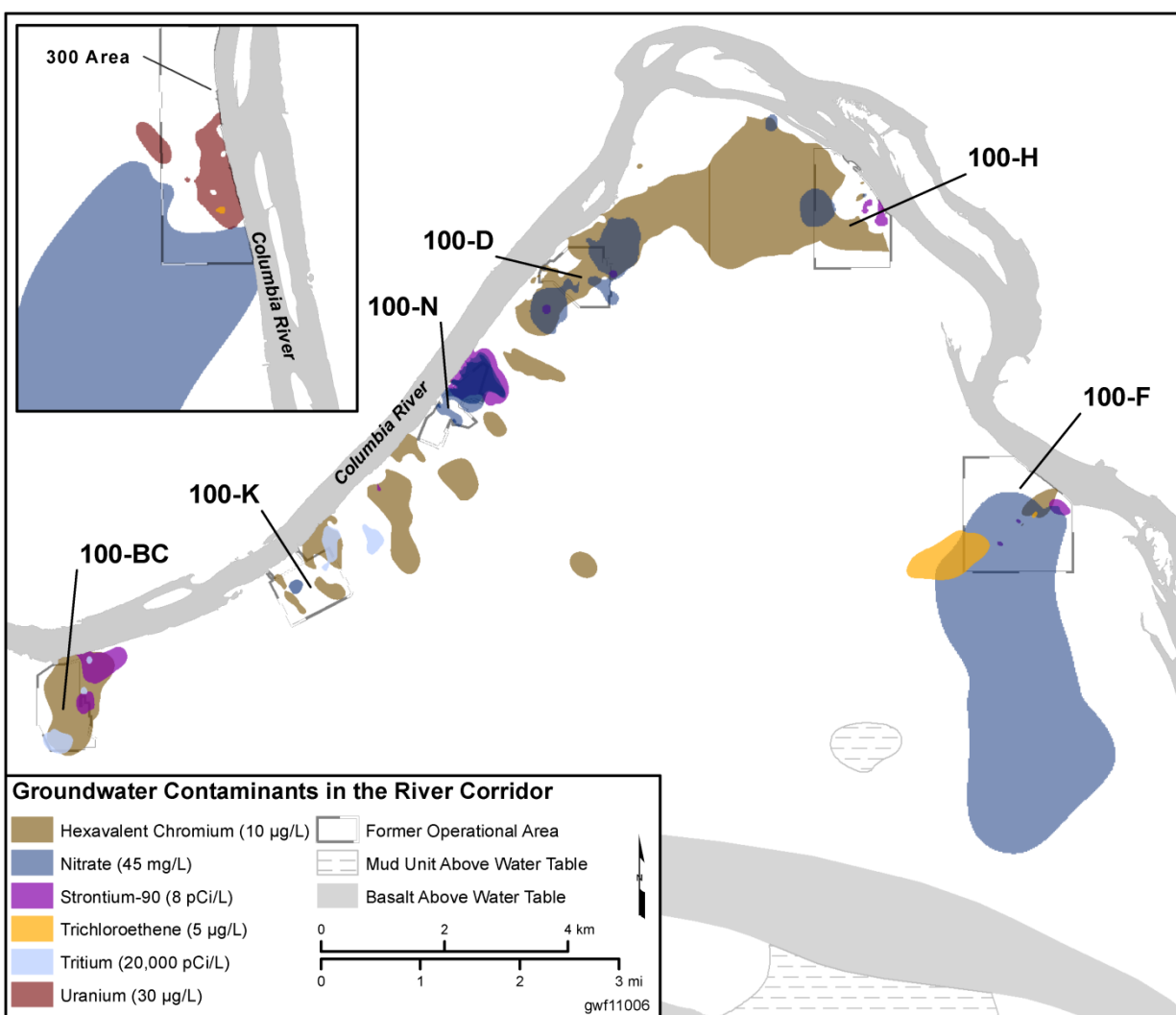
systems in the 100 Area are limiting the amount of contamination reaching the Columbia River and reducing the mass of contaminants in the groundwater.

Interim cleanup of the River Corridor has achieved a great deal, but final decisions are yet to be made. CERCLA provides a process for making cleanup decisions. This process is known as an RI/FS, and the decision will be published in a ROD. DOE conducted CERCLA investigations and drafted RI/FS reports in 2010 and 2011 for each of the river corridor units. DOE began submitting these reports to regulatory agencies for review in 2012.

**Table 8.1. River Corridor Overview**

River Corridor Overview									
Area	Primary Operations	Status of Waste Site Remediation under interim ROD <sup>(a)</sup>	Groundwater Contamination: Maximum Concentration and Plume Area						
			Carbon-14	Hexavalent Chromium	Nitrate	Strontium-90	Trichloro-ethene	Tritium	Uranium
100-BC	Reactor operations -- B Reactor 1944-69; C Reactor 1952-69	>90% complete	N		<DWS		<DWS		N
100-K	Reactor operations -- KE Reactor 1955-71; KW Reactor 1955-70	>30% complete							
100-N	Reactor operations -- N Reactor 1963-87	>30% complete	<DWS				N	<DWS	<DWS
100-D & 100-H	Reactor operations -- D Reactor 1944-67; DR Reactor 1950-64; H Reactor 1949-65	>45% complete	N				N	<DWS	<DWS
100-F	Reactor operations -- F Reactor 1945-65; Biological experiments until 1976	>85% complete	N					<DWS	
300	Nuclear fuel fabrication and research -- 1940s-1960s	>75% complete	N	N	(b)	<DWS			
1100	Vehicle maintenance, 1954-85; solid waste landfill --1950s-1970	100% (final ROD)	N	N	(b)	N	N	<DWS	<DWS
Standards			2000 pCi/L	10 ug/L	45 mg/L	8 pCi/L	5 ug/L	20,000 pCi/L	30 ug/L
Mobility in subsurface			High	High to Moderate	High	Slight	Moderate	High	Moderate
Legend									
Colors indicate maximum concentration in 2011			Height of bar indicates plume area above standard (km <sup>2</sup> )						
<div><div></div><div></div><div></div><div></div><div>N</div></div>			<div><div>&gt;10</div><div>&gt;1 and ≤ 10</div><div>&gt;0.1 and ≤ 1</div><div>&gt;0, ≤0.1</div></div>						
NOTES									
(a) Approximate percentage by number of waste sites classified as closed, interim closed, no action, rejected, or not accepted (end of 2011).									
(b) Nitrate in 300-FF-5 and 1100-EM-1 groundwater interest area originates from offsite sources, so plume area and maximum concentration are not shown									
ABBREVIATIONS									
COC Contaminant of concern			ISRM		P&T Pump and treat system				
DWS Drinking water standard			MNA		ROD Record of decision				



**Figure 8.5. River Corridor Groundwater Contaminants**

### 8.1.1 100-BC-5 Operable Unit

Groundwater contamination in the 100-BC-5 Operable Unit is related to disposal of solid and liquid waste associated with the operation of two water-cooled reactors. Contaminants include hexavalent chromium, which forms a large plume at relatively low concentrations (less than 50 µg/L). Concentrations appear to be declining very slowly in most wells. However, concentrations increased sharply in early 2012 downgradient of a large excavation at a contaminated waste site. Tritium and strontium-90 concentrations exceed the drinking water standards in several wells, and are declining overall.

Nearly all former waste sites have been excavated and backfilled under an interim ROD. No groundwater interim action was required. RI/FSs were completed in 2011, and DOE is developing alternatives for the remaining waste sites and groundwater cleanup.

### 8.1.2 100-KR-4 Operable Unit

The principal groundwater issues for the 100-KR-4 Operable Unit are cleaning up hexavalent chromium in the groundwater, tracking contaminant plumes, and monitoring groundwater near the former K East and K West Fuel Storage Basins. Remediation of waste sites is underway. Groundwater contaminant plumes are decreasing in size due to remediation and natural processes including dispersion, discharge to the Columbia River, degradation, and radioactive decay.

**Figure 8.6. Hexavalent Chromium in 100-KR-4 before Groundwater Remediation (left) and during Interim Remediation (right)**



***Pump-and-Treat systems in 100-KR-4 can process up to 1.2 million gallons (4.6 million liters) of contaminated groundwater every day. The systems have removed 1,394 pounds (632 kilograms) of hexavalent chromium since 1997.***

Hexavalent chromium is the primary contaminant of concern for groundwater. Three pump-and-treat systems operate as interim actions to remove hexavalent chromium from the groundwater. Between 1997 and 2011, 1,394 pounds (632 kilograms) of hexavalent chromium have been removed, and the size of the plume (at the 20 µg/L contour) has shrunk by 32 percent (Figure 8.6).

Other groundwater contaminants in the 100-KR-4 Operable Unit include tritium, carbon-14, strontium-90, nitrate, and trichloroethene. Tritium contamination is migrating downgradient from the 118-K-1 Burial Ground. The plume is intercepted by extraction wells near the Columbia River. Smaller tritium plumes are

present near the K East and K West Reactors. Two wells in the K West region continued to have concentrations above the drinking water standard. The plume did not change significantly between 2010 and 2011. Few wells in 100-KR-4 Operable Unit had strontium-90 concentrations above the 8 pCi/L drinking water standard in 2011, and results were similar to 2010. A new, temporary well drilled through the 116-K-2 Trench had higher strontium-90 concentrations than other wells. The high concentrations have not migrated far from the source since strontium-90 has not been detected in downgradient wells. Nitrate continued to exceed the drinking water standard in a few wells in 100-K Area. Trichloroethene exceeded the drinking water standard in a single well in 2011.

The CERCLA process is underway to make final cleanup decisions for 100-KR-4 Operable Unit. Remedial investigations in 2010 and 2011 included installing 15 wells and boreholes.

The concrete K East and K West Basins were integral parts of each reactor building. Until 2004, the water-filled basins were used to store irradiated fuel from the last run of N Reactor, as well as miscellaneous fuel fragments recovered during remedial actions at other reactor areas. Leaks at and around the basins have contaminated groundwater in the past. K East Basin was demolished, and soil remediation has begun. Demolition of the K West Basin is scheduled to begin after 2015. Groundwater monitoring in 2011 did not show new groundwater impacts from the basins.

### **8.1.3 100-NR-2 Operable Unit**

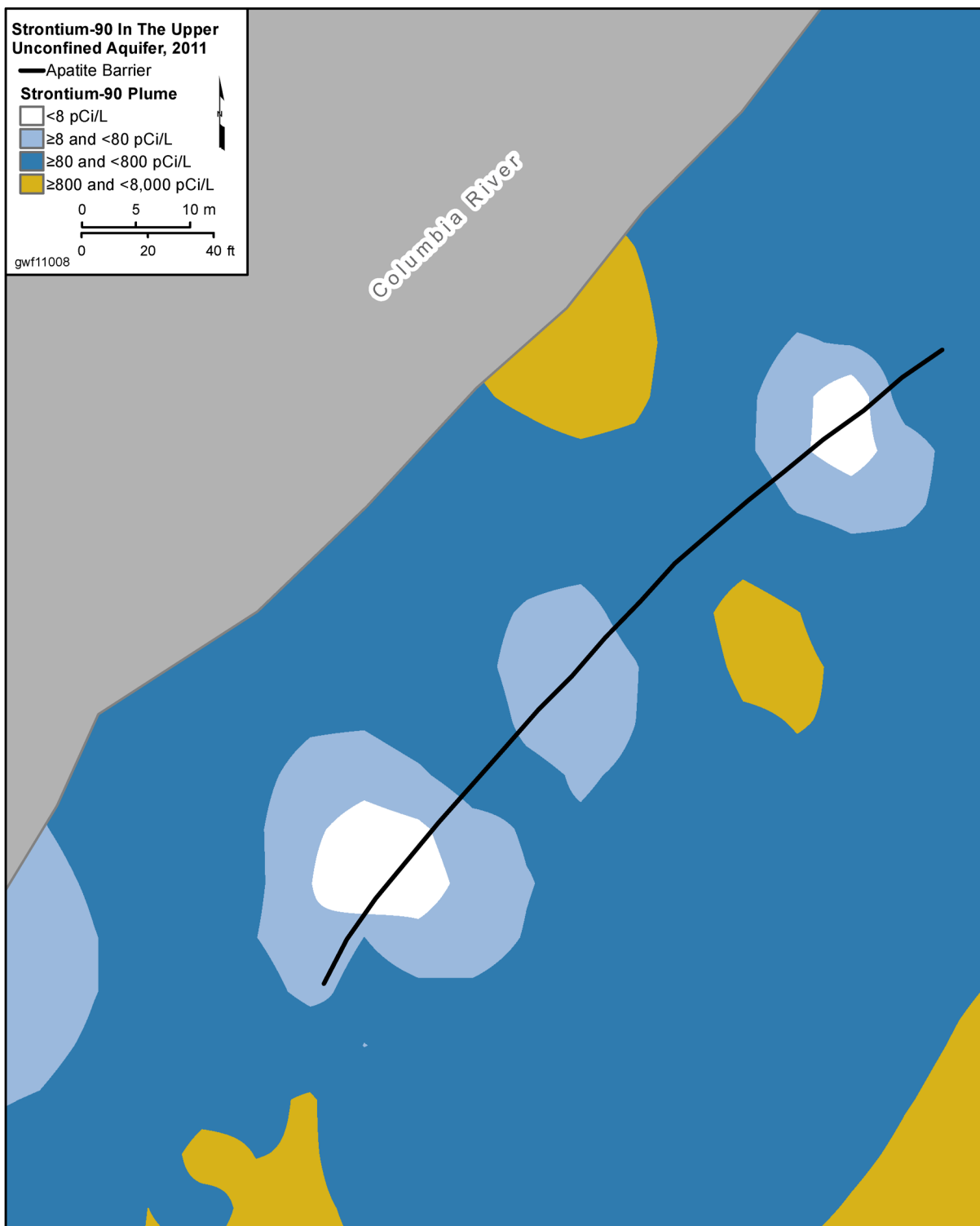
Principal groundwater issues for the 100-NR-2 Operable Unit include remediation of strontium-90 and RCRA monitoring. The major liquid waste sites have been remediated, and excavation is continuing at remaining waste sites.

The primary groundwater contaminant is strontium-90, which originated at the 116-N-1 and 116-N-3 waste sites. Strontium-90 tends to bind to sediment grains and the shape and size of the plume does not change significantly from year to year. Pump-and-treat technology was found to be ineffective in cleaning up strontium-90; therefore, DOE is applying an in situ technology, apatite sequestration. The goal is to create a reactive zone in the aquifer that captures strontium-90 as groundwater flows through it to the Columbia River. Apatite-forming chemicals were injected into a line of wells along the river shoreline several times since 2006 (Figure 8.7). As the injected chemicals reacted with the aquifer and sediments, strontium-90 levels temporarily increased in downgradient wells and aquifer tubes. Subsequently, strontium-90 and gross beta concentrations declined. DOE expanded the barrier with additional injections in fall 2011 by 182 yards (183 meters).

Other groundwater contaminants include nitrate and total petroleum hydrocarbons. Tritium concentrations have declined below the drinking water standard in recent years.

RCRA monitoring continued under detection programs in 2011 at the 1301-N, 1324-N/NA, and 1325-N facilities (waste sites 116-N-1, 120-N-1, 120-N-2, and 116-N-3). Results indicated no releases of dangerous waste constituents from the RCRA units.

DOE released an RI/FS work plan addendum in 2011 and drilled eight boreholes that were completed as wells. Soil and water samples were collected from each of the boreholes during drilling.

**Figure 8.7. Strontium-90 at the Permeable Reactive (Apatite) Barrier in 100-NR-2**

### 8.1.4 100-HR-3 Operable Unit

The 100-D and 100-H Areas, and the 600 Area between them, are combined into the 100-HR-3 Operable Unit. Remediation of waste sites continued in 2011. Hexavalent chromium is the primary contaminant of concern for groundwater, and a large plume extends from 100-D Area to 100-H Area. Hexavalent chromium also was detected at relatively high levels within the Ringold upper mud unit beneath 100-H Area, unlike elsewhere in the 100 Areas. Additional groundwater contaminants include strontium-90 and nitrate.

Pump-and-treat systems remove hexavalent chromium contamination from the groundwater as part of an interim action. Between 1997 and 2011, these systems removed 2,679 pounds (1,215 kilograms) of hexavalent chromium (Figure 8.8). The new DX pump-and-treat system began operation in December 2010 and the new HX system in October 2011. The DX pump-and-treat system removed nearly as much chromium in 2011 as the older, lower-capacity 100-HR-3 system removed in its entire period of operation. Maximum concentrations have declined more than 75 percent in some areas.

**Figure 8.8. Hexavalent Chromium in 100-HR-3 in Early Years of Groundwater Remediation (left) and in 2011 (right)**

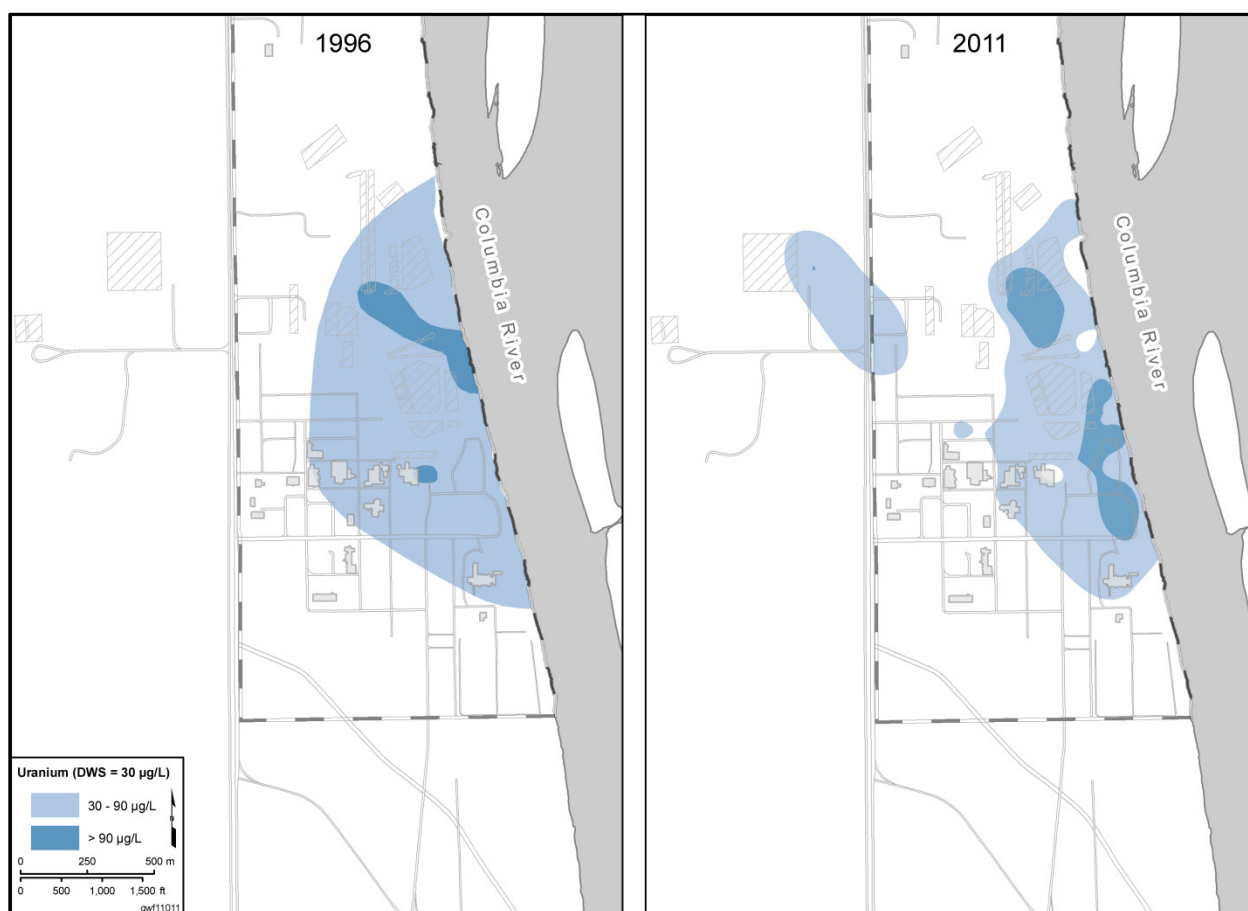


**DOE expanded pump-and-treat systems in 100-HR-3 in 2010 and 2011. Treatment capacity is now 2,006,400 gallons (7.6 million liters) per day. Since 1997, the systems have removed 2,680 pounds (1,215 kilograms) of hexavalent chromium from the groundwater.**

DOE is remediating part of the southern 100-D Area hexavalent chromium plume using a permeable reactive barrier that immobilizes chromium in the aquifer. However, data from recent years indicate that contamination is breaking through in some areas of the barrier. New extraction wells downgradient of the barrier will remediate this contamination as part of the DX pump-and-treat system.

The CERCLA process is underway to make final cleanup decisions for the 100-HR-3 Operable Unit. Remedial investigations included installing 15 wells and 10 boreholes in 2010 and 2011, and characterizing the vadose zone and groundwater. During the remedial investigation, hexavalent chromium was identified farther south in 100-D Area than previously indicated. This new information will be evaluated in the feasibility study.

**Figure 8.9. 300-FF-5 Operable Unit Uranium Plume (1996 and 2011)**



The former 183-H Solar Evaporation Basins (waste site 116-H-6) constitute the only RCRA site in the 100-HR-3 Operable Unit. The site is monitored in accordance with RCRA corrective action requirements during the post-closure period to track contaminant trends during operation of the CERCLA interim action for chromium. Concentrations of waste indicators increased in 2011.

### 8.1.5 100-FR-3 Operable Unit

Groundwater contamination in the 100-FR-3 Operable Unit originated from disposal of solid and liquid waste associated with operating the water-cooled F Reactor and biological experiments. Nitrate concentrations in groundwater exceed the drinking water standard beneath much of the 100-F Area and a large region downgradient. Smaller plumes of hexavalent chromium, strontium-90, and trichloroethene are present. Strontium-90, hexavalent chromium, and trichloroethene concentrations are declining, and nitrate concentrations are stable. Uranium was detected at a level above the drinking water standard in a new well that was drilled through a former waste site.

Nearly all of the former waste sites have been excavated and backfilled under an interim ROD. No groundwater interim action was required. Remedial investigation field studies were completed in 2011, and DOE is developing alternatives for final waste site and groundwater cleanup.

### 8.1.6 300-FF-5 Operable Unit

Three geographic regions comprise the 300-FF-5 Operable Unit: 1) the 300 Area Industrial Complex, 2) the 618-11 Burial Ground region, and 3) a region including the 618-10 Burial Ground and 316-4 Cribs. Most of the liquid waste sites have been remediated.

Contaminants of concern in 300 Area groundwater are uranium, trichloroethene, and *cis*-1,2-dichloroethene. Uranium has persisted longer than expected, and concentrations remain above the 30 µg/L drinking water standard in 300 Area groundwater (Figure 8.9). Another area of uranium contamination developed downgradient of a burial ground as a result of waste site remediation in 2007 and 2008. This plume has migrated downgradient and is merging with the larger uranium plume. Trichloroethene concentrations increased to levels above the drinking water standard in a few wells screened in the upper part of the unconfined aquifer in 2011. Higher concentrations were detected in groundwater samples collected from a deeper, finer-grained sediment during the remedial investigation, but only in a limited area. This sediment produces little water; therefore, the monitoring wells are not screened in it. However, at aquifer tube sites along the Columbia River, at least one aquifer tube is screened in this finer-grained sediment, and sampling reveals trichloroethene contamination.

Groundwater downgradient of the 618-11 Burial Ground contains a high-concentration tritium plume, likely originating from irradiated material in the burial ground. Concentrations at a well adjacent to the burial ground have decreased from the peak values, and the plume has maintained its basic shape since its discovery in 1999. Concentrations are stable in the central portion of the plume, while increasing slightly at the downgradient edge of the plume, reflecting migration to the east.

Remedial investigation activities continued in 2011. Eleven wells and five boreholes were installed in 2010 and 2011. DOE issued a draft remedial investigation report and proposed plan in 2011 that will support remedy selection.

***Concentrations of uranium, trichloroethene, and cis-1,2-dichloroethene are relatively constant or gradually decreasing in 300-FF-5.***



RCRA groundwater monitoring continued at the 300 Area Process Trenches (waste site 316-5). The unit is monitored in accordance with post-closure corrective action requirements. Uranium concentrations increased sharply in June 2011 near the southern end of the trenches. The temporary increase likely was caused by mobilization of deep vadose zone contamination by the seasonal high water table.

### **8.1.7 1100-EM-1 Operable Unit**

The only portion of the River Corridor for which final cleanup decisions have been made is the 1100-EM-1 Operable Unit. This operable unit was removed from the National Priorities List in 1996. The selected remedy for groundwater was monitored natural attenuation of volatile organic compounds, with institutional controls on drilling new water supply wells. Trichloroethene was the primary contaminant of concern, but concentrations have remained below the cleanup level since 2001.

Wells in the North Richland Well Field are monitored frequently to detect any changes in potential Hanford Site contaminants near these wells. Tritium associated with the plume originating from sources in the 200 East Area has not been detected in these wells.

Uranium concentrations in wells downgradient of DOE's inactive Horn Rapids Landfill have been slowly increasing since 1996, but remained below the drinking water standard in 2011. The presence of uranium at these locations is likely associated with the plume moving northeast from an offsite facility.

### **8.1.8 Columbia River**

Groundwater discharges to the Columbia River via riverbank springs and areas of upwelling in the riverbed. DOE has taken actions to protect the Columbia River and groundwater. These protective actions include the following:

- Ceasing discharge of all unpermitted liquids in the central Hanford Site
- Remediating the former liquid waste sites in the 100 and 300 Areas to reduce the potential for future groundwater contamination
- Containing groundwater plumes and reducing the mass of primary contaminants through remedial actions such as pump-and-treat.

DOE samples Columbia River water, river sediment, and riverbank seeps to determine the extent of Hanford Site contaminants or other contaminants. The data provide a historical record of radionuclides and chemicals in the environment. Concentrations of tritium and uranium in river water downstream of the Hanford Site are slightly higher than upstream of the Hanford Site, but meet water quality standards. Concentrations of other contaminants are no higher in downstream samples.

The 100 Area and 300 Area component of DOE's River Corridor baseline risk assessment addresses post-remediation, residual contaminant concentrations in these areas, as well as the Hanford and White Bluffs town sites. The assessment also is investigating the risks related to the potential transport of Hanford Site contaminants into Columbia River riparian and near-shore environments adjacent to the operational areas.

DOE completed an investigation of Hanford Site contaminant releases in the Columbia River in 2010. Samples were collected of pore water (i.e., groundwater upwelling beneath the river bottom into the space between rocks and sediment of the riverbed), river sediment, river water, fish, and island soil. Pore water in some of the 100 Area samples had concentrations of hexavalent chromium above the aquatic standard, and strontium-90 exceeded the drinking water standard in some 100-N Area samples. Tritium concentrations exceeded the drinking water standard in some pore water samples near the former Hanford town site, and

uranium near the 300 Area. The information obtained from this investigation will be used to help make final cleanup decisions for Hanford Site contaminants that exist in and along the Columbia River.

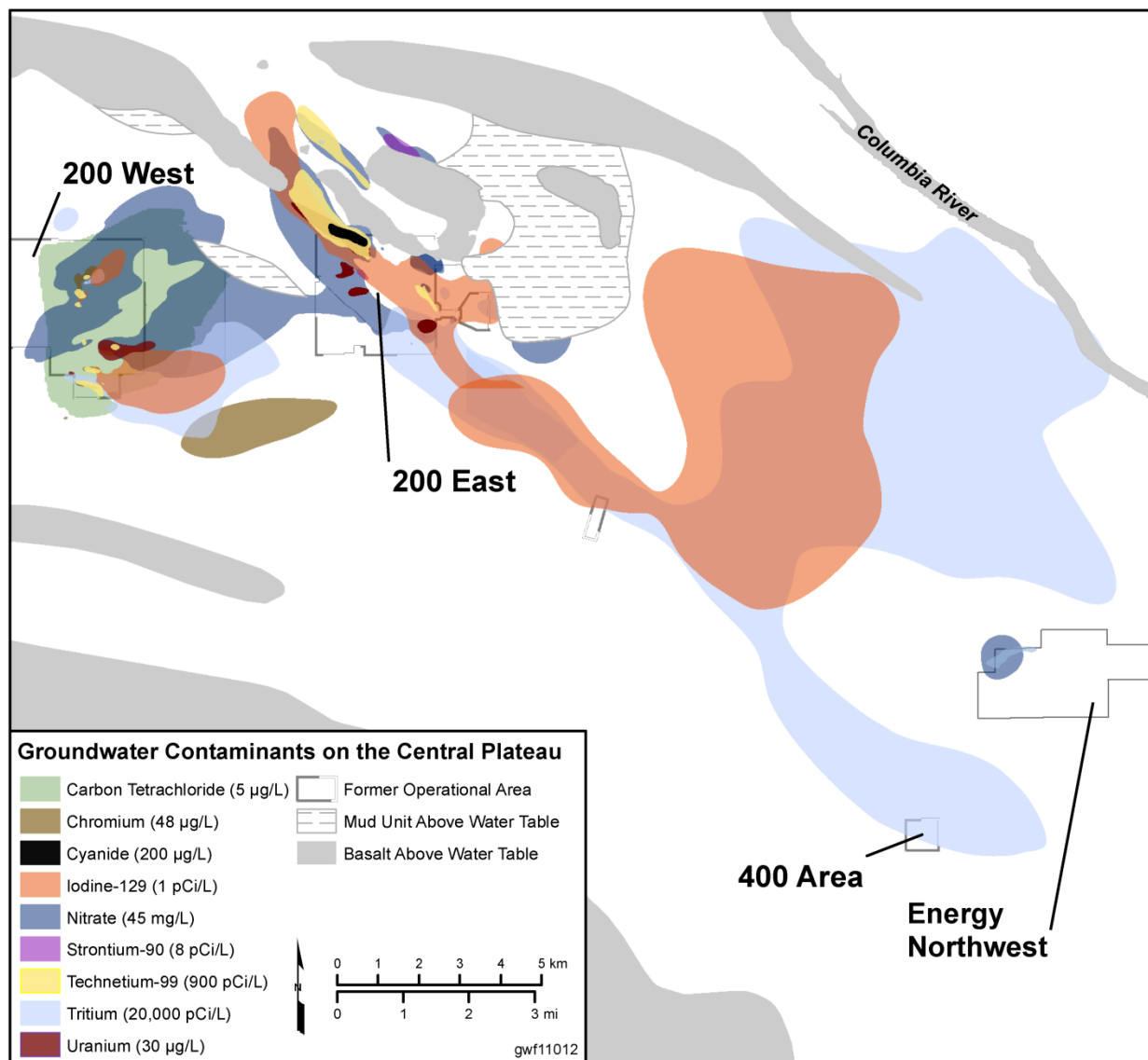
## 8.2 Central Plateau

When the Hanford Site was operating, irradiated fuel reprocessing, isotope recovery, and associated waste management activities occurred in the 200 East and 200 West Areas in the central portion of the Hanford Site. For the purpose of Hanford Site cleanup, this region is defined as the Central Plateau and is divided into Inner and Outer Areas. The Inner Area is the final footprint area of the Hanford Site that will be dedicated to waste management and containment of residual contamination, while the Outer Area is the remainder of the Central Plateau. Contaminant sources included unlined cribs, trenches, and ponds, and leakage from underground storage tanks, and other unplanned releases. Table 8.2 summarizes information about the Central Plateau.

Groundwater in the unconfined aquifer beneath the Central Plateau generally flows from upland areas in the west toward the regional discharge areas along the Columbia River. The flow of water divides beneath the 200 East Area, with some water flowing toward the north through Gable Gap and some flowing southeast. Previous effluent discharges caused groundwater mounds to form beneath the 200 Area that significantly affected regional flow patterns in the past. These discharges largely ceased in the mid-1990s and water levels declined, but remnants of groundwater mounds remain.

**Table 8.2. Central Plateau Overview**

Area	Primary Operations	Status of Groundwater ROD	Groundwater Remedial Action	Groundwater Contamination: Maximum Concentration and Plume Area									
				Carbon Tetrachloride	Chromium	Cyanide	Iodine-129	Nitrate	Strontium-90	Trichloroethene	Technetium-99	Tritium	Uranium
200-ZP-1	T Plant (Pu separation) 1944-1956; Pu Finishing Plant: 1949-1989	Signed 2008	Interim action carbon tet. P&T: 1995-present; Soil vapor extraction 1991-present. Final remedy P&T to begin in 2012										
200-UP-1	REDOX Plant (Pu separation) 1952-1967; U Plant (U recovery) 1952-1957	Expected 2012	Interim action U plant Tc-99 & U: 1994-2011; Interim action S-SX P&T to begin 2012	See 200-ZP-1		N							
200-BP-5	B Plant Pu separation: 1945-1952; B Plant Sr and Cs recovery: 1967-1985	Expected 2016	Perched aquifer P&T test: 2011	N									
200-PO-1	PUREX Plant Pu separation: 1956-1972 and 1983-1989	Expected 2016	Vadose zone desiccation test: 2011										
Standards				5 ug/L	48 ug/L	200 ug/L	1 pCi/L	45 mg/L	8 pCi/L	5 ug/L	900 pCi/L	20,000 pCi/L	30 ug/L
Mobility in subsurface				Multi-phase	High to Moderate	Moderate	High	High	Slight	Moderate	High	High	Moderate
Legend													
Colors indicate maximum concentration in 2011													
<div><div>≥1000 x standard</div><div>≥100 x standard and &lt;1000 x standard</div><div>≥10 x standard and &lt;100 x standard</div><div>≥Standard and &lt;10 x standard</div><div>N Not detected or not analyzed</div></div>													
Height of bar indicates plume area above standard (km <sup>2</sup> )													
<div><div>&gt;10</div><div>&gt;1 and ≤10</div><div>&gt;0.1 and ≤1</div><div>&gt;0, ≤0.1</div></div>													
ABBREVIATIONS													
DWS Drinking water standard				P&T Pump and treat system				ROD Record of decision					

**Figure 8.10. Central Plateau Groundwater Contaminants**

***The vadose zone is up to 164 feet (50 meters) thick beneath the Central Plateau.***

***Portions of it are contaminated with hazardous and radioactive waste.***

***DOE is studying ways to clean up the deep vadose zone to prevent additional contaminants from reaching the groundwater.***

There are seven single-shell tank waste management areas (WMAs) in the 200 Area. Some of these tanks have leaked, contaminating the vadose zone and groundwater beneath the tanks. To minimize additional leaks, DOE has removed the drainable liquid in all of the single-shell tanks.

Waste sites in the Central Plateau generally currently are a lower priority for cleanup than waste sites in the River Corridor because they are farther from the Columbia River and pose less risk to human and ecological receptors. Remediation of the Central Plateau waste sites is expected to accelerate after River Corridor remediation is complete. Until then, cleanup activities on the Central Plateau focus on completing decision documents, remediating groundwater plumes, decontaminating and decommissioning facilities, and beginning cleanup of waste sites in the Outer Area.

Groundwater contaminant plumes of tritium, iodine-129, and nitrate formed when the waste discharged to ponds and cribs reached the aquifer (Figure 8.10). These contaminants form regional plumes originating on the Central Plateau. The tritium and nitrate plumes have shrunk over the years due to dispersion and radioactive decay. A large carbon tetrachloride plume originated in 200 West Area. This plume is expanding at the edges, but the high-concentration core is contained by a pump-and-treat system. Other groundwater contaminants in the Central Plateau include technetium-99, uranium, strontium-90, trichloroethene, and cyanide.

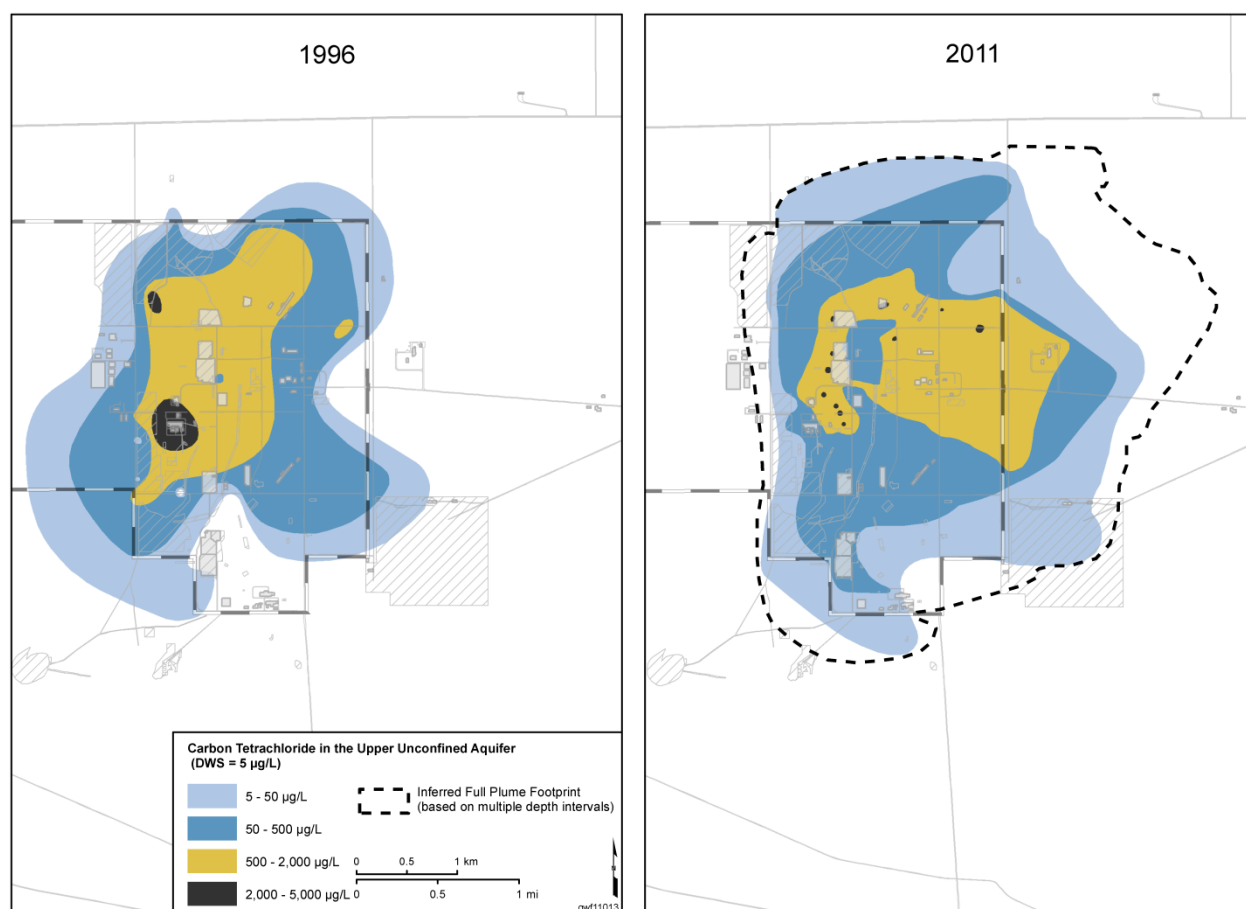
### 8.2.1 200-ZP-1 Operable Unit

Contaminant sources in the 200-ZP-1 Operable Unit located in 200-West Area included cribs, ponds, and single-shell storage tanks. A final ROD for 200-ZP-1 Operable Unit groundwater identified carbon tetrachloride as the primary contaminant of concern. Other contaminants of concern are trichloroethene, iodine-129, technetium-99, nitrate, hexavalent chromium, total chromium, and tritium. Groundwater studies in recent years have improved DOE's knowledge of the complex, and vertical distribution of carbon tetrachloride. Contamination occurs at increasing depth to the east (downgradient) of the source areas in the 200-ZP-1 Operable Unit.

***Groundwater and vadose zone remediation systems have removed more than 205,065 pounds (93,000 kilograms) of carbon tetrachloride from groundwater. That's equivalent to the weight of 30 full-size pickup trucks.***

Drillers installed six injection wells in 2011 in support of the final ROD. When completed, the network will include 36 injection and extraction wells. These wells will support the new pump-and-treat system, which will remediate groundwater from the entire aquifer thickness. Construction activities for the new treatment facility were completed in 2011 and the system will be operational in 2012.

DOE has operated an interim action pump-and-treat system since 1994 to prevent carbon tetrachloride in the upper portion of the aquifer from spreading (Figure 8.12). The system is limiting movement of the shallow, high-concentration portion of the plume but does not address contamination deeper in the aquifer and at the periphery of the plume. The pump-and-treat system has removed 28,768 pounds (13,500 kilograms) of carbon tetrachloride from groundwater. Soil vapor extraction systems have removed an additional 176,279 pounds (79,945 kilograms) since 1992. Other pump-and-treat systems (200-UP-1 and WMA T) have removed more than 485 pounds (220 kilograms).

**Figure 8.11. 200 West Carbon Tetrachloride Plume**

A second interim remediation, pump-and-treat test system has operated since 2007 to remove technetium-99 contamination downgradient of WMA T. This pump-and-treat test system extracted 13.3 grams (0.23 curies) of technetium-99, 128 pounds (57.9 kilograms) of carbon tetrachloride, 15 pounds (6.9 kilograms) of chromium, 14 ounces (405 grams) of trichloroethene, and 50,768 pounds (23,024 kilograms) of nitrate in 2011 from the aquifer.

DOE conducted a treatability test in 2011 using one of the soil vapor extraction systems and associated vadose zone wells. The purpose of the test was to evaluate the flux of carbon tetrachloride from the vadose zone to the groundwater to assess the soil vapor concentrations to ensure that they are protective of groundwater. Results are currently being evaluated.

Two Low-Level Waste Management Areas (LLWMA) in the 200-ZP-1 Operable Unit are monitored under RCRA interim-status, contaminant indicator parameter programs. At LLWMA-3, upgradient/downgradient comparisons have not been conducted in recent years because the upgradient wells were dry. A new upgradient well was installed in 2011, which will allow statistical evaluations to resume. No significant changes occurred at LLWMA-4 in 2011.

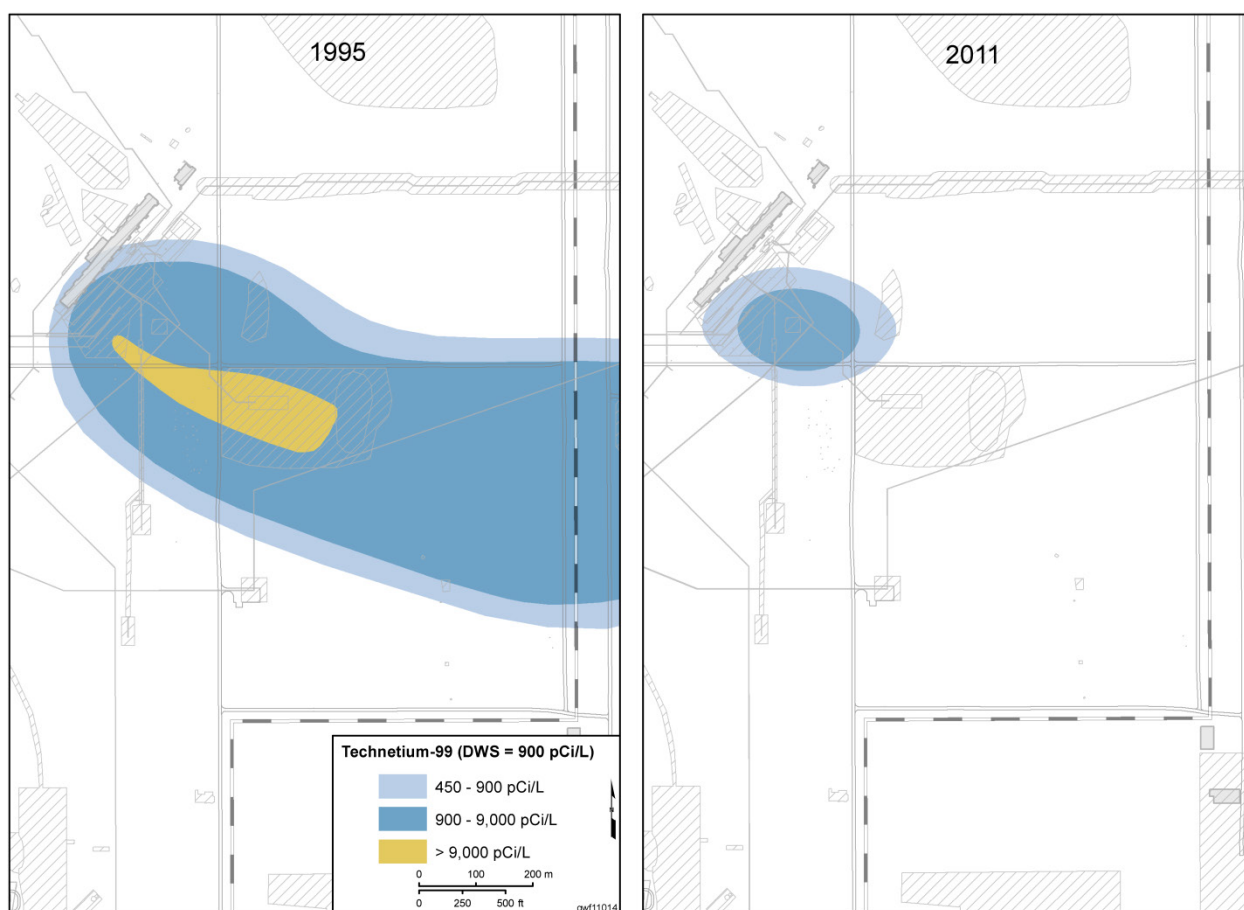
RCRA assessment monitoring continued at WMA T and WMA TX-TY. The concentrations and extent of dangerous waste constituents from these facilities are declining.

The State-Approved Land Disposal Site (SALDS) receives treated water from the Hanford Site's Effluent Treatment Facility. It is regulated under a state waste discharge permit. The declining water table in the 200-West Area has caused several of the SALDS monitoring wells to go dry over the years, including two additional wells during 2011. This issue is being addressed during the permit renewal process.

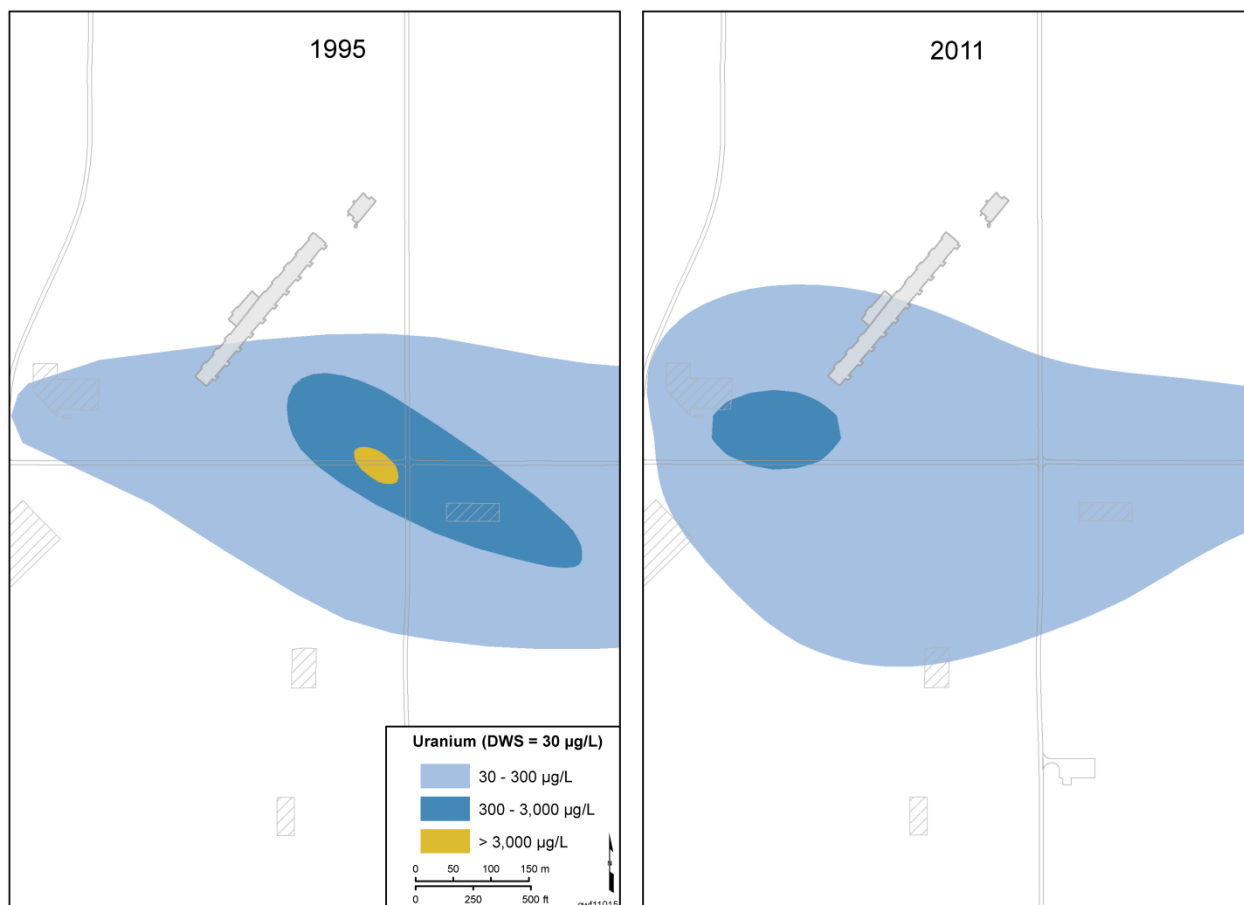
### 8.2.2 200-UP-1 Operable Unit

The southern portion of the 200-West Area and adjacent areas to the east and south comprise the 200-UP-1 Operable Unit. Contaminant sources included cribs, ponds, and single-shell tanks. Carbon tetrachloride, technetium-99, uranium, tritium, iodine-129, nitrate, and chromium plumes are present in groundwater. Strontium-90 and trichloroethene exceed drinking water standards in some areas. Carbon tetrachloride originated from sources in the 200-ZP-1 Operable Unit. The technetium-99 plume area has decreased substantially at the U Plant pump-and-treat system, but the plume near WMA S-SX has grown. The tritium plume is attenuating due to dispersion and radioactive decay. The areal extents of other plumes have remained unchanged or have decreased slightly since 2003.

**Figure 8.12. 200-UP-1 Operable Unit Technetium-99 Plume Before and After Interim Groundwater Remediation**



**Figure 8.13. 200-UP-1 Operable Unit Uranium Plume Before and After Interim Groundwater Remediation**



DOE and EPA resolved their comments in 2011 concerning the technical approach and administrative strategy for remedial actions. Rather than including 200-UP-1 Operable Unit remedial actions in the existing 200-ZP-1 ROD (by amendment), DOE and EPA agreed that a separate ROD would be prepared for the 200-UP-1 Operable Unit. This ROD is expected to contain interim actions for all 200-UP-1 Operable Unit contaminants of concern.

***Technetium-99 concentrations in 200-UP-1 groundwater are the highest on the Hanford Site. Pump-and-treat remediation has addressed one plume, but another plume near WMA S-SX has grown. A new pump-and-treat system will address that plume.***

A CERCLA pump-and-treat system is being installed to remediate the technetium-99 plumes from WMA S-SX. Drillers installed three extraction wells in 2011. This system will replace extended purging of a monitoring well, which has removed ~.011 curie (~0.63 gram) of technetium-99 since 2003.

The U Plant interim action pump-and-treat system operated until March 2011, when it was shut down in accordance with an agreement between DOE and EPA (Figures 8.12 and 8.13). Flow rates from extraction wells had decreased due to regional decline of the water table and reduced well efficiency. Since startup in



1994, the pump-and-treat system removed 486 pounds (220.5 kilograms) of uranium and 4.5 ounces (127.4 grams) of technetium-99. Overall, the U Plant pump-and-treat system achieved its objectives. The interim remedial action goal of 9,000 pCi/L for technetium-99 was achieved in 2005, and the goal of 300 µg/L for uranium was achieved in 2009. The final remedy for the 200-UP-1 Operable Unit will address further remediation of the groundwater contaminant plumes.

RCRA monitoring in the 200-UP-1 Operable Unit included interim status groundwater quality assessment monitoring at WMA S-SX and WMA U, and interim status indicator parameter evaluation monitoring at the 216-S-10 Pond and Ditch. Revised monitoring plans were implemented in 2011 at WMA S-SX and WMA U. Monitoring results did not show major changes in the extent of contamination. Indicator parameters did not exceed statistical comparison values in 2011 at the 216-S-10 Pond and Ditch.

The Environmental Restoration Disposal Facility is a low-level radioactive mixed waste landfill used for disposal of waste from surface remedial actions on the Hanford Site. The results of groundwater monitoring in 2011 continued to indicate that the facility has not adversely affected groundwater quality.

### 8.2.3 200-BP-5 Operable Unit

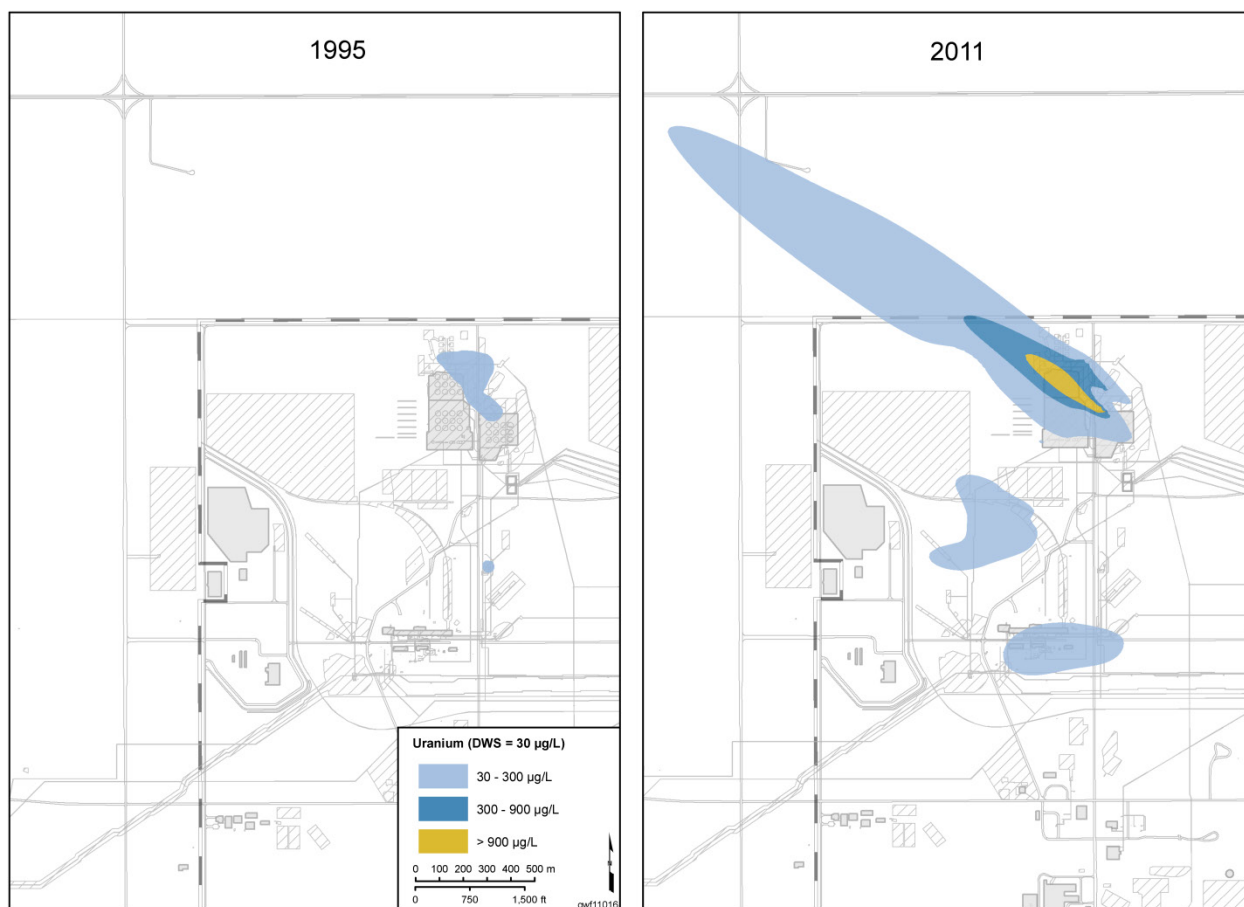
The 200-BP-5 Operable Unit includes groundwater beneath the northern 200-East Area and the region to the northwest where mobile contaminants have migrated between Gable Mountain and Gable Butte. Most of the groundwater contamination is concentrated beneath WMA B-BX-BY and adjacent waste sites in the northwestern portion of the 200-East Area. Cleanup decisions for the 200-BP-5 Operable Unit are yet to be made, and preparation of a draft remedial investigation report began in 2011.

Nitrate, iodine-129, technetium-99, and tritium form the largest contaminant plumes in the 200-BP-5 Operable Unit. These mobile contaminants have migrated to the northwest as a result of past groundwater flow. The tritium plume has shrunk significantly, but the other large plumes have either grown or remained stable over the past decade. Cyanide and uranium (Figure 8.14) are present in smaller plumes that have increased in size since 2002. A strontium-90 plume has decreased in size, and low-mobility contaminants cobalt-60, cesium-137, and plutonium-239/240 are present only near their former sources.

***Wells in 200-BP-5 have the highest uranium concentrations in groundwater on the Hanford Site. DOE is testing methods to remove this contamination from the vadose zone and groundwater.***

Scientists and engineers have designed a treatability test to evaluate pumping and treating groundwater to remediate uranium and technetium-99 contaminant plumes near WMA B-BX-BY. Drillers began installing an extraction well in 2011 to support the test.

A fine-grained geologic unit beneath the B Plant region has created an area of saturated sediments (a 'perched' aquifer) in the deep vadose zone above the regional water table. This perched water is contaminated with uranium and other contaminants at concentrations higher than in the underlying aquifer. DOE began pumping in 2011 to remove this perched water before it reaches groundwater. The pumping successfully removed ~ 25,080 pounds (~95,000 liters) of contaminated, perched water. Plans for a treatability test to use enhanced methods for continued pumping of perched water and pore water were completed in 2011.

**Figure 8.14. 200-BP-5 Operable Unit Uranium Plume**

RCRA interim-status, indicator evaluation monitoring continued at LLWMA-1, LLWMA-2, and the 216-B-63 Trench with no significant changes in 2011. Assessment monitoring continued at WMA B-BX-BY, and WMA C, and results were consistent with previous years. The WMA B-BX-BY assessment plan will be revised in 2012 to incorporate the results of the recent CERCLA remedial investigation and the addition of new monitoring wells.

DOE monitors the Liquid Effluent Retention Facility under a RCRA final-status detection program. Monitoring results in 2011 indicated that all required constituents were undetected or below drinking water standards except for nitrate, which is from a regional plume. Drillers installed a new characterization well in 2011 near this facility.

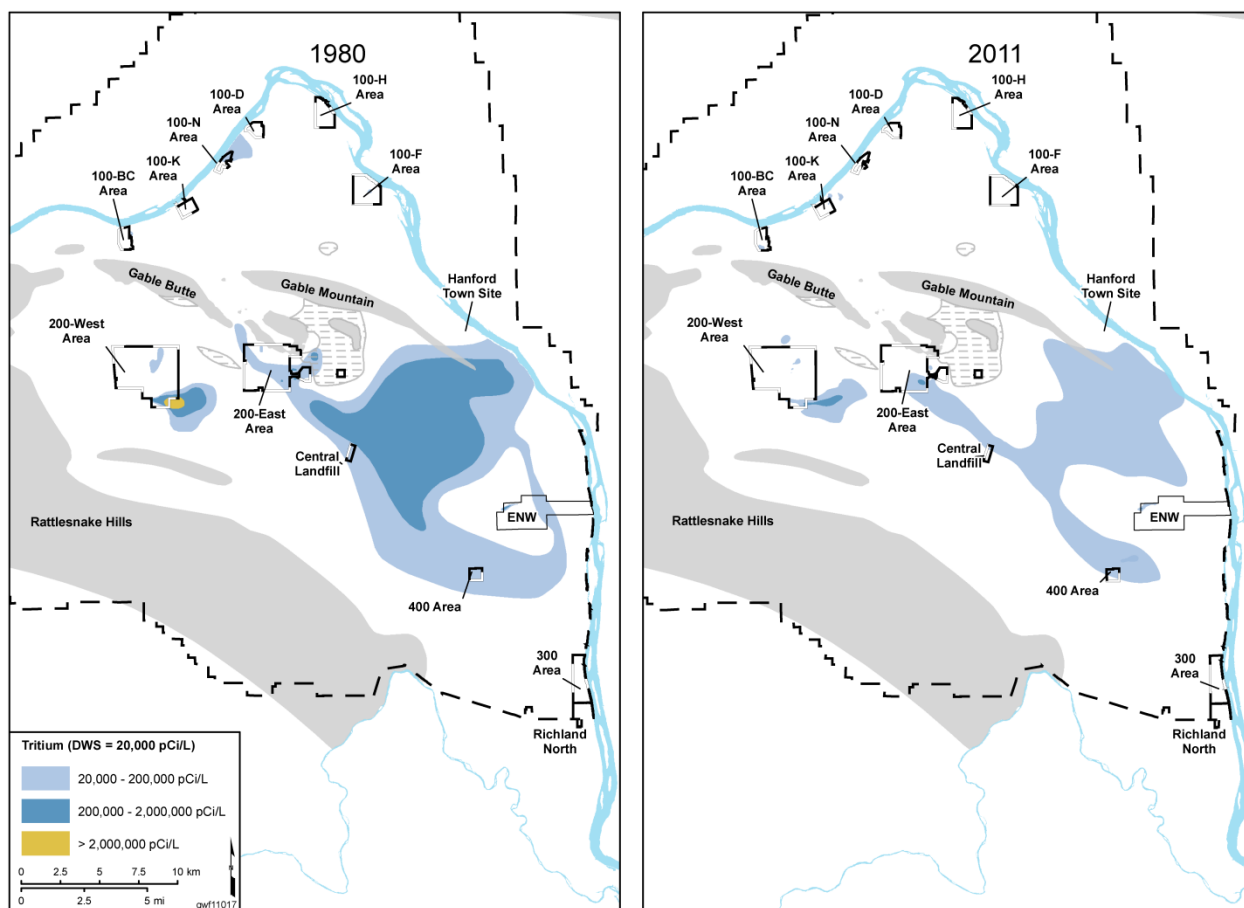
### 8.2.4 200-PO-1 Operable Unit

The southern portion of the 200-East Area and a large region of the Hanford Site to the east and southeast comprise the 200-PO-1 Operable Unit. Disposal of large volumes of liquid waste created regional groundwater plumes of tritium, iodine-129, and nitrate. Concentrations of tritium are declining as the groundwater plume attenuates naturally due to radioactive decay and dispersion. The size of the tritium plume has decreased since 1980 by one-third and the maximum concentrations has declined 90 percent (Figure 8.15). The area of the iodine-129 plume above the 1 pCi/L contour has decreased slightly over the past decade, and maximum concentrations have declined significantly as a result of dispersion. Radioactive decay has not decreased the level of iodine-129 contamination noticeably because this isotope has a half-life of 15.7 million

years. The nitrate plume covers a large area, with concentrations above background but mostly below the drinking water standard. Other contaminants in the 200-PO-1 Operable Unit include strontium-90, technetium-99, and uranium in smaller areas near their sources.

DOE conducted a CERCLA remedial investigation in 2008 and 2009 in the 200-PO-1 Operable Unit. DOE submitted a draft remedial investigation to Ecology in 2010; a final report is scheduled to be issued in 2012.

**Figure 8.15. Hanford Site Tritium Plumes**



***The tritium and iodine-129 plumes from sources in 200-PO-1 are the largest on the Hanford Site, having migrated more than 9 miles (15 kilometers).***

A soil desiccation treatability test was conducted in 2011 in an interval containing high moisture and associated technetium-99 contamination near the BC Cribs and Trenches. This technology is being considered as a remedy for contamination in the deep vadose zone. For approximately 6 months, nitrogen was injected into a well, and soil gas was extracted from another well. A combination of in situ sensors and geophysical measurements provided data to monitor performance. As anticipated, desiccation occurred more rapidly from higher-permeability sediment. The active portion of the test was completed and DOE continues to monitor rewetting of the desiccated region. A comprehensive report will be issued in 2012.

RCRA assessment monitoring continued in 2011 at WMA A-AX and data were consistent with previous results. RCRA indicator parameter monitoring continued at the 216-B-3 Pond. Monitoring results provided no indication of releases from this facility to groundwater.

The Integrated Disposal Facility is an expandable, double-lined landfill that is regulated under RCRA and the AEA. It is not yet in use, and current groundwater monitoring is directed at obtaining baseline data.

New RCRA groundwater monitoring plans were implemented in 2011 at the 216-A-36B Crib and the 216-A-37-1 Crib. Background samples were collected so that critical mean values of contamination indicator parameters can be established.

The Treated Effluent Disposal Facility is a state-permitted liquid waste site. The uppermost aquifer beneath this facility is confined beneath the Ringold Formation lower mud unit. Groundwater monitoring is performed to demonstrate that the mud unit continues to protect the confined aquifer from potential impacts of discharges from the facility. The Permit is currently undergoing renewal; in the draft revised permit, it is proposed that groundwater monitoring be discontinued and the effluent monitored prior to discharge to the facility to comply with the Permit.

During 2010, DOE submitted a combination groundwater monitoring plan for the Nonradioactive Dangerous Waste Landfill and the adjacent Solid Waste Landfill to Ecology for review. Until that plan is approved and implemented the Nonradioactive Dangerous Waste Landfill continues to be monitored under a RCRA detection program. Specific conductance in downgradient wells continued to exceed the critical mean during 2011 but was previously determined to be caused by nonhazardous groundwater constituents from the nearby Solid Waste Landfill.

The Solid Waste Landfill is regulated under Washington State solid waste handling regulations. As in previous years, some of the downgradient wells showed higher concentrations of regulated constituents than the statistically calculated background threshold values. Background threshold values exceeded during 2011 included coliform bacteria, pH, specific conductance, nitrite, sulfate, and total organic carbon.

Three water supply wells provide drinking water and serve as an emergency water supply for the 400 Area, which is in the footprint of the 200-PO-1 Operable Unit. Because the 400 Area is in the path of the Hanford Site-wide tritium plume, DOE routinely monitors the wells for tritium. These wells are screened deep in the unconfined aquifer, just above the Ringold lower mud unit. The 2011 sampling event has been delayed until January 2012; concentrations were below the drinking water standard.

### **8.3 Confined Aquifers**

Although most Hanford Site groundwater contamination is found in the unconfined aquifer, DOE monitors wells in deeper aquifers due to potential downward movement of contamination and potential migration of that contamination off site through the confined aquifers. There is no evidence of offsite migration via the confined aquifers.

One confined aquifer occurs within sand and gravel at the base of the Ringold Formation. Carbon tetrachloride, nitrate, and technetium-99 have contaminated this unit in a portion of the 200-West Area where the upper confining unit is absent. New wells have been installed in recent years to monitor and remediate this contamination. The Ringold confined aquifer is the uppermost aquifer in a region east of 200-East Area (within portions of 200-BP-5 and 200-PO-1 Operable Units). Iodine-129 and tritium are detected in wells at this location, but the contamination has not migrated to wells farther downgradient.

In the northern portion of the Hanford Site, fine-grained sedimentary units informally called the Ringold upper mud confine deeper sediments in the Ringold Formation. This unit is contaminated with hexavalent chromium in some parts of 100-HR-3 Operable Unit.

Groundwater within basalt fractures and joints, interflow contacts, and sedimentary interbeds make up the upper basalt-confined aquifer system. No significant contamination is detected in the basalt-confined aquifer, except in the northwestern 200 East Area, where poor well construction and temporary drilling effects allowed local migration of groundwater from the overlying unconfined aquifer.

## 8.4 Wells

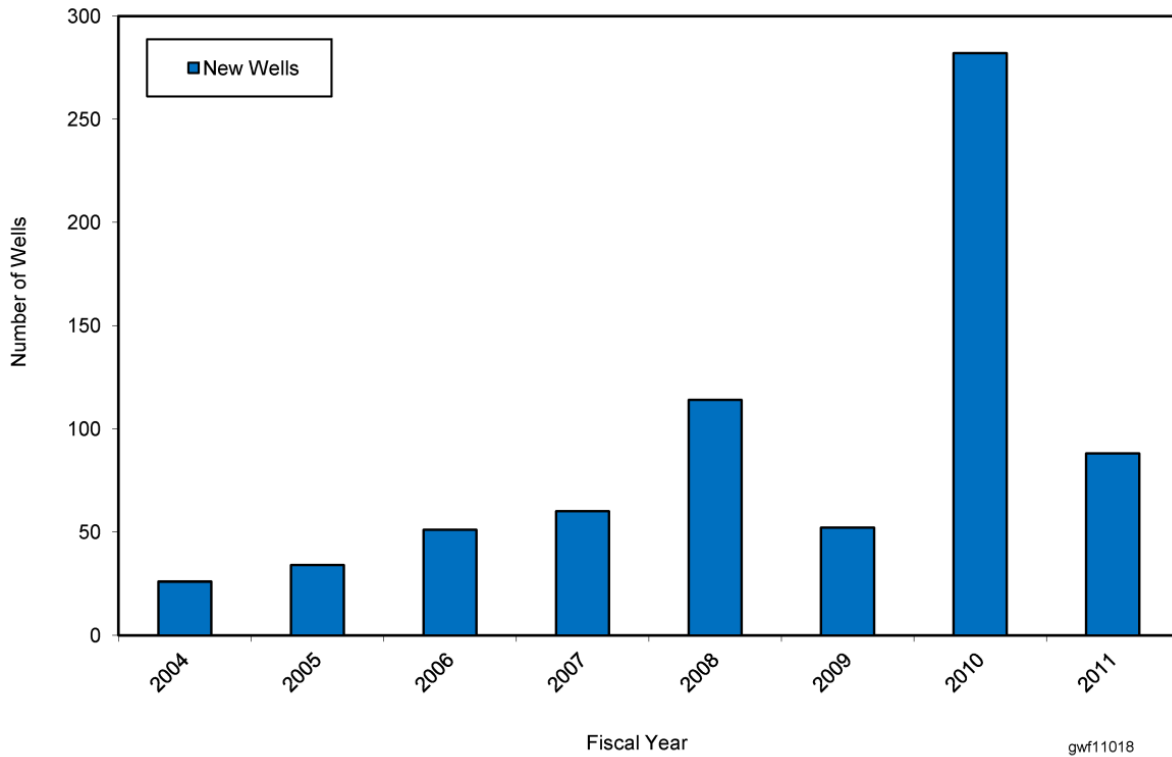
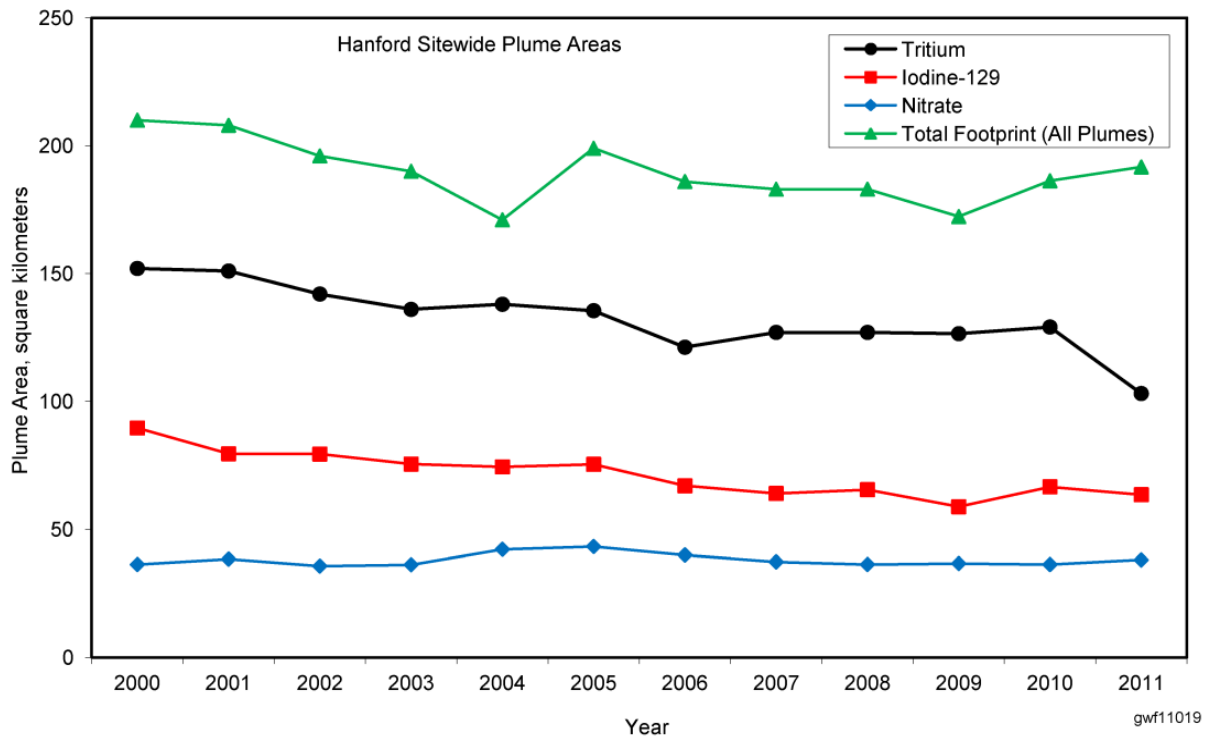
Over the lifetime of the Hanford Site, DOE has installed thousands of wells to monitor and remediate groundwater and provide geologic data. DOE installed 89 new wells in 2011, primarily in support of remedial investigation studies or groundwater remediation (Table 8.3 and Figure 8.16).

**Table 8.3. New Wells Installed in 2011**

Location	Number of Wells
100-BC-5	6
100-KR-4	15
100-NR-2	8
100-HR-3	25
100-FR-3	2
200-ZP-1	6
200-UP-1	4
200-BP-5	1
200-PO-1	2
300-FF-5	20
<b>Total</b>	<b>89</b>

During 2011, 49 direct-push and characterization boreholes were installed. The boreholes supported subsurface characterization of radiological constituents, volatile organics (e.g., carbon tetrachloride), or vadose zone properties (e.g., moisture content or grain-size distribution). The boreholes were decommissioned after data collection was complete.

DOE identifies wells, boreholes, or other subsurface installations for decommissioning when they are no longer needed. In 2011, 108 wells were physically decommissioned. This involved sealing the wells in compliance with Washington State groundwater protection laws. In addition to the physical decommissioning, 13 wells were administratively decommissioned. These wells could not be located and further investigation showed they no longer exist.

**Figure 8.16. New Wells Installed (2007 through 2011)****Figure 8.17. Size of Hanford Site Contaminant Plumes –Tritium, Iodine-129, and Nitrate**

## 8.5 Conclusions

Table 8.4 summarizes information about the primary groundwater contaminants on the Hanford Site. The items below highlight conclusions based on Hanford Site groundwater monitoring in 2011.

- Decades of waste disposal have contaminated a large area of the Hanford Site's groundwater. The largest contaminant plume—tritium, from waste sites on the Central Plateau—is decreasing in size due to radioactive decay and dispersion (Figure 8.17). Hexavalent chromium is the primary concern in the River Corridor.
- Groundwater flows toward the Columbia River and is the primary exposure route for contaminants to reach human, environmental, and ecological receptors.
- More than half of the former waste sites in the River Corridor have been remediated or are classified as not needing remediation under interim records of decision. The rest of the waste sites will be remediated in the next few years. Thus, potential sources of additional groundwater contamination are being removed from the region that poses the greatest threat to the Columbia River. Remedial investigations have collected data to determine appropriate remedies for remaining vadose zone and groundwater contamination. The Tri-Party Agencies will develop final RODs for the River Corridor units in coming years.
- Interim remediation of hexavalent chromium contamination in 100-KR-4 and 100-HR-3 continued in 2011. DOE has expanded pump-and-treat systems in these regions to control larger portions of the plumes. Chromium concentrations in compliance wells remained above cleanup goals, so remediation will continue.
- An in situ remediation method being applied in 100-NR-2 is reducing the amount of strontium-90 discharging to the Columbia River.
- Contamination is still present in many parts of the thick vadose zone in the Central Plateau and may continue to drain into the groundwater. Remediation of the Central Plateau waste sites and vadose zone will accelerate after River Corridor remediation is complete. Meanwhile, DOE has been remediating groundwater and testing methods to remediate the deep vadose zone.
- Interim remediation of carbon tetrachloride contamination in 200-ZP-1, and the overlying vadose zone (200-PW-1), continued in 2011. Pump-and-treat is being used to clean up groundwater, and soil vapor extraction is being used to clean up the vadose zone. A second pump-and-treat system is being used in 200-ZP-1 to remove technetium-99.
- DOE continued to implement elements of the final remedy to clean up groundwater in 200-ZP-1. A total of 26 wells were installed between 2009 and 2011, and in 2011 construction of the new groundwater treatment facility was completed. The new pump-and-treat system will begin to operate in 2012.
- Final cleanup decisions for 200-UP-1, 200-BP-5, and 200-PO-1 are yet to be made. Remedial investigation studies have gathered information to support cleanup decisions in coming years.
- Groundwater discharges to the Columbia River via springs and areas of upwelling. Contaminant concentrations in some springs are above applicable water quality standards. Concentrations are below these standards in river water samples.



**Table 8.4. Groundwater Contaminants on the Hanford Site**

Contaminant	Primary Locations	Plume Area above Standard (km <sup>2</sup> )	Drinking Water Standard	Remediation in Place?	Mobility <sup>a</sup> and Half-Life
Carbon Tetrachloride	200-ZP-1	13.3	5 µg/L	Yes	Mobile and denser than water
Chromium (hexavalent)	100-KR-4, 100-HR-3	5.76	48 µg/L <sup>b</sup>	Yes	Mobile to moderate
Cyanide	200-BP-5	0.24	200 µg/L	No	Mobile
Iodine-129	200 Areas	60.1	1 pCi/L	No	Mobile; 17 million years
Nitrate (as NO <sub>3</sub> -)	200 Areas, 100-FR-3, 100-HR-3, 199-NR-2	37.7	45 mg/L	No <sup>c</sup>	Mobile
Strontium-90	100 Areas, 200-BP-5	1.51	8 pCi/L	Yes 100-NR-2	Slightly mobile; 28.9 years
Technetium-99	200 Areas	3.1	900 pCi/L	Yes 200 West <sup>d</sup>	Mobile; 213,000 years
Trichloroethene	100-FR-3, 200-ZP-1	0.90	5 µg/L	Yes 200-ZP-1	Mobile to moderate
Tritium	200 Area, 300-FF-5, 100-BC-5, 100-KR-4	103	20,000 pCi/L	No	Mobile; 12.3 years
Uranium	200-UP-1, 200-BP-5, 300-FF-5	1.7	30 µg/L	No	Moderate; 246,000 years (U-234), 4.5 billion years (U-238)
Area of combined plumes <sup>e</sup>		191			

- (a) Mobility: A contaminant moves readily in groundwater  
 Moderate: A contaminant undergoes geochemical reactions in the aquifer and moves slower than the groundwater.  
 Slight: A contaminant binds to sediment grains and moves much slower than the groundwater.
- (b) Washington State Model Toxics Control Act groundwater cleanup level
- (c) Removed from treated water for the 200-ZP-1 pump-and-treat
- (d) 200-UP-1, WMA S-SX, and WMA T
- (e) Many plumes overlap so the area of combined plumes is less than the sum of the individual plume areas

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## 9.0 Soil Monitoring

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*MC Dorsey and ME Hoefer*

The following sections summarize soil monitoring efforts conducted in 2011 at and around the Hanford Site. Radiological monitoring of soil is conducted at a variety of locations: onsite near facilities and operations, onsite away from facilities and operations (Hanford Site), and offsite at perimeter and distant locations and in nearby communities. Contaminant concentration data are used for the following:

- Determine the effectiveness of effluent monitoring and controls within facilities
- Assess the adequacy of containment at waste-disposal sites
- Detect and monitor unusual conditions
- Provide information on long-term radionuclide contamination trends in soil at undisturbed locations.

Soil samples have been collected on and around the Hanford Site for more than 50 years. Consequently, a large amount of data exists that document onsite and offsite levels of manmade radionuclides in Hanford Site soils. These data provide a baseline which unplanned releases can be compared to. For further information about the purpose of soil monitoring efforts and the programs that support them, see [Section 8.0](#) and [DOE/RL-91-50](#), Rev. 4.

### 9.1 Monitoring Results

*MC Dorsey*

Soil monitoring provides information about long-term contamination trends and baseline environmental radionuclide activities at undisturbed locations both on and off the Hanford Site ([DOE/RL-91-50](#), Rev. 4.). Soil samples, collected on and around the Hanford Site for more than 50 years, have been added to a large database documenting onsite and offsite levels of manmade radionuclides in soil at specific locations. This database contains baseline data against which data from unplanned releases from the Hanford Site can be compared. Offsite soil samples are collected every 3 to 5 years, and were last collected in 2008. The next scheduled collection will occur in 2013.

### 9.2 Sampling Results

*ME Hoefer*

Soil samples are collected near facilities and operations to evaluate long-term trends in the environmental accumulation of radioactive materials, and to detect potential migration and deposition of facility emissions. Soil contamination can occur as the result of direct deposition from facility emissions, re-suspension and movement of contaminants from radiologically contaminated surface areas, uptake of contaminants into plants whose roots contact belowground waste, or translocation of buried waste by intruding animals.

Soil samples were collected on or adjacent to waste disposal sites and from locations downwind and near or in the boundaries of operating facilities and remedial action sites. The number and locations of soil samples collected during 2011 are summarized in Table 9.1. Only radionuclides with concentrations consistently above analytical detection limits are discussed in this section.

**Table 9.1. Soil Sample Locations (2011)**

Number of Samples	Operational Area							
	100-N	100-F	200-West <sup>(a)</sup>	200-East <sup>(a)</sup>	600 <sup>(a)</sup>	300 <sup>(a)</sup>	400	ERDF
85	3	3	28	15	18	16	1	1

(a) Number of samples includes one or more replicate samples.

Soil samples are 2.2-pound (1-kilogram), which represents a composite of five plugs of soil; each sample is 1 inch (2.5 centimeters) deep and 4 inches (10 centimeters) in diameter. Soil samples were sieved in the field to remove potential sample intrusions such as rocks and plant debris, and then dried in the laboratory prior to analysis to remove residual moisture.

Soil samples were analyzed for radionuclides expected to occur in the areas sampled (i.e., gamma-emitting radionuclides, strontium-90, uranium isotopes, and/or plutonium isotopes). The analytical results from Hanford Site soil samples were compared to concentrations of radionuclides measured in samples collected offsite in previous years at various sampling locations in Grant, Yakima, Walla Walla, Adams, Benton, and Franklin Counties. These comparisons were used to differentiate concentrations of Hanford Site-produced contaminants from levels resulting from natural sources and worldwide fallout.

Soil sampling results can be compared to the accessible soil concentrations (WHC-SD-EN-TI-070) developed specifically for use at the Hanford Site. These concentration values for radionuclides were established to ensure that effective dose equivalents to the public do not exceed the established limits for any reasonable scenario, such as direct exposure, inadvertent ingestion, inhalation, and consumption of foods, including animal products. The accessible soil concentration values are based on a radiation-dose estimate scenario (WHC-SD-EN-TI-070) in which an individual would have to spend 100 hours per year in direct contact with the contaminated soil. The conservatism inherent in pathway modeling ensures the required degrees of protection are in place. These concentrations apply specifically to the Hanford Site with respect to onsite waste disposal operations and cleanup, and decontamination, and decommissioning activities. A partial list of these values is provided in Table 9.2.

**Table 9.2. Accessible Soil Concentration Limits for Selected Radionuclides**

*pCi/g<sup>(a)</sup> dry weight*

	Cobalt- 60	Strontium- 90	Cesium- 137	Uranium- 234	Uranium- 235	Uranium- 238	Plutonium- 239/240
Accessible soil <sup>(b)</sup> concentration limits (WHC-SD-EN-TI-070)	7.1	2,800	30	630	170	370	190

(a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.

(b) Hanford Site soil that is not behind security fences.

Some degree of variability is always associated with collecting and analyzing environmental samples; therefore, variations in sample concentrations from year to year are expected. In general, radionuclide concentrations in soil samples collected from or adjacent to waste disposal facilities in 2011 were higher than the concentrations in samples collected farther away, including concentrations measured offsite. The data also show, as expected, that concentrations of certain radionuclides in 2011 were higher in different operational

areas when compared to concentrations measured in distant communities in previous years. Generally, the predominant radionuclides detected were activation and fission products in the 100 Areas, fission products in the 200 and 600 Areas, and uranium in the 300 and 400 Areas.

Cesium-137, strontium-90, plutonium-238, plutonium-239/240, and uranium were detected consistently in the 2011 soil samples. Concentrations of these radionuclides were elevated near and within facility boundaries when compared to historical concentrations measured offsite at distant communities. Figure 9.1 shows the average concentrations of selected radionuclides in soil samples collected during 2011 and the preceding 4 years. Some individual levels demonstrate a high degree of variability, although overall trends are stable.

Table 9.3 provides a summary of selected analytical results for near-facility soil samples collected and analyzed. The average and maximum results were reported for six operational areas, along with comparative data for the preceding 5 years. Complete lists of radionuclide concentrations for all soil samples collected during 2011, as well as sampling location maps, are available upon request (refer to Preface).

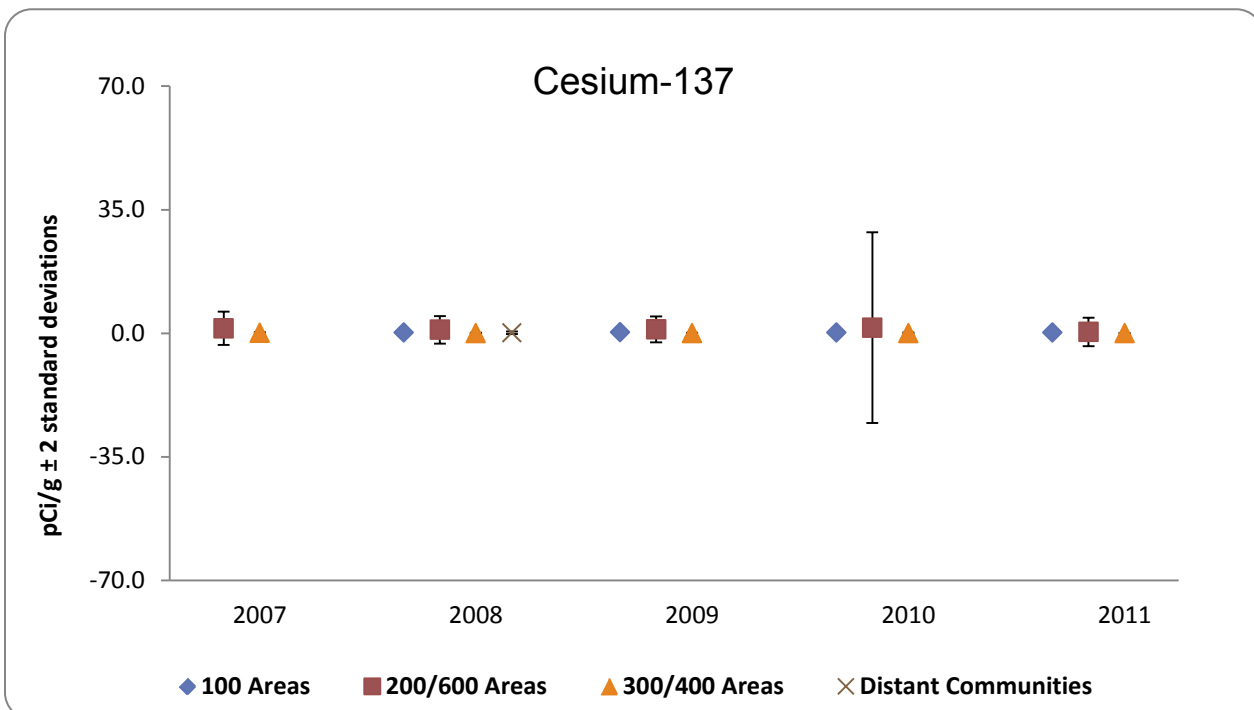
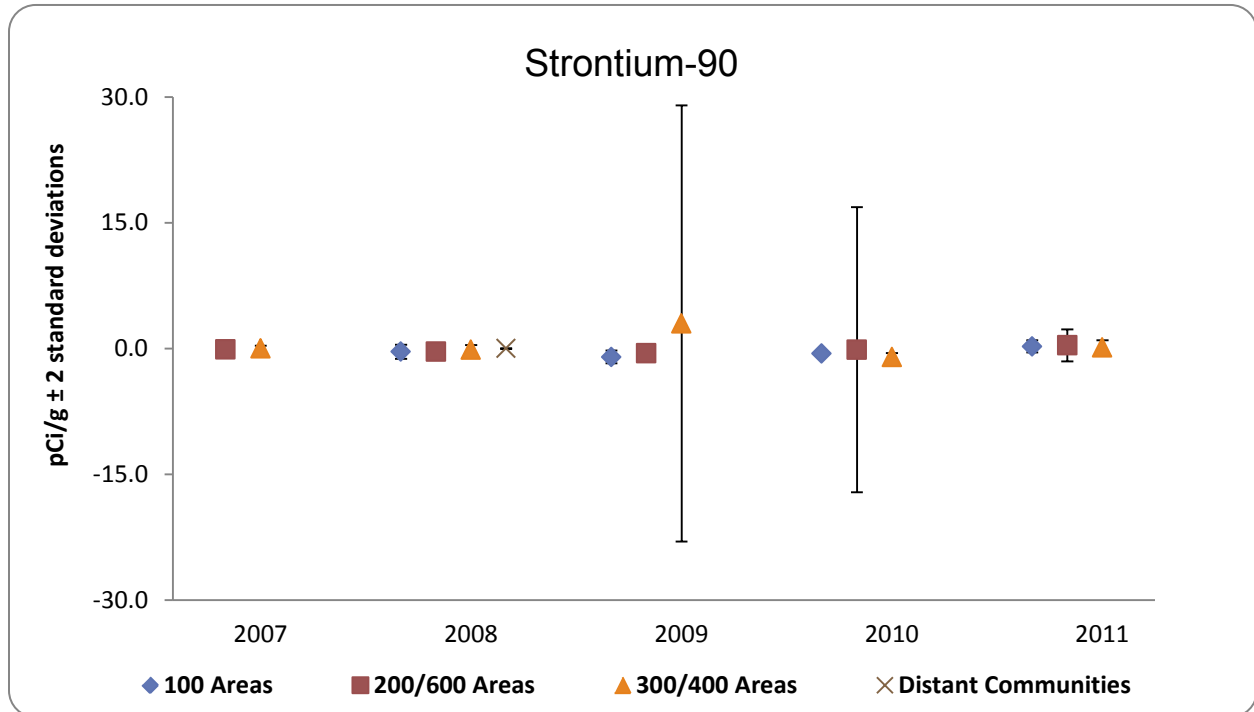
Soil samples collected in 2011 at locations in the 100 Areas, 200-East, 200-West, 300 and 600 Areas were comparable to previous years. Soil samples collected in the 300 Area showed concentrations of uranium-234 and uranium-238 that were comparable to historical data but remained higher than those measured in the 200 Areas. The higher uranium levels in the 300 Area were expected because of uranium releases to the environment during past fuel-fabrication operations. Plutonium-238 and plutonium-239/240 were found at higher levels in a small number of soil samples in the 200 and 600 Areas. Uranium isotopes were also elevated in a small number of samples from the 200-West Area and 600 Area; the 600 Area also had elevated levels of europium-155 in two samples. Cesium-137 levels were above historical levels in both the 200 Area and 600 Area and were likely attributable to the radiological releases associated with the Fukushima nuclear plant incident in March of 2011.

Non-routine soil samples from the 100 Areas were taken in 2011 in support of environmental restoration contractor projects. Six soil samples were taken from three locations in the 100-F Area; four samples were collected at the field remediation project in the 100-H Area; two from the 100-K Area; three from the 100-N Area; and one from the Environmental Restoration Disposal Facility. Analytical results from each of these locations were comparable to those observed at other near-facility sampling locations at the Hanford Site. Table 9.4 provides a summary of selected analytical results for samples from these sites.

**Figure 9.1. Hanford Site Soil Samples Average Concentrations of Selected Radionuclides (2007 through 2011) and those Collected in Distant Communities (2008)**

*Radionuclide concentrations below analytical detection limits are not shown.*

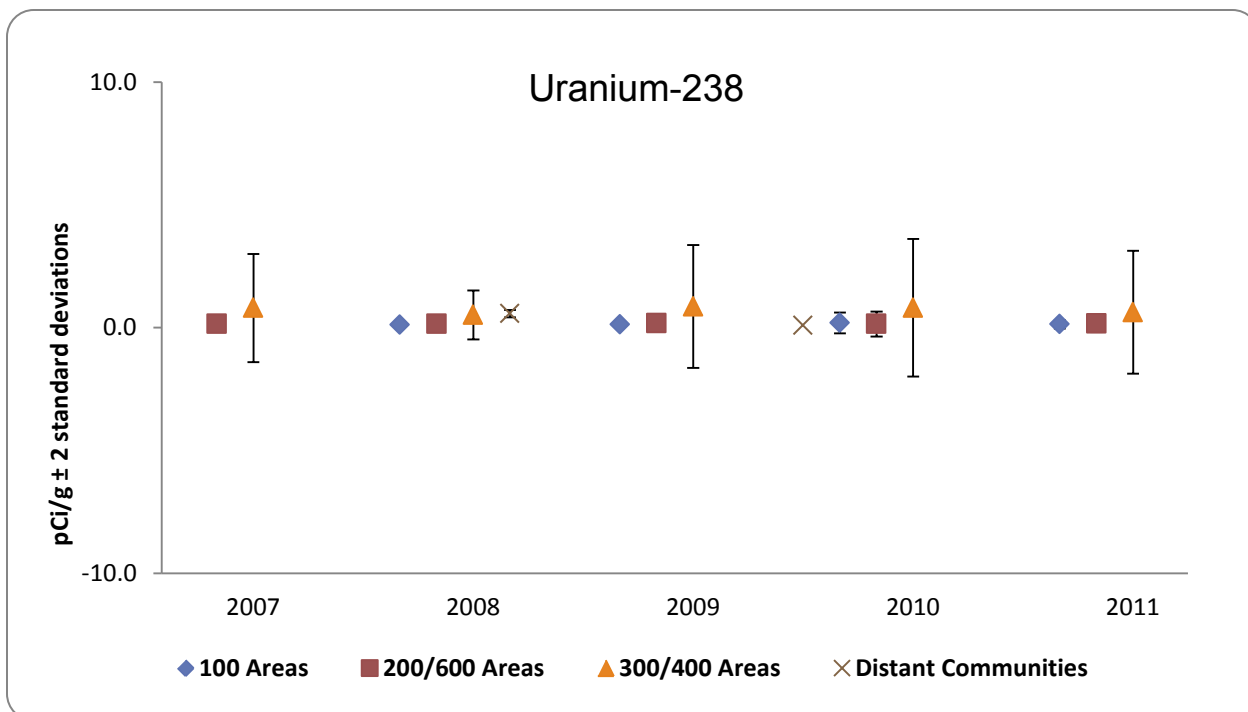
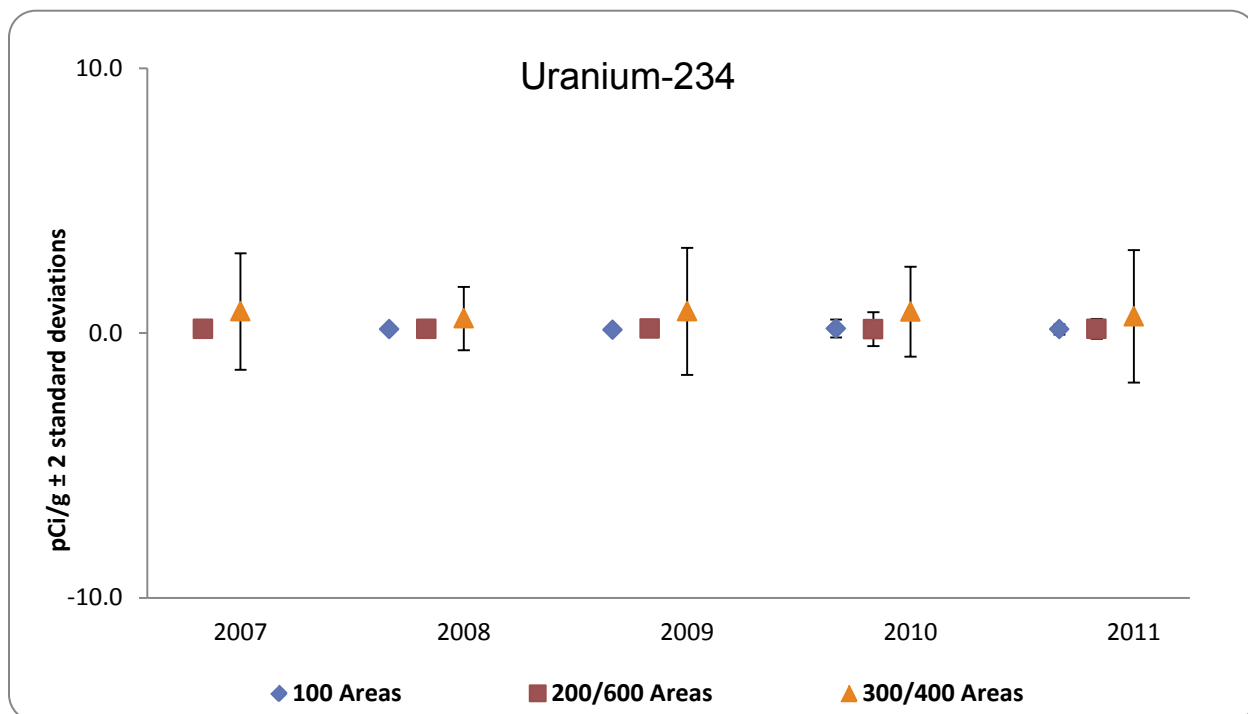
*As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.*



**Figure 9.1. Hanford Site Soil Samples Average Concentrations of Selected Radionuclides (2007 through 2011) and those Collected in Distant Communities (2008) (Cont.)**

*Radionuclide concentrations below analytical detection limits are not shown.*

*As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.*





**Figure 9.1. Hanford Site Soil Samples Average Concentrations of Selected Radionuclides (2007 through 2011) and those Collected in Distant Communities (2008) (Cont.)**

*Radionuclide concentrations below analytical detection limits are not shown.*

*As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.*

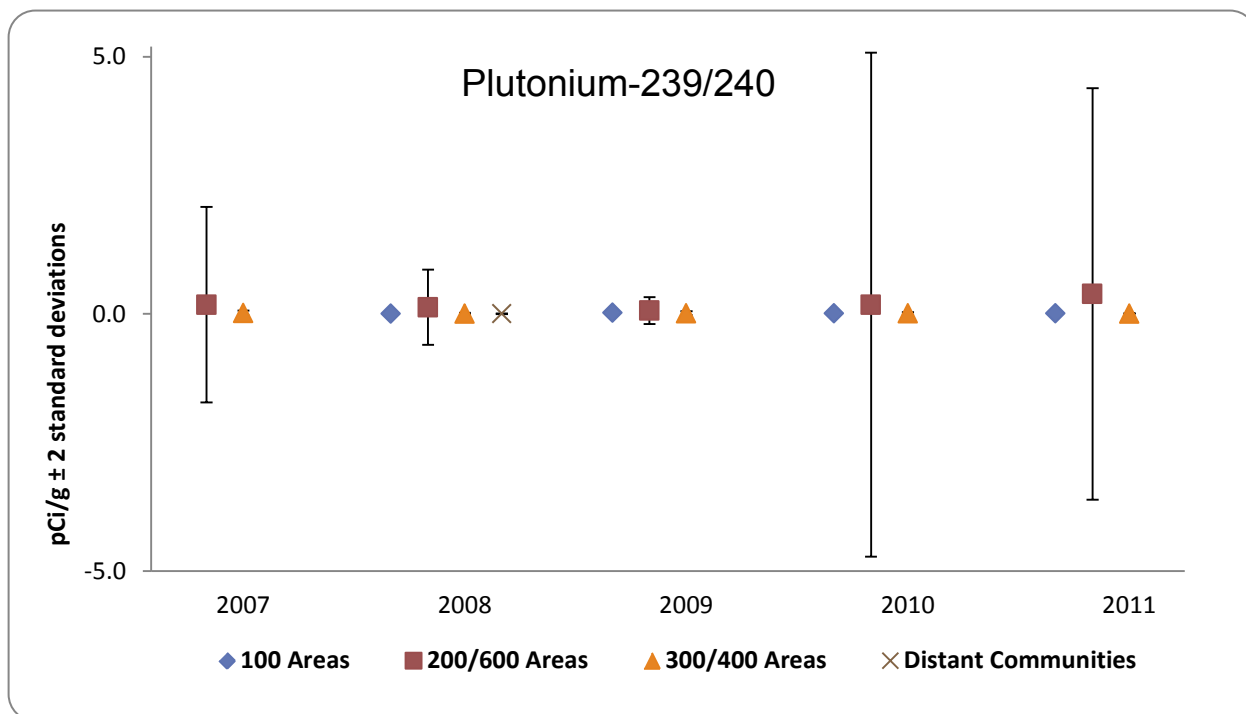


Table 9.3. Concentrations of Selected Radionuclides in Near-Facility Soil Samples, 2011 Compared to Previous Years

Radionuclide	Area	2011				2006-2010			
		Samples	Detections <sup>(b)</sup>	Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	Samples	Detections <sup>(b)</sup>	Average <sup>(c)</sup>	Maximum <sup>(d)</sup>
Cobalt-60	100	6	3	2.6E-02 ± 4.9E-02	6.7E-02 ± 1.3E-02	57	9	2.8E-01 ± 4.3E+00	1.6E+01 ± 1.5E+00
	200-East	15	0	-1.3E-04 ± 1.0E-02	6.4E-03 ± 1.0E-02 <sup>(e)</sup>	75	0	-4.8E-04 ± 8.3E-03	1.0E-02 ± 7.8E-03 <sup>(e)</sup>
	200-West <sup>(f)</sup>	28	0	-2.4E-04 ± 9.0E-03	1.3E-02 ± 1.3E-02 <sup>(e)</sup>	136	1	-3.8E-05 ± 9.1E-03	1.1E-02 ± 9.6E-03 <sup>(e)</sup>
	300	16	0	-6.3E-04 ± 7.1E-03	2.8E-03 ± 5.6E-03 <sup>(e)</sup>	77	0	-2.8E-04 ± 7.5E-03	9.7E-03 ± 8.5E-03 <sup>(e)</sup>
	400	1	0	-9.1E-03 <sup>(g)</sup>	9.1E-03 ± 9.1E-03 <sup>(e)</sup>	5	0	1.3E-03 ± 5.6E-03	5.2E-03 ± 6.9E-03 <sup>(e)</sup>
	600	18	0	-2.0E-04 ± 7.8E-03	7.6E-03 ± 7.3E-03 <sup>(e)</sup>	85	0	-1.6E-02 ± 2.8E-01	1.4E-02 ± 1.3E-02 <sup>(e)</sup>
Strontium-90	100	6	1	2.7E-01 ± 5.4E-01	7.3E-01 ± 5.5E-01 <sup>(e)</sup>	57	0	-3.3E-01 ± 9.2E-01	3.4E-01 ± 4.1E-01
	200-East	15	5	3.2E-01 ± 6.8E-01	9.2E-01 ± 4.9E-01	75	6	-5.0E-02 ± 4.1E+00	1.7E+01 ± 2.2E+00
	200-West <sup>(f)</sup>	28	15	5.5E-01 ± 1.0E+00	1.9E+00 ± 4.7E-01	136	10	-1.9E-01 ± 2.7E+00	1.1E+01 ± 1.4E+00
	300	16	1	9.3E-02 ± 6.6E-01	8.9E-01 ± 5.3E-01 <sup>(e)</sup>	77	5	5.0E-01 ± 1.3E+01	5.5E+01 ± 7.1E+00
	400	1	0	-5.9E-01 <sup>(g)</sup>	-5.9E-01 ± 5.9E-01 <sup>(e)</sup>	5	0	-2.3E-01 ± 1.1E+00	2.8E-01 ± 2.6E-01 <sup>(e)</sup>
	600	18	6	3.0E-01 ± 8.7E-01	1.2E+00 ± 4.6E-01 <sup>(e)</sup>	85	4	-2.6E-01 ± 8.5E-01	1.2E+00 ± 5.0E-01
Cesium-137	100	6	6	1.7E-01 ± 2.7E-01	4.5E-01 ± 5.8E-02	57	56	2.8E+00 ± 3.8E+01	1.4E+02 ± 2.6E+01
	200-East	15	15	1.9E+00 ± 6.5E+00	1.1E+01 ± 1.4E+00	75	75	1.8E+00 ± 6.0E+00	1.4E+01 ± 2.2E+00
	200-West <sup>(f)</sup>	28	28	1.1E+00 ± 2.1E+00	4.0E+00 ± 5.3E-01	136	134	1.4E+00 ± 3.6E+00	1.4E+01 ± 2.3E+00
	300	16	14	5.0E-02 ± 8.2E-02	1.4E-01 ± 2.2E-02	77	65	7.1E-02 ± 1.4E-01	3.6E-01 ± 6.4E-02
	400	1	1	3.2E-02 <sup>(g)</sup>	3.2E-02 ± 9.6E-03	5	5	2.8E-02 ± 1.3E-02	3.9E-02 ± 2.5E-02
	600	18	18	4.9E-01 ± 1.2E+00	2.5E+00 ± 3.3E-01	85	81	1.9E+00 ± 2.1E+01	9.4E+01 ± 1.7E+01
Thorium-228	100	3	3	4.2E-01 ± 1.9E-01	5.4E-01 ± 1.4E-01	8	8	6.2E-01 ± 6.9E-01	1.2E+00 ± 4.9E-01
Thorium-230	100	3	3	4.6E-01 ± 3.3E-01	6.5E-01 ± 1.6E-01	8	8	8.6E-01 ± 1.9E+00	3.2E+00 ± 8.9E-01
Thorium-232	100	3	3	3.8E-01 ± 1.6E-01	4.9E-01 ± 1.3E-01	8	8	6.9E-01 ± 1.0E+00	1.7E+00 ± 6.4E-01
Uranium-234	100	6	6	1.4E-01 ± 5.7E-02	1.9E-01 ± 6.2E-02	56	56	1.5E-01 ± 1.1E-01	3.4E-01 ± 1.1E-01
	200-East	15	15	1.5E-01 ± 1.0E-01	2.3E-01 ± 6.2E-02	75	75	1.6E-01 ± 1.8E-01	8.4E-01 ± 2.8E-01
	200-West <sup>(f)</sup>	28	28	1.6E-01 ± 1.2E-01	3.8E-01 ± 9.5E-02	136	136	1.7E-01 ± 1.3E-01	5.1E-01 ± 1.4E-01
	300	16	16	6.6E-01 ± 1.5E+00	2.5E+00 ± 6.5E-01	77	77	8.8E-01 ± 2.4E+00	5.3E+00 ± 1.4E+00
	400	1	1	1.4E-01 <sup>(g)</sup>	1.4E-01 ± 5.0E-02	5	5	1.7E-01 ± 1.1E-01	2.4E-01 ± 7.4E-02
	600	18	18	1.7E-01 ± 1.0E-01	3.4E-01 ± 1.0E-01	85	85	1.7E-01 ± 1.4E-01	6.4E-01 ± 1.8E-01

Table 9.3. Concentrations of Selected Radionuclides in Near-Facility Soil Samples, 2011 Compared to Previous Years

Radionuclide	Area	2011				2006-2010			
		Samples	Detections <sup>(b)</sup>	Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	Samples	Detections <sup>(b)</sup>	Average <sup>(c)</sup>	Maximum <sup>(d)</sup>
Uranium-235	100	6	1	8.5E-03 ± 7.5E-03	1.5E-02 ± 1.2E-02	54	34	1.3E-02 ± 1.4E-02	3.4E-02 ± 1.9E-02
	200-East	15	10	1.2E-02 ± 1.0E-02	2.8E-02 ± 1.8E-02	75	39	1.3E-02 ± 1.3E-02	3.3E-02 ± 1.9E-02
	200-West <sup>(f)</sup>	21	12	1.4E-02 ± 1.9E-02	4.4E-02 ± 2.3E-02	136	74	1.6E-02 ± 2.1E-02	5.4E-02 ± 2.4E-02
	300	16	12	4.5E-02 ± 9.7E-02	1.7E-01 ± 6.6E-02	77	60	5.8E-02 ± 1.4E-01	3.5E-01 ± 1.0E-01
	400	1	0	8.7E-03 <sup>(g)</sup>	8.7E-03 ± 9.0E-03 <sup>(e)</sup>	5	2	1.6E-02 ± 1.5E-02	2.9E-02 ± 1.8E-02
	600	8	6	1.5E-02 ± 9.9E-03	2.3E-02 ± 1.5E-02	85	43	1.5E-02 ± 2.0E-02	6.1E-02 ± 2.7E-02
Uranium-238	100	6	6	1.4E-01 ± 3.4E-02	1.7E-01 ± 5.5E-02	57	57	1.4E-01 ± 1.2E-01	4.2E-01 ± 1.2E-01
	200-East	15	15	1.5E-01 ± 6.8E-02	2.2E-01 ± 6.8E-02	75	75	1.6E-01 ± 1.7E-01	7.7E-01 ± 2.6E-01
	200-West <sup>(f)</sup>	28	28	1.6E-01 ± 1.0E-01	3.4E-01 ± 8.8E-02	136	136	1.6E-01 ± 1.4E-01	5.3E-01 ± 1.5E-01
	300	16	15	6.6E-01 ± 1.5E+00	2.5E+00 ± 6.8E-01	77	77	8.8E-01 ± 2.4E+00	5.3E+00 ± 1.4E+00
	400	1	1	1.2E-01 <sup>(g)</sup>	1.2E-01 ± 4.8E-02	5	5	1.7E-01 ± 6.1E-02	2.1E-01 ± 6.9E-02
	600	18	18	1.7E-01 ± 9.5E-02	3.0E-01 ± 9.0E-02	85	85	1.6E-01 ± 1.2E-01	5.1E-01 ± 1.5E-01
Plutonium-238	100	6	0	2.9E-03 ± 9.3E-03	8.6E-03 ± 9.3E-03 <sup>(e)</sup>	57	1	1.9E-03 ± 3.6E-02	4.8E-02 ± 2.9E-02
	200-East	15	2	-7.2E-04 ± 4.0E-02	5.1E-02 ± 2.2E-02 <sup>(e)</sup>	75	1	3.2E-03 ± 4.1E-02	1.2E-01 ± 5.5E-02
	200-West <sup>(f)</sup>	28	3	-2.9E-04 ± 3.1E-02	2.7E-02 ± 1.8E-02	136	8	1.3E-02 ± 6.1E-02	2.1E-01 ± 5.9E-02
	300	16	1	-1.2E-04 ± 2.6E-02	3.2E-02 ± 4.2E-02 <sup>(e)</sup>	77	1	1.5E-03 ± 2.4E-02	3.5E-02 ± 3.8E-02 <sup>(e)</sup>
	400	1	0	-4.9E-02 <sup>(g)</sup>	-4.9E-02 ± 4.9E-02 <sup>(e)</sup>	5	0	-1.0E-03 ± 2.7E-02	1.1E-02 ± 3.8E-02 <sup>(e)</sup>
	600	18	1	2.6E-03 ± 1.5E-02	1.9E-02 ± 1.3E-02	85	3	7.9E-03 ± 8.2E-02	3.7E-01 ± 1.1E-01
Plutonium-239/240	100	6	3	9.9E-03 ± 1.5E-02	2.0E-02 ± 1.4E-02	57	18	1.2E-02 ± 1.8E-02	4.4E-02 ± 2.2E-02
	200-East	15	6	2.4E-01 ± 1.7E+00	3.5E+00 ± 7.7E-01	75	24	1.1E-02 ± 3.0E-02	9.7E-02 ± 3.9E-02
	200-West <sup>(f)</sup>	28	22	7.9E-02 ± 3.1E-01	7.5E-01 ± 1.7E-01	136	102	2.1E-01 ± 1.4E+00	7.3E+00 ± 1.9E+00
	300	16	3	9.2E-03 ± 2.7E-02	5.8E-02 ± 2.9E-02	77	26	1.4E-02 ± 3.8E-02	7.6E-02 ± 2.8E-02
	400	1	0	6.7E-03 <sup>(g)</sup>	6.7E-03 ± 1.0E-02 <sup>(e)</sup>	5	0	2.0E-03 ± 4.4E-03	4.7E-03 ± 9.5E-03 <sup>(e)</sup>
	600	18	6	6.8E-02 ± 3.3E-01	7.1E-01 ± 1.7E-01	85	47	9.5E-02 ± 1.1E+00	4.9E+00 ± 1.3E+00

(a) pCi/g dry wt., 1 pCi = 0.037 Bq.

(b) Number of samples with measurable concentrations of contaminant.

(c) Average ± two standard deviations of all samples analyzed.

(d) Maximum ± analytical uncertainty.

(e) Maximum value reported is a non-detect.

(f) Includes one sample collected at the Environmental Restoration Disposal Facility.

(g) Average cannot be calculated from a single sample.

NA = Not applicable.

**Table 9.4. Radionuclide Concentrations in Environmental Restoration Contractor Field Remediation Projects' Soil Samples, 2011**  
(pCi/g<sup>(a)</sup> dry wt.)<sup>(b)</sup>

Project/Facility	Location <sup>(c)</sup>	Date	Cobalt-60	Strontium-90	Cesium-137	Uranium-234	Uranium-238	Plutonium-239/240
100-F Field Remediation	D154	12/20/11	1.9E-02 ± 2.3E-02	-2.2E-02 ± 1.7E-01	8.1E-02 ± 6.1E-02	1.1E-01 ± 3.8E-02	1.3E-01 ± 4.2E-02	1.7E-02 ± 1.2E-02
	D155	12/20/11	5.2E-04 ± 5.2E-03	1.3E-01 ± 1.7E-01	2.1E-01 ± 3.0E-02	1.2E-01 ± 3.8E-02	1.3E-01 ± 4.1E-02	3.2E-03 ± 6.5E-03
	D170	12/20/11	2.1E-03 ± 7.0E-03	3.6E-02 ± 1.8E-01	1.3E-01 ± 2.1E-02	1.3E-01 ± 4.4E-02	1.2E-01 ± 4.2E-02	1.6E-03 ± 5.7E-03
100-N D4	D156	6/14/11	5.1E-02 ± 9.1E-03	2.3E-01 ± 5.0E-01	4.5E-01 ± 5.8E-02	1.2E-01 ± 4.4E-02	1.2E-01 ± 4.2E-02	1.6E-02 ± 1.3E-02
	D158	6/14/11	6.7E-02 ± 1.3E-02	5.2E-01 ± 5.4E-01	1.4E-01 ± 2.7E-02	1.9E-01 ± 6.2E-02	1.5E-01 ± 5.1E-02	2.0E-02 ± 1.4E-02
	D183	6/14/11	1.4E-02 ± 7.6E-03	7.3E-01 ± 5.5E-01	2.2E-02 ± 1.2E-02	1.7E-01 ± 5.6E-02	1.7E-01 ± 5.5E-02	2.1E-03 ± 2.1E-03
618-10 Field Remediation	D179	2/22/11	-9.0E-03 ± 1.3E-02	-9.0E-01 ± 9.0E-01	1.7E-01 ± 4.1E-02	9.3E-02 ± 3.8E-02	1.5E-01 ± 5.4E-02	1.2E-02 ± 1.0E-02
	D180	2/22/11	1.1E-03 ± 9.1E-03	-4.9E-01 ± 4.9E-01	4.6E-02 ± 2.0E-02	1.0E-01 ± 4.0E-02	1.5E-01 ± 5.3E-02	3.9E-03 ± 9.6E-03
	D181	2/22/11	-6.0E-04 ± 6.0E-03	-2.8E-01 ± 5.2E-01	4.3E-02 ± 1.9E-02	1.0E-01 ± 3.9E-02	1.2E-01 ± 4.6E-02	1.7E-02 ± 1.4E-02
	D182	2/22/11	5.8E-04 ± 5.4E-03	2.8E-01 ± 5.0E-01	3.8E-02 ± 1.1E-02	1.2E-01 ± 4.7E-02	1.1E-01 ± 4.3E-02	3.9E-03 ± 5.6E-03
ERDF	D146	5/23/11	4.9E-03 ± 6.1E-03	6.7E-01 ± 4.4E-01	1.5E-02 ± 9.0E-03	1.4E-01 ± 4.9E-02	1.7E-01 ± 5.6E-02	3.3E-03 ± 6.7E-03
Accessible soil concentration <sup>(d)</sup>			7.1	2,800	30	630	370	190

(a) 1 pCi = 0.037 Bq.

(b) ± total analytical uncertainty.

(c) Sampling location code.

(d) Hanford soils that are not behind security fences.

ERDF = Environmental Restoration Disposal Facility (200-West Area).

### 9.3 Radiological Results

Investigations for radioactive contamination in soil were conducted in and near operational areas to monitor the presence or movement of radioactive materials around areas of known or suspected contamination or to verify radiological conditions at specific project sites. All samples collected during investigations were field surveyed for alpha and beta-gamma radiation. Generally, the predominant radionuclides in samples from the 100 Area and 200 Area have been strontium-90, cesium-137, and plutonium-239/240. Uranium-234, uranium-235, and uranium-238 have been routinely found in 300 Area samples.

Ten instances of radiological contamination in soil samples were collected in 2011 during the investigations. Of the 10, 8 were identified as speck contamination, and all were cleaned up and disposed onsite in licensed burial grounds. None of the soil samples were submitted for radioisotopic analysis. The number of soil investigation contamination incidents and range of radiation dose levels in 2011 were generally within historical values ([WHC-MR-0418](#)). Table 9.5 summarizes the number and general locations of soil contamination incidents investigated during 2011. Table 9.6 provides the number of contamination incidents investigated in 2011 and during the previous 12 years.

**Table 9.5. Soil Contamination Incidents Investigated (2011)**

Locations	Incidents
<b>100 Areas</b>	<b>1</b>
200-East Area	
Tank farms	3
Burial grounds	0
Cribs, ponds, and ditches	0
Fence lines	0
Roads and railroads	0
Unplanned release sites	0
Underground pipelines	1
Miscellaneous	1
<b>200-West Area</b>	
Tank farms	4
Burial grounds	0
Cribs, ponds, and ditches	0
Fence lines	0
Roads and railroads	0
Unplanned release sites	0
Underground pipelines	0
Miscellaneous	0
Cross-site transfer line	0
200-BC cribs and trenches	0
200-North Area	0
<b>300 Area</b>	<b>0</b>
<b>400 Area</b>	<b>0</b>
<b>600 Area</b>	<b>0</b>
<b>1100 Area (former)</b>	<b>0</b>
<b>TOTAL</b>	<b>10</b>

**Table 9.6. Soil Contamination Incidents Investigated (1999 through 2011)**

<b>Year</b>	<b>Incidents</b>	<b>Year</b>	<b>Incidents</b>
1999	42	2006	25
2000	25	2007	17
2001	20	2008	16
2002	22	2009	28
2003	30	2010	22
2004	19	2011	10
2005	20		

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## 10.0 Biota Monitoring

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### 10.1 Agricultural Monitoring

*ME Hoefer*

Food and farm products (alfalfa, cherries, leafy vegetables, milk, potatoes, tomatoes, and wine) were collected in 2011 at locations near the Hanford Site (Figure 10.1). Samples analyzed to determine radiological contaminant concentrations were obtained from the following locations:

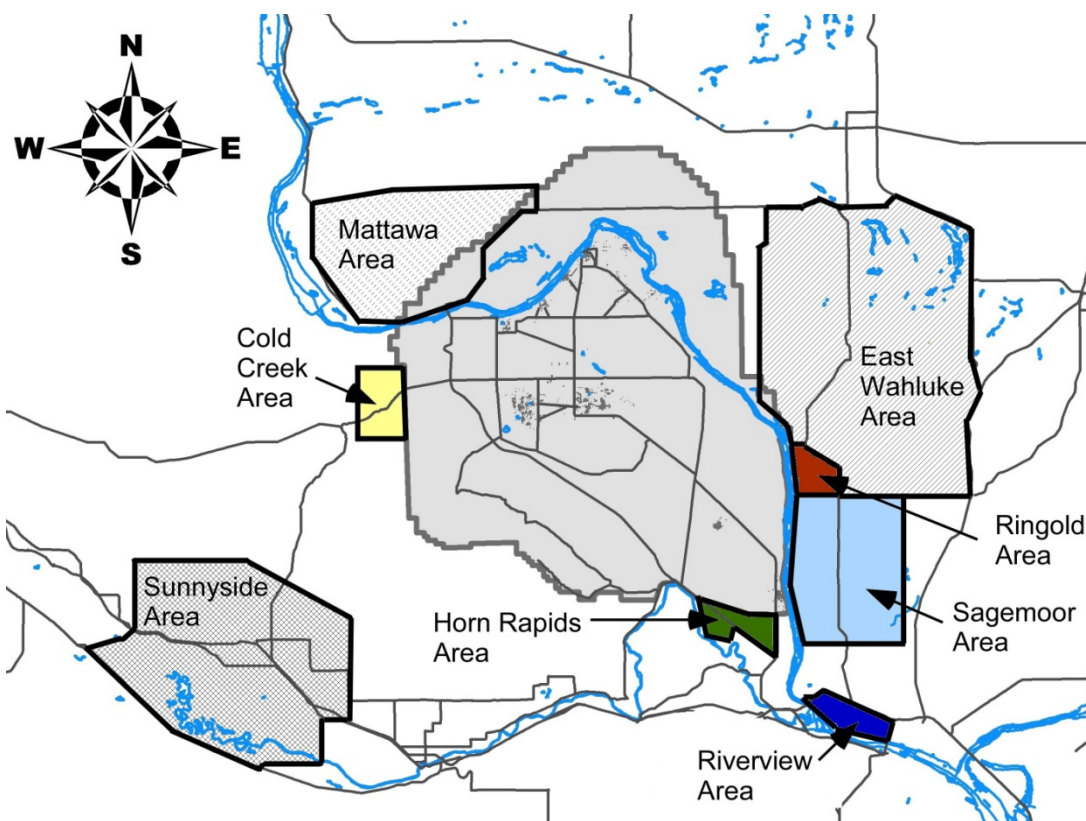
- Generally downwind (east and southeast) of the Hanford Site where airborne emissions or contaminated dust from the site potentially would be deposited
- Generally upwind of and distant from the Hanford Site to provide information about reference (background) contaminant levels
- Farms irrigated with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

Results of sample analyses are used to assess the amounts of Hanford Site contaminants in food and farm products by comparing:

- Analytical results obtained from similar samples collected from the same regions over long periods of time
- Analytical results from samples collected at downwind locations to results from samples obtained from generally upwind or distant locations
- Analytical results from samples collected in areas irrigated with water withdrawn from the Columbia River downstream from 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 2011 were below levels that could be detected by analytical laboratories; however, some contaminants that potentially could have originated from the Hanford Site (e.g., tritium and uranium) were found at low levels in some samples. These findings are presented in the following sections. Data for naturally occurring potassium-40 are included to show the amounts of this natural radioactive element in food products relative to concentrations of contaminants potentially from the Hanford Site. Radiological doses associated with possible site-produced contaminants are discussed in [Section 4.0](#). Where possible, the measured concentrations are compared to the applicable unusual concentration reporting levels. Unusual concentration reporting levels have been established based on environmental concentrations that would result in a 1-millirem (10-microsievert) dose per year ([DOE/RL-91-50](#), Rev. 4).

Agricultural products sampled are listed in Table 10.1, and described in the following sections.

**Figure 10.1. Agricultural Monitoring Locations (2011)****Table 10.1. Agricultural Products Monitored (2011)**

Product	Sampling Locations	Analytes
Alfalfa	Horn Rapids, Riverview, Sagemoor, and Sunnyside	Gamma, Strontium-90
Cherries	East Wahluke, Ringold, Riverview, Sagemoor, and Sunnyside	Gamma, Strontium-90
Leafy Vegetables	Riverview, Sagemoor, and Sunnyside	Gamma, Strontium-90
Milk	East Wahluke, Sagemoor, and Sunnyside	Gamma, Strontium-90, Tritium
Potatoes	East Wahluke, Horn Rapids, Riverview, and Sunnyside	Gamma, Strontium-90
Tomatoes	Riverview, and Sunnyside	Gamma, Strontium-90, Tritium
Wine	Columbia Basin, Mattawa, and Yakima Valley	Gamma, Tritium

### 10.1.1 Milk Results

Milk samples were obtained quarterly in 2011 from multiple dairies in the East Wahluke sampling area, multiple dairies in the Sagemoor area, and one dairy in the Sunnyside sampling area. The Sagemoor and East Wahluke sampling areas are located near the Hanford Site perimeter and potentially could 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 gamma-emitting radionuclides, tritium, and strontium-90. 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, and concentrations in samples obtained from dairies downwind of the Hanford Site are now similar to levels measured in samples obtained from the dairy generally upwind of the Hanford Site.

**Tritium** – Tritium was detected in all milk samples collected in 2011. Concentrations ranged from a maximum of 55 pCi/L (2.0 Bq/L) in both a Sunnyside and Wahluke area sample to 13 pCi/L (0.48 Bq/L) in another Sunnyside area sample. Annual average concentrations for the three sampling areas were 35 pCi/L (1.3 Bq/L) for Sagemoor (n = 4); 25 pCi/L (0.93 Bq/L) for East Wahluke (n = 4); and 29 pCi/L (1.1 Bq/L) for Sunnyside (n = 4). These are lower concentrations than historically measured in these areas. The unusual concentration reporting level for tritium in milk is an annual average of 54,000 pCi/L (2,000 Bq/L).

**Potassium-40** – Potassium-40 was detected in all milk samples collected in 2011. Potassium-40 is a naturally occurring radionuclide found in soil and in fertilizers applied to soil. It is the predominant radionuclide in foods and human tissues (Eisenbud 1987). Concentrations ranged between 1,400 pCi/L (52 Bq/L) and 1,700 pCi/L (63 Bq/L).

**Strontium-90** – Strontium-90 was not measured at detectable concentrations in any milk samples collected in 2011. The nominal analytical detection limit for strontium-90 in milk was 1.5 pCi/L (0.06 Bq/L), or 18 times below the unusual concentration reporting level for strontium-90 in milk (27 pCi/L [1.0 Bq/L]).

**Cesium-137** – No manmade gamma emitters were detected in milk samples collected and analyzed in 2011.

### 10.1.2 Fruit and Vegetable Results

Cherries, leafy vegetable (e.g., lettuce), potato, and tomato samples were collected from upwind and downwind sampling areas during the 2011 growing season (Figure 10.1). All samples were analyzed for gamma-emitting radionuclides and strontium-90. Tomato samples were also monitored for tritium (Table 10.1). Potassium-40 was detected in all of the fruit and vegetable samples collected. Additionally, one leafy vegetable sample had a detectable concentration of beryllium-7 (a naturally occurring radionuclide), and one leafy vegetable sample had detectable concentrations of strontium-90. The leafy vegetable sample collected in the Riverview area had the highest strontium-90 concentration (0.007 pCi/g [0.26 mBq/g]). This concentration is approximately 37 times lower than the unusual concentration reporting level for strontium-90 in leafy vegetables (0.27 pCi/g [10 mBq/g]).

### 10.1.3 Alfalfa Results

Alfalfa samples were collected in the spring of 2011 from commercial fields in the Horn Rapids, Riverview, Sagemoor, and Sunnyside sampling areas (Figure 10.1). Samples were analyzed for gamma-producing radionuclides and strontium-90 (Table 10.1). Collections from the Horn Rapids and the Riverview area had detectable concentrations of strontium-90 (0.06 and 0.07 pCi/g, respectively). Potassium-40 and beryllium-7

also had detectable radionuclide concentrations in all sampling locations. The maximum potassium-40 concentration measured in alfalfa in 2011 was 12.2 pCi/g (.44 Bq/g), which was collected in the Sunnyside area. The radionuclide concentration was comparable to historical limits and naturally occurring concentrations in soil that can also be found in fertilizers applied to the soil.

#### 10.1.4 Wine Results

Red and white wine samples were obtained in November 2011 from two wineries near the Hanford Site and at an upwind location. The wines were produced from 2011 vintage grapes that were harvested in the fall from vineyards located in the Columbia Basin area just north of Pasco (downwind of the site), near Mattawa (site perimeter) and just east of Yakima (generally upwind of the Hanford Site). Each wine was divided (split) into two samples and all samples were analyzed for gamma-emitting radionuclides and tritium (Table 10.1).

**Cesium-137** – Cesium-137 was the only manmade gamma emitter measured in wine samples analyzed in 2011. Samples ranged from non-detect to 1.8 pCi/L and all were well within historical ranges of acceptable maximum detection limits of less than 3.0 pCi/L.

**Potassium-40** – Naturally occurring potassium-40 was measured in all wine samples analyzed in 2011. Concentrations in all samples ranged from 640 to 1,840 pCi/L (24 to 68 Bq/L). Potassium-40 concentrations were higher in red wines than in white wines at upwind and downwind locations, but not at the site perimeter location. This may be attributable to higher yeast amounts at time of collection as the Mattawa sample was early in the fermentation process.

**Tritium** – Tritium was detected at low levels in all wine samples analyzed in 2011. Concentrations in all samples ranged from 15 to 117 pCi/L (0.56 to 4.3 Bq/L). The average concentration for all samples was 52 pCi/L (1.9 Bq/L). Concentrations measured in samples collected in the Yakima Area were lower than concentrations measured in samples collected from the Columbia Basin and Mattawa areas. While there is no health-based standard for tritium in wine, the standard for tritium in drinking water is 20,000 pCi/L (740 Bq/L).

### 10.2 Animal Monitoring

*JW Wilde*

Animal monitoring conducted on and around the Hanford Site in 2011 included fish and wildlife. Fish and wildlife on and around the Hanford Site are monitored for site-produced contaminants. Monitoring various biota for uptake and exposure to radionuclides both near and distant from Hanford Site operations continues to ensure that consumption of fish and wildlife obtained from the site environs does not pose a threat to humans. Monitoring also provides long-term contamination trends in selected ecosystem components. Fish and wildlife sampled and analyzed during 2011 for radioactive constituents included Nuttall's cottontail (*Sylvilagus nuttallii*), Smallmouth bass (*Micropterus dolomieu*), Canada goose (*Branta canadensis*), and Mountain whitefish (*Prosopium williamsoni*). The monitored species provide a potential pathway for offsite human consumption.

Several types of wildlife and fish were collected in 2011 from locations at and around the Hanford Site as part of routine monitoring for site-produced contaminants (Figure 10.2). Samples from these organisms were analyzed for selected radionuclides and metals that are suspected or known to be present at the Hanford Site. Samples also were collected from locations distant from the site to obtain reference (background) contaminant measurements. Most fish and wildlife samples collected on or near the Hanford Site for routine human-

exposure pathway assessments are obtained annually, but specific species are sampled only every 2 or 3 years. Samples obtained at locations believed to be unaffected by Hanford Site effluents and emissions are collected approximately every 5 years.

All fish and wildlife samples collected in 2011 were monitored for strontium-90 contamination and were analyzed by gamma spectrometry to detect a number of gamma emitters, including cesium-137 (Appendix D). Since the 1990s, strontium-90 and cesium-137 have been the most frequently measured radionuclides in fish and wildlife samples

**Table 10.2. Animal Results (2011)**

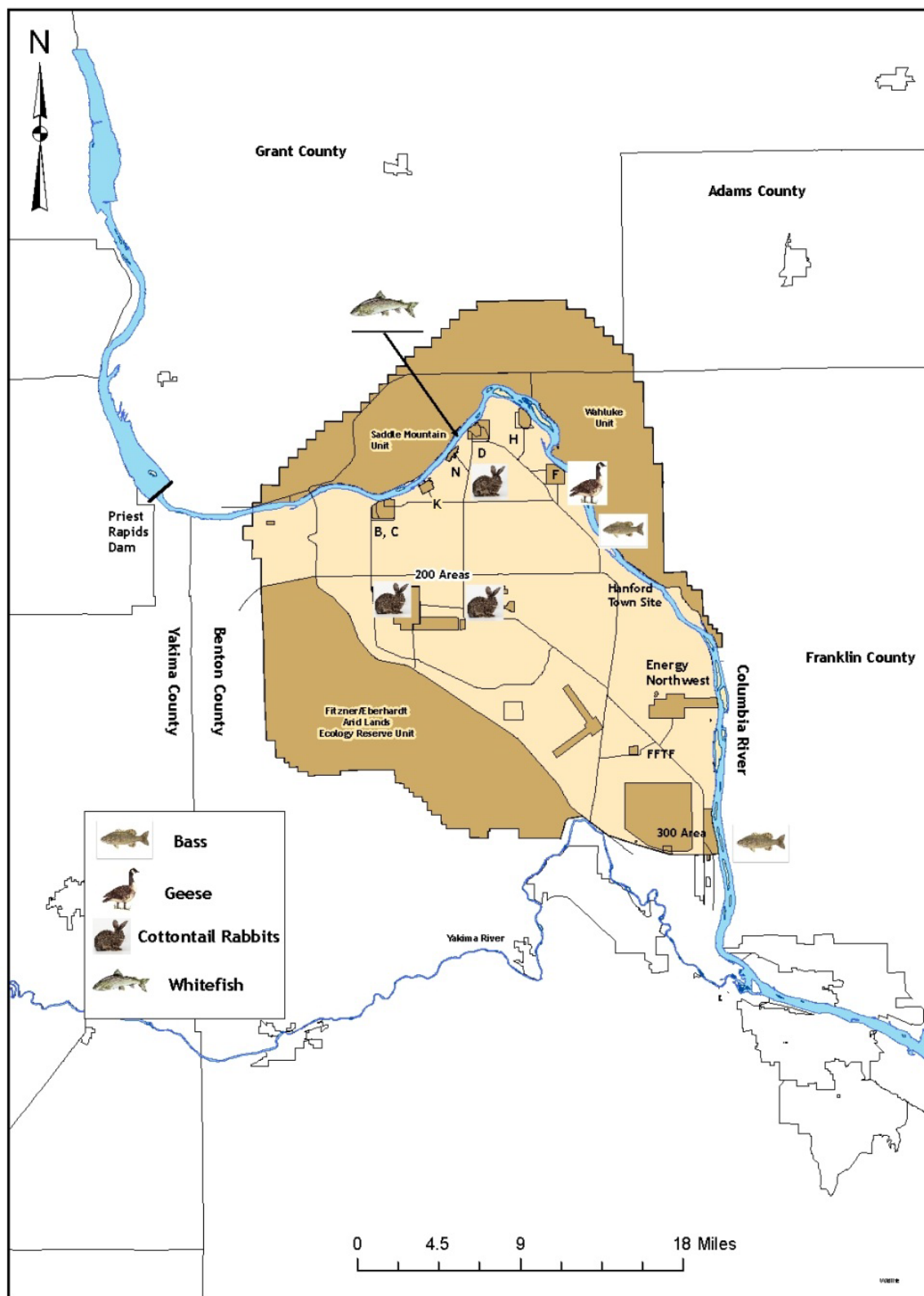
Biota	Offsite Locations	Onsite Locations	Gamma	Strontium-90	Trace Metals
Fish (Smallmouth bass)	0	2	8	8	8
Fish (Mountain whitefish)	1	1	10	10	10
Cottontail Rabbits	0	3	10	10	10
Waterfowl (goose)	0	1	1	1	1

Strontium-90 is present in Hanford Site environments because of past site operating and waste disposal practices. Contaminated groundwater entering the Columbia River through shoreline springs in the 100-N Area and 100-H Area is the primary source of measurable site-produced strontium-90 in the Columbia River. Strontium-90 is chemically similar to calcium; consequently, it accumulates in hard tissues rich in calcium such as bones, antlers, and eggshells. Strontium-90 has a biological half-life in hard tissue of 14 to 600 days ([PNL-9394](#)). Hard-tissue concentrations may profile an organism's lifetime exposure to strontium-90, but since it does not accumulate in the edible portions of fish and wildlife, it generally does not contribute much to human dose (National Council on Radiation Protection and Measurements, 1991).

Cesium-137 is particularly important to the human food chain because it is chemically similar to potassium and is found in the muscle tissues of fish and wildlife. Having a relatively short biological half-life (less than 200 days in muscle and less than 20 days in the gastrointestinal tract ([PNL-9394](#)), cesium-137 is an indicator of recent exposure to radioactive materials. Cesium-137 is present in the environment because of past Hanford Site operating and waste disposal practices as well as from historical worldwide fallout resulting from nuclear weapons testing.

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 levels that could be detected by the analytical laboratory. Results, propagated analytical uncertainties, and minimum detection amounts for all 2011 fish and wildlife samples are available upon request.

A number of trace metals associated with Hanford Site operations have the 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. Historical operations at the Hanford Site resulted in the production of both radiological and non-radiological wastes, including trace-metal emissions in a variety of forms. Liquid and solid wastes were placed in various disposal sites, including trenches, cribs, ditches, ponds, and underground storage tanks. In the past, fly ash, produced from burning coal in coal-fired steam/power plants associated with some reactors, was released to the atmosphere. Fly ash contains trace metals and natural radionuclides that may have deposited on soil surfaces around the reactor areas.

**Figure 10.2. Animal Monitoring Locations (2011)**

Other sources have contributed trace metals to the Hanford Site environment as well. Trace metals, generated from upriver mining and smelting, have been transported down the Columbia River and into the Hanford Reach (Johnson et al. 2005). Contaminants associated with past and present agricultural practices also have contributed to the metals inventory at the Hanford Site ([Yokel and Delistraty, 2003](#)); one example is arsenic. Lead arsenate was once the most commonly used insecticide in fruit orchards. The presence of arsenic at some Hanford Site locations is likely associated with the historical applications of this lead arsenate insecticide on fruit orchards that were common on the site prior to World War II. Studies that examined the extent of arsenic contamination in pre-World War II orchard soil near the 100 Areas found elevated levels of arsenic when compared to levels in soil from background locations ([Yokel and Delistraty, 2003](#)).

Organisms can accumulate metals through incidental soil ingestion, by drinking contaminated water, and by consuming contaminated foods. The spatial variability of trace-metal concentrations in the environment is influenced by the contributions of both natural sources and industrial contaminants, and organisms may range widely over areas influenced to varying degrees by both; therefore, trace-metal concentrations and organism exposures can vary between locations. This variability can produce some uncertainty in terms of identifying the source of trace-metal concentrations found in a given organism. Fish and wildlife have been collected upstream of the Hanford Site and from reference areas (between Wanapum and Priest Rapids dams) distant from the site to determine the Hanford Site contributions to trace-metal levels identified in biota-sampled onsite or in the Hanford Reach. Trace-metal concentrations measured in the upstream and reference samples are compared with samples collected on the Hanford Site. This comparison could indicate increases in concentrations of trace metals potentially due to onsite activities.

The utility of this evaluation is limited by a somewhat small set of data for wildlife and fish that have been sampled from the Hanford Reach, Hanford Site, and background locations. Sample sizes have been relatively small for targeted organisms in these areas, and sampling events have alternated by organism type, resulting in three to possibly four sampling events over an 8-year period. Small sample sizes taken over a relatively short period, along with the spatial variability inherent in an organism's exposure, underlie to some degree the inconsistency found in the trace-metal data presented in the following discussions. The addition of future sampling data may reduce this variability and, therefore, enhance its utility for determining potential Hanford Site contributions to trace-metal concentrations in organisms sampled from the Hanford Site environment. Fish and wildlife species sampled and analyzed in 2011 for radionuclides and/or trace metals included: Smallmouth bass, Mountain whitefish, Nuttall's cottontail, and Canada goose (Figure 10.2). Data results are summarized in the following discussions.

### **10.2.1 Fish Results**

Fishing is a popular activity along the Hanford Reach of the Columbia River. Fish, such as the Smallmouth bass and Mountain whitefish, are sometimes harvested for food and could potentially contribute to human exposure. Smallmouth bass are a predatory fish that feeds on invertebrates and smaller fish along the Hanford Reach and, therefore, may be exposed to trace metals and persistent radionuclides in the Columbia River environment through food sources.

#### **10.2.1.1 Mountain Whitefish**

Five Mountain whitefish were collected in 2011 from a single location in the Hanford Reach: five from the region between the 100-N Area and 100-D Area. Five additional Mountain whitefish were collected from an upriver location below the Wanapum Dam (Figure 10.2). Fillets and the eviscerated remains (carcasses) of



Mountain whitefish were analyzed for a variety of radiological contaminants, and liver samples were analyzed for metals.

**Cesium-137.** Manmade gamma-emitting radionuclides, including cesium-137, were not found above the reporting limit (0.03 pCi/g [0.001 Bq/g] wet weight) in any of the muscle samples analyzed in 2011. These results are consistent with historic values reported the past 10 years both at reference locations and near the Hanford Site.

**Strontium-90.** Strontium-90 was not discovered above the reporting limit (0.05 pCi/g [0.0019 Bq/g] wet weight) in Mountain whitefish samples collected in 2011 from the Hanford Reach or upriver reference locations. These results are consistent with historic values reported the past 10 years both at reference locations and near the Hanford Site.

**Trace Metals.** Liver samples were measured for trace-metal concentrations in all Mountain whitefish samples collected in 2011 along the Hanford Reach and the upriver reference site. Seventeen metals were tested on all liver samples. Only copper, mercury, nickel, and zinc were detected above the analytical detection limit at any location. With the exception of manganese and uranium, the average concentration of metals was higher in the five samples from the Hanford Reach compared to those from the reference area (Table 10.3).

**Table 10.3. Mountain Whitefish Results for Selected Metals (2011)**  
(ug/kg)

Isotope	Samples	Detects	100N - 100D	Reference <sup>(a)</sup>
Aluminum	10	0	12232.00	6650.00
Antimony	10	0	603.20	322.80
Arsenic	10	0	899.20	489.00
Beryllium	10	0	179.86	97.82
Cadmium	10	0	230.56	117.18
Chromium	10	0	296.60	246.80
Copper	10	10	7128.00	3266.00
Lead	10	0	594.00	322.80
Manganese	10	0	1852.00	1920.00
Mercury	8	7	41.27	32.60
Nickel	10	1	2796.20	181.60
Selenium	10	0	1731.20	860.20
Silver	10	0	182.26	97.82
Thallium	10	0	899.20	489.00
Thorium	10	0	48.38	29.24
Uranium	10	0	9.97	10.14
Zinc	10	10	41820.00	34840.00

(a) Reference area was between Wanapum and Priest Rapids Dams

### 10.2.1.2 Smallmouth Bass

Eight Smallmouth bass were collected in 2011 from two locations in the Hanford Reach: three from the region known as the Hanford Slough and five from the areas around the 300 Area. No reference samples were obtained in 2011 due to low collection success in other sampling areas. Fillets and the eviscerated remains (carcasses) of the Smallmouth bass were analyzed for a variety of radiological contaminants, and liver samples were analyzed for metals.

**Cesium-137.** Manmade gamma-emitting radionuclides, including cesium-137, were not found above the reporting limit (0.03 pCi/g [0.001 Bq/g] wet weight) in 2011 in any of the muscle samples analyzed. These results are consistent with those reported historically near the Hanford Site.

**Strontium-90.** Strontium-90 was not discovered above the reporting limit (0.05 pCi/g [0.0019 Bq/g] wet weight) in Smallmouth bass samples collected in 2011 from the Hanford Reach locations. These results are consistent with those reported throughout the past 10 years for Smallmouth bass collected from the reference area and Hanford Site sampling locations.

**Trace Metals.** Liver samples were measured for trace-metal concentrations in all Mountain whitefish samples collected in 2011 along the Hanford Reach and the upriver reference site. Seventeen metals were tested on all liver samples. Only aluminum, cadmium, mercury, and zinc were detected above the analytical detection limit at any location (Table 10.4).

Surveillance data sets for trace-metal concentrations in fish, both on and near the Hanford Site, are relatively small and the results are variable. At this time, no established state or federal 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 the effects of this contribution 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.

**Table 10.4. Smallmouth Bass Results for Selected Metals (2011)**  
(ug/kg)

Isotope	Samples	Detects	100N - 100D	Hanford Slough
Aluminum	10	1	28252.00	6480.00
Antimony	10	0	305.20	314.67
Arsenic	10	0	461.80	476.33
Beryllium	10	0	92.42	95.30
Cadmium	10	2	303.92	309.60
Chromium	10	0	145.80	147.33
Copper	10	8	4360.00	3436.67
Lead	10	0	305.20	314.67
Manganese	10	0	1863.40	1095.67
Mercury	8	0	30.86	23.40
Nickel	10	0	138.40	143.00
Selenium	10	0	1340.80	1257.67
Silver	10	0	92.42	95.30
Thallium	10	0	461.80	476.33
Thorium	10	0	30.34	31.40
Uranium	10	0	6.26	6.48
Zinc	10	5	27360.00	21933.33

### 10.2.2 Cottontail Rabbit Results

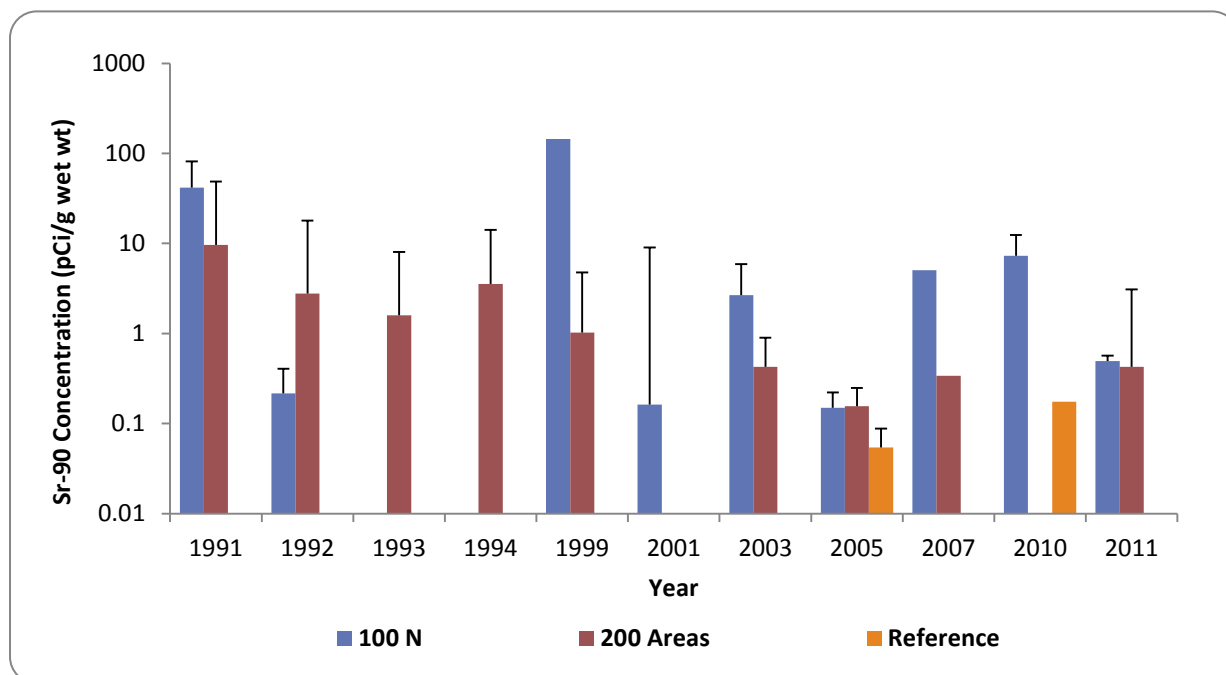
Cottontail rabbits are useful for detecting localized radioactive contamination because they have relatively small home ranges, forage or live in potentially contaminated soil, and can enter fenced restricted areas that contain radioactive waste materials. They also may be useful as sentinel organisms both on and off the Hanford Site. Two cottontail rabbits were collected in 2011 near the Hanford Site 100-N Area, four were collected from the 200-West Area, and four from the 200-East Area (Figure 10.2). Attempts were made to collect offsite reference samples, but proved to be unsuccessful. The rabbits were monitored for cesium-137 and other manmade gamma-emitting radionuclides in muscle tissue, strontium-90 in bones, and trace metals in the liver.



**Cesium-137.** Cesium-137 concentrations were detected above the analytical detection limit (0.03 pCi/g [0.0011 Bq/g] wet weight) in 6 of the 10 cottontail rabbit muscle samples collected in 2011 from all locations. Cesium-137 concentrations were detected in two samples from the 200-East Area, two samples from the 200-West Area, and two samples from the 100-N Area. These results may be attributed to a higher sample number collected and closer proximity to Hanford Site operations than in years past.

**Strontium-90.** Strontium-90 concentrations in bone tissues collected from rabbits in 2011 were above the analytical detection limit (0.05 pCi/g [0.0019 Bq/g] wet weight) (Figure 10.3). Maximum strontium-90 concentrations (3.08 pCi/g [0.46 Bq/g] wet weight) were elevated in a rabbit collected from the 200-East Area compared to the maximum concentration in reference samples in 2010 (0.175 pCi/g [0.0065 Bq/g] wet weight). Strontium-90 concentrations in the samples collected from the 100-N Area were less than the maximum value reported in 2010 from samples collected at the 100-N Area. Strontium-90 concentrations in the samples collected from the 200 Areas were within historic levels to those reported from the 200 Area during the previous 10 years. Although small sample sizes may limit the ability to interpret long-term trends, major changes in strontium-90 levels found in rabbit bone tissues have not been apparent over the past decade (Figure 10.3).

**Trace Metals.** Liver samples collected from rabbits in 2011 in the 100-N Area, 200-East Area, and the 200-West Area were analyzed for 17 trace metals. Attempts to collect reference samples were unsuccessful due to poor weather conditions during the reference-trapping period. Copper, selenium, and zinc were the only metals detected above laboratory detection limits in the 2011 samples collected. The 200-West Area contained the higher average metal concentration than the other two areas for many of the 17 metals analyzed excluding copper, mercury, antimony, selenium, and thorium (Table 10.5).

**Figure 10.3. Cottontail Rabbit Bone Strontium-90 Median and Maximum Concentrations (1991 through 2011)***(Maximum concentrations are represented by the upper bar)***Table 10.5. Cottontail Rabbit Results for Selected Metals (2011)**  
(ug/kg)

Isotope	Samples	Detects	100 N Area	200 West Area	200 East Area
Aluminum	10	0	6340.00	6580.00	6467.50
Antimony	10	0	308.00	319.50	356.75
Arsenic	10	0	466.00	483.75	475.50
Beryllium	10	0	93.25	96.80	95.13
Cadmium	10	0	93.25	129.53	95.43
Chromium	10	0	141.00	145.25	142.50
Copper	10	10	3105.00	2912.50	2955.00
Lead	10	0	308.00	321.75	314.00
Manganese	10	0	2070.00	2712.50	2292.50
Mercury	8	0	3.67		3.72
Nickel	10	0	139.50	145.25	142.50
Selenium	10	1	2800.00	1557.75	1354.75
Silver	10	0	93.25	96.80	95.13
Thallium	10	0	466.00	483.75	475.50
Thorium	10	0	27.70	30.85	40.38
Uranium	10	0	5.71	6.37	6.33
Zinc	10	10	39850.00	41825.00	36925.00

### 10.2.2.1 Waterfowl Results

One Canada goose was collected in the summer of 2011 along the Hanford Reach of the Columbia River, near the 100 Area. Due to the low 2011 sample success, no statistics or trending could be performed; however, the goose sample analyzed provided the following results:

**Cesium-137.** Manmade gamma-emitting radionuclides, including cesium-137, were below the detection limit (0.03 pCi/g [0.001 Bq/g] wet weight).

**Strontium-90.** Strontium-90 concentrations were below the analytical detection limit (0.05 pCi/g [0.0019 Bq/g] wet weight).

**Trace Metals.** The goose liver was analyzed for 17 trace metals. Only copper and zinc were detected at levels higher than their respective detection limits.

### 10.2.3 Pests and Contaminated Biota Control

*RC Roos, JM Rodriguez, JW Wilde*

Animal species such as the domestic pigeon (*Columba livia*), Northern pocket gopher (*Thomomys talpoides*), house mouse (*Mus musculus*), and deer mouse (*Peromyscus maniculatus*) must be controlled when they become a nuisance or a health problem, or if they become contaminated with radioactivity. Biological control personnel responded to approximately 29,000 animal control requests from Hanford Site employees in 2011, (ranging from requests to remove animals within radioactive waste facilities to insect invasions of work areas). Approximately 2,500 trap or bait stations were used to control populations of animals in and near site facilities and offices. Pest control captured 1,947 animals in 2011 and four were radiologically contaminated.

Nineteen contaminated animal-related materials were discovered in 2011 (e.g., urine or feces), which is approximately 41 percent less than the peak number of 46 in 1999, and 27 less than 2009. Of the 19 animal contamination incidents in 2011, there were seven contaminated rabbit feces. A study to determine where rabbit species (black-tailed jackrabbit [*Lepus californicus*] or Mountain Nuttall's cottontail [*Sylvilagus nuttallii*]) ingest and spread radioactive contamination via their fecal material began in 2009 and continued in 2010, with a final effort in 2011. No contaminated rabbits were captured in 2011, nor was contaminated rabbit feces found that appeared fresh or recent. These findings suggest that the source or sources of radioactive contamination have been neutralized within the waste sites.

Five radiological contamination incidents in 2011 were attributed to insects or insect-related materials (e.g., harvester ants, and mud-dauber wasp nests). Three legacy mud dauber wasp nests were found and removed for proper disposal during cleanup activities. Ant mounds accounted for the two remaining radioactive contamination incidents related to insects. Insect contamination is included in the count of animal-related radioactive contamination.

## 10.3 Plant Monitoring

Plant monitoring conducted on and around the Hanford Site in 2011 is summarized in this section. Included are discussions of surveys and monitoring of Hanford Site plant populations, monitoring contaminants in perennial vegetation growing near facilities and operations, and control of contaminated or unwanted vegetation.

Plant populations and habitats that occur on the Hanford Site are surveyed and monitored to assess the abundance, vigor or condition, and distribution of populations and species. These data can be integrated with

contaminant monitoring results and used to help characterize potential risks or impacts to biota. Vegetation near onsite facilities and operations is monitored for radiation to determine the effectiveness of effluent monitoring and controls within facilities, assess the adequacy of containment at waste disposal sites, and detect and monitor unusual conditions. Site-wide and offsite vegetation samples are analyzed for information about atmospheric deposition of contaminants in uncultivated areas offsite and around operational areas onsite. These data provide a baseline against which unplanned releases can be compared. Vegetation management activities help prevent, limit, or remove contaminated plants or undesirable plant species. For further information about these monitoring and control efforts, the programs that support them, and their purposes, refer to [Section 10.3](#) in this report or [DOE/RL-91-50](#), Rev. 4.

Monitoring of rabbitbrush and sagebrush leaves and stems provides information about atmospheric deposition of radioactive materials in uncultivated areas and at site-wide locations that potentially could be affected by contaminants from Hanford Site operations. Vegetation samples have been collected on and around the Hanford Site for more than 50 years. Data from these samples are maintained in a database to document onsite and offsite levels of manmade radionuclides in vegetation at specific locations. This database contains baseline data against which data from unplanned releases from the Hanford Site can be compared.

### **10.3.1 Monitoring Results**

*ME Hoefer*

Vegetation samples were collected on or adjacent to waste disposal sites and from locations downwind and near or within the boundaries of operating facilities and remedial action sites. Samples were collected to evaluate long-term trends in environmental accumulation and potential migration of radioactive material. 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 number and location of Hanford Site vegetation samples collected during 2011 are summarized in Table 10.6. Only those radionuclides with concentrations consistently above analytical detection limits are discussed in this section. Vegetation samples from offsite locations are collected every 3 to 5 years, and were last collected in 2008 (PNNL-18427).

Each sample (approximately 17.6 ounces [500 grams]) consisted of new-growth leaf cuttings taken from the available brushy, deep-rooted species (e.g., sagebrush and/or rabbitbrush). Often, the sample consisted of a composite of several like members of the sampling-site plant community to avoid decimation of any individual plant through overharvesting. Vegetation samples were dried prior to analyses, and analytical results were reported on a dry weight basis.

Samples were analyzed for the radionuclides expected to occur in the areas sampled (i.e., gamma-emitting radionuclides [cobalt-60 and cesium-137], strontium-90, uranium isotopes, and/or plutonium isotopes). Selected analytical results were compared to concentrations in samples collected during 2008 at offsite sampling locations in Yakima, Benton, and Franklin Counties (PNNL-18427). Comparisons can be used to determine the differences between contributions from site operations and remedial action sites and contributions from natural sources and worldwide fallout.

**Table 10.6. Vegetation Monitoring by Operational Area (2011)**

Hanford Site Samples	Operational Area					
	100-N	200-East	200-West <sup>(a)</sup>	300 <sup>(a)</sup>	400	600 <sup>(a)</sup>
63	3	10	21	12	N/A	17

(a) Number of samples includes one or more replicate samples.

Some degree of variability is always associated with collecting and analyzing environmental samples; therefore, variations in sample concentrations from year to year are expected. In general, radionuclide concentrations in vegetation samples collected from, or adjacent to, waste disposal facilities in 2011 were higher than concentrations in samples collected farther away, including concentrations measured offsite. Generally, the predominant radionuclides were activation and fission products in the 100 Areas, fission products in the 200 Area and 600 Area, and uranium in the 300 Area and 400 Area.

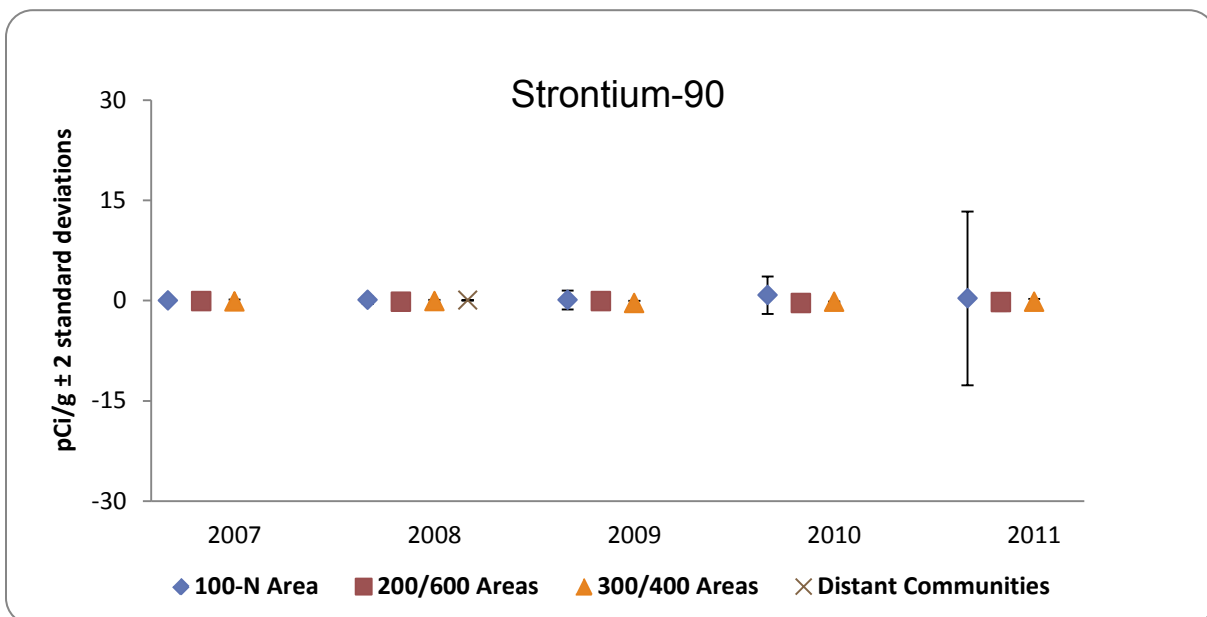
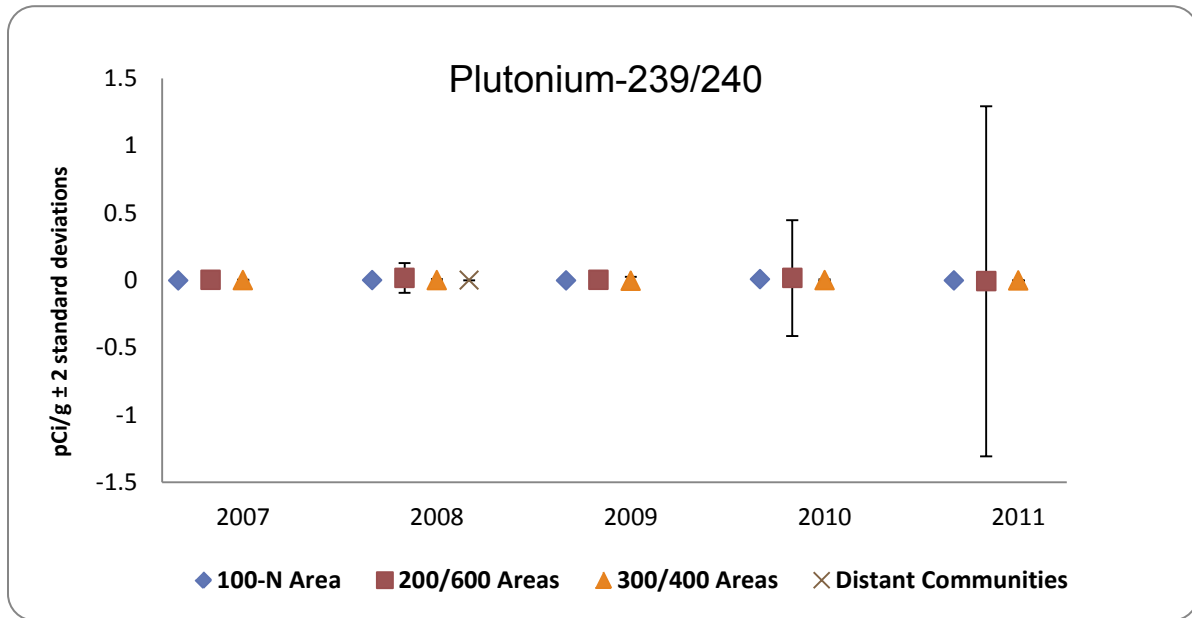
Uranium was detected consistently, and strontium-90, cesium-137, plutonium-238, and plutonium-239/240 were detected occasionally in the 2011 samples. Concentrations of these radionuclides were elevated near and within facility boundaries compared to historic concentrations measured at distant communities. Figure 10.4 shows the Hanford Site and distant community's average concentration of selected radionuclides for vegetation samples. The results demonstrate a high degree of variability in concentrations.

Table 10.7 provides a summary of selected radionuclides detected in vegetation samples collected and analyzed in 2011 and in previous years. The average and maximum results are reported for the six primary waste facility/operational areas of interest, along with comparative data for the preceding 5 years. A complete list of 2011 radionuclide concentrations, as well as sampling location maps, are available upon request (refer to Preface).

Vegetation samples collected in 2011 at locations in the 100-N Area, 200-East Area, 200-West Area, 400 Area, and 600 Area were comparable to those collected in previous years. Vegetation samples collected in the 300 Area showed concentrations of uranium-234 and uranium-235 that were comparable to historical data, and higher than vegetation samples measured in the 100 Area and 200 Area. The higher uranium levels in the 300 Area were expected due to uranium releases to the environment during past fuel-fabrication operations in that area. Cesium 137 concentrations were recorded at higher levels than previous years in the 300 Area and were likely attributable to fallout from radioactive releases that occurred during the Fukushima, Japan nuclear incident in March of 2011. Plutonium-238 and plutonium-239/240 were found at higher levels in a small number of vegetation samples in the 200-West Area, 600 Area, and 300 Area. One sample from the 200-West Area had a uranium-234 concentration higher than historical levels. These elevated values may be due to facility operations in each area.



**Figure 10.4. Vegetation Monitoring Average Concentration of Selected Radionuclides for Hanford Site and Distant Community's (2007 through 2011)**



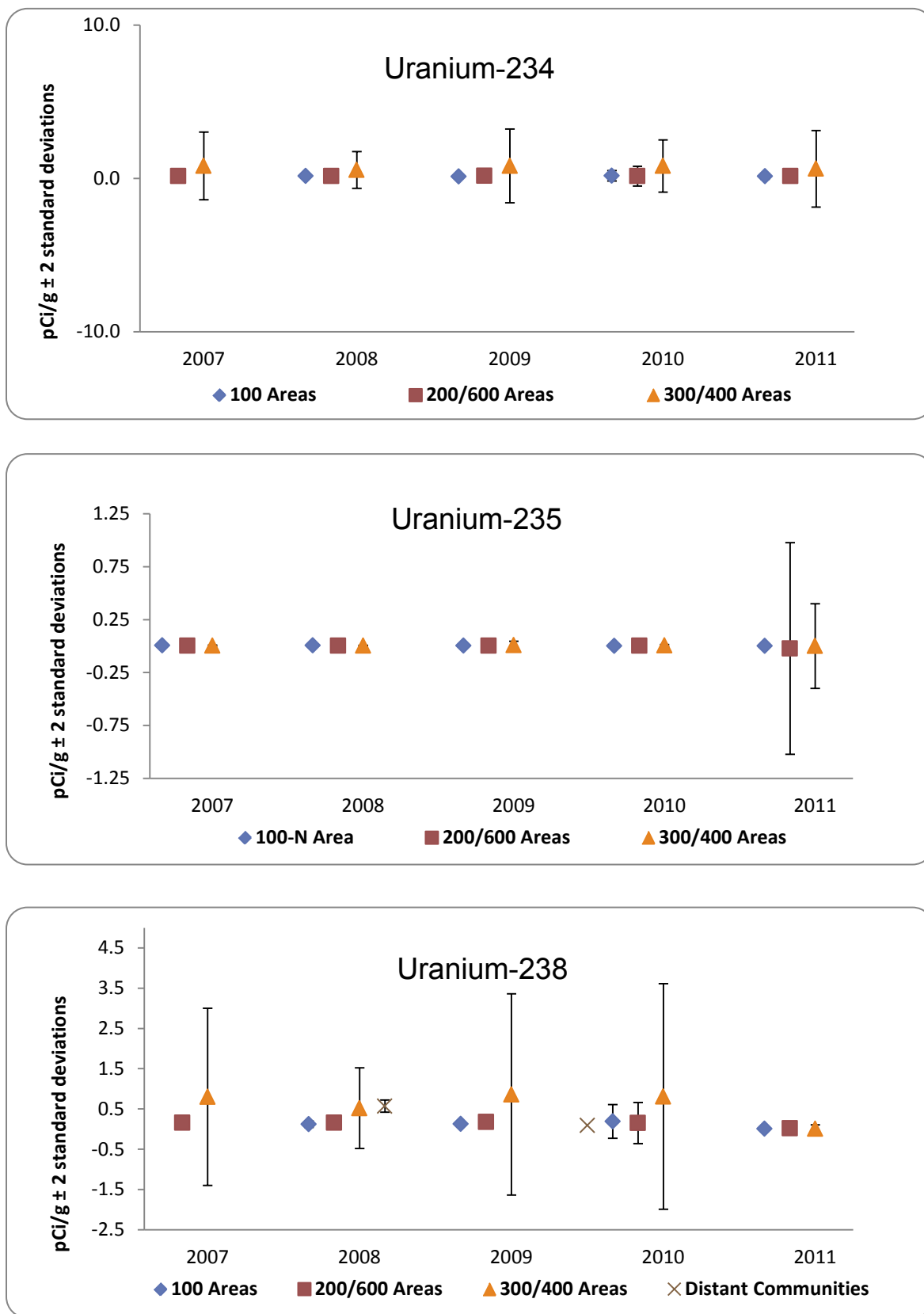
**Figure 10.4. Average Concentration of Selected Radionuclides in Vegetation Samples for Hanford Site and Distant Community's (cont.)**

Table 10.7 Vegetation Concentrations of Selected Radionuclides (2006 through 2011)

		2011				2006-2010			
Radionuclide	Area	Number of		Average <sup>(b, c)</sup>	Maximum <sup>(b, d)</sup>	Number of		Average <sup>(b, c)</sup>	Maximum <sup>(b, d)</sup>
		Samples	Detections <sup>(a)</sup>			Samples	Detections <sup>(b)</sup>		
Cesium-137	100-N	3	1	3.1E-02 ± 4.6E-02	5.7E-02 ± 5.0E-02	16	0	-5.3E-04 ± 7.6E-02	8.7E-02 ± 8.5E-02 <sup>(e)</sup>
	200-East	10	2	8.1E-02 ± 1.4E-01	2.3E-01 ± 1.0E-01	48	9	4.0E-02 ± 1.6E-01	3.3E-01 ± 1.4E-01
	200-West	21	7	9.8E-02 ± 1.5E-01	3.2E-01 ± 1.2E-01	111	16	5.5E-02 ± 2.5E-01	1.2E+00 ± 2.1E+00 <sup>(e)</sup>
	300	12	8	1.6E-01 ± 1.7E-01	3.6E-01 ± 9.7E-02	72	0	-1.9E-02 ± 2.8E-01	7.2E-02 ± 8.5E-02 <sup>(e)</sup>
	600	17	6	8.9E-02 ± 1.3E-01	2.0E-01 ± 8.6E-02	78	6	3.9E-02 ± 4.1E-01	1.7E+00 ± 2.2E+00 <sup>(e)</sup>
Cobalt-60	100-N	3	0	1.2E-02 ± 1.2E-02	1.9E-02 ± 4.4E-02 <sup>(e)</sup>	16	0	8.0E-03 ± 4.8E-02	3.6E-02 ± 8.8E-02 <sup>(e)</sup>
	200-East	10	0	-6.2E-03 ± 5.5E-02	5.4E-02 ± 1.1E-01 <sup>(e)</sup>	48	0	-8.8E-03 ± 7.1E-02	5.2E-02 ± 7.4E-02 <sup>(e)</sup>
	200-West	21	0	-1.0E-02 ± 5.4E-02	5.3E-02 ± 5.9E-02 <sup>(e)</sup>	111	0	-5.3E-03 ± 7.4E-02	1.1E-01 ± 9.5E-02 <sup>(e)</sup>
	300	12	0	-1.3E-02 ± 6.2E-02	3.6E-02 ± 1.2E-01 <sup>(e)</sup>	72	0	-1.7E-02 ± 1.6E-01	7.5E-02 ± 5.8E-02 <sup>(e)</sup>
	600	17	0	1.7E-02 ± 4.6E-02	5.4E-02 ± 8.2E-02 <sup>(e)</sup>	78	0	-2.4E-03 ± 1.2E-01	2.6E-01 ± 1.3E-01
Plutonium-238	100-N	3	0	1.2E-03 ± 2.9E-03	2.7E-03 ± 6.5E-03 <sup>(e)</sup>	16	0	6.0E-04 ± 2.3E-02	1.9E-02 ± 1.8E-02 <sup>(e)</sup>
	200-East	10	0	3.0E-03 ± 1.7E-02	1.6E-02 ± 1.9E-02 <sup>(e)</sup>	47	2	1.6E-03 ± 1.8E-02	3.5E-02 ± 1.4E-02
	200-West	21	1	1.9E-03 ± 1.8E-02	2.7E-02 ± 1.2E-02	111	5	1.2E-03 ± 1.9E-02	6.4E-02 ± 2.9E-02
	300	12	0	1.7E-03 ± 1.3E-02	1.9E-02 ± 2.1E-02 <sup>(e)</sup>	72	5	2.9E-03 ± 3.6E-02	8.7E-02 ± 4.7E-02
	600	17	0	3.0E-03 ± 2.1E-02	3.2E-02 ± 2.3E-02 <sup>(e)</sup>	78	1	2.1E-03 ± 1.7E-02	2.0E-02 ± 1.7E-02 <sup>(e)</sup>
Plutonium-239/240	100-N	3	0	3.3E-04 ± 1.6E-03	9.1E-04 ± 3.1E-03 <sup>(e)</sup>	16	2	1.7E-03 ± 8.2E-03	9.2E-03 ± 7.3E-03
	200-East	10	0	8.0E-04 ± 1.9E-03	2.2E-03 ± 3.4E-03 <sup>(e)</sup>	48	3	2.2E-03 ± 1.7E-02	5.9E-02 ± 2.2E-02
	200-West	21	5	6.9E-02 ± 5.5E-01	1.3E+00 ± 2.8E-01	111	44	1.8E-02 ± 1.1E-01	4.3E-01 ± 9.9E-02
	300	12	0	8.8E-04 ± 2.7E-03	3.4E-03 ± 6.1E-03 <sup>(e)</sup>	72	3	6.2E-04 ± 1.5E-02	1.0E-02 ± 6.5E-03
	600	17	1	9.8E-04 ± 6.4E-03	7.3E-03 ± 9.7E-03 <sup>(e)</sup>	78	10	3.3E-03 ± 1.2E-02	3.6E-02 ± 1.6E-02
Strontium-90	100-N	3	3	4.7E+00 ± 1.2E+01	1.3E+01 ± 1.7E+00	16	5	8.8E-01 ± 4.6E+00	9.0E+00 ± 1.4E+00
	200-East	10	7	4.0E-01 ± 6.3E-01	1.0E+00 ± 2.8E-01	48	8	-1.0E-01 ± 1.1E+00	1.3E+00 ± 2.6E-01
	200-West	21	6	1.5E-01 ± 4.5E-01	6.4E-01 ± 4.3E-01	111	1	-1.8E-01 ± 5.8E-01	3.6E-01 ± 1.3E-01
	300	12	7	1.6E-01 ± 3.8E-01	4.3E-01 ± 2.2E-01	72	0	-1.9E-01 ± 3.7E-01	1.7E-01 ± 2.0E-01 <sup>(e)</sup>
	600	17	2	1.6E-01 ± 6.4E-01	1.3E+00 ± 3.4E-01	78	5	-1.1E-01 ± 6.8E-01	6.0E-01 ± 2.4E-01
Uranium-234	100-N	3	3	1.3E-02 ± 5.5E-03	1.7E-02 ± 8.8E-03	16	11	1.2E-02 ± 1.1E-02	2.1E-02 ± 1.1E-02
	200-East	10	10	1.2E-02 ± 7.7E-03	1.8E-02 ± 1.0E-02	48	46	1.5E-02 ± 1.0E-02	2.6E-02 ± 1.2E-02
	200-West	21	21	1.5E-02 ± 1.4E-02	3.7E-02 ± 1.3E-02	111	103	1.7E-02 ± 2.2E-02	1.1E-01 ± 3.5E-02
	300	12	10	2.9E-02 ± 6.6E-02	1.1E-01 ± 3.8E-02	72	65	3.7E-02 ± 1.2E-01	4.4E-01 ± 1.8E-01
	600	17	13	1.0E-02 ± 9.9E-03	1.9E-02 ± 1.1E-02	78	63	1.5E-02 ± 2.0E-02	8.4E-02 ± 2.8E-02

Table 10.7 Vegetation Concentrations of Selected Radionuclides (2006 through 2011)

Radionuclide	Area	2011				2006-2010			
		Number of		Average <sup>(b, c)</sup>		Number of		Average <sup>(b, c)</sup>	
		Samples	Detections <sup>(a)</sup>	Average <sup>(b, c)</sup>	Maximum <sup>(b, d)</sup>	Samples	Detections <sup>(b)</sup>	Average <sup>(b, c)</sup>	Maximum <sup>(b, d)</sup>
Uranium-235	100-N	3	1	5.3E-03 ± 6.1E-03	9.2E-03 ± 6.2E-03	16	6	4.7E-03 ± 5.5E-03	1.0E-02 ± 7.5E-03
	200-East	10	2	1.0E-01 ± 6.0E-01	1.0E+00 ± 0.0E+00 <sup>(e)</sup>	48	10	3.9E-03 ± 5.4E-03	1.6E-02 ± 9.3E-03
	200-West	21	6	3.5E-03 ± 4.6E-03	8.1E-03 ± 6.1E-03	111	30	3.5E-03 ± 5.0E-03	1.3E-02 ± 7.9E-03
	300	12	1	4.3E-03 ± 5.5E-03	8.8E-03 ± 7.3E-03	72	18	5.5E-03 ± 1.8E-02	7.9E-02 ± 7.1E-02 <sup>(e)</sup>
	600	16	2	2.7E-03 ± 4.1E-03	6.4E-03 ± 5.5E-03	78	19	3.9E-03 ± 5.2E-03	1.2E-02 ± 7.6E-03
Uranium-238	100-N	3	3	8.2E-03 ± 5.3E-03	1.1E-02 ± 6.1E-03	16	9	7.0E-03 ± 7.9E-03	1.4E-02 ± 8.1E-03
	200-East	10	8	8.8E-03 ± 8.3E-03	1.6E-02 ± 9.7E-03	48	42	1.1E-02 ± 8.4E-03	2.3E-02 ± 1.1E-02
	200-West	21	17	1.3E-02 ± 1.3E-02	2.4E-02 ± 9.9E-03	111	97	1.4E-02 ± 2.8E-02	1.4E-01 ± 4.3E-02
	300	12	12	2.9E-02 ± 5.7E-02	9.7E-02 ± 3.6E-02	72	67	3.2E-02 ± 1.3E-01	5.2E-01 ± 1.9E-01
	600	17	14	8.9E-03 ± 9.6E-03	1.9E-02 ± 9.8E-03	78	65	1.1E-02 ± 1.5E-02	6.1E-02 ± 2.1E-02

(a) Number of samples with measurable concentrations of contaminant

(b) (pCi/g dry wt.); 1 pCi = 0.037 Bq

(c) Average ± two standard deviations

(d) Maximum ± analytical uncertainty

(e) Maximum value reported is a non-detect

**10.3.1.1 Radiological Results***MC Dorsey and RC Roos*

Investigations of radioactive contamination in vegetation were conducted in and near operational areas to monitor the presence or movement of radioactive materials around areas of known or suspected contamination, or to verify radiological conditions at specific project sites. All samples collected during investigations were field-surveyed for alpha and beta-gamma radiation.

Radiological contamination was found during 2011 in 29 vegetation samples collected during investigations. Twenty-eight of the samples were tumbleweeds (Russian thistle), or tumbleweed fragments, and one sample was rabbitbrush. None of the samples was analyzed for specific radionuclides, and all samples were disposed at a licensed facility.

[Section 10.3.2](#) provided a discussion of the 2011 vegetation control on the Hanford Site. Table 10.8 summarizes the number and general locations of vegetation contamination incidents investigated from 1999 through 2011.

**Table 10.8 Vegetation Contamination Incidents Investigated**

Year	Number of Incidents	Location	2011 Incidents
1999	85	<b>200-East Area</b>	
2000	66	Tank Farms	12
2001	31	Burial grounds	6
2002	16	Cribs, ponds, and ditches	0
2003	32	Fence lines	0
2004	60	Roads and railroads	0
2005	66	Unplanned release sites	0
2006	75	Underground pipelines	1
2007	62	Miscellaneous	2
2008	127	<b>200-West Area</b>	
2009	109	Tank Farms	2
2010	36	Burial grounds	1
2011	29	Cribs, ponds, and ditches	0
		Fence lines	0
		Roads and railroads	0
		Unplanned release sites	0
		Underground pipelines	2
		Miscellaneous	1
		Cross-site transfer line	0
		200-BC Cribs and trenches	1
		<b>200-North Area</b>	0
		100 Areas	1
		300 Area	0
		400 Area	0
		600 Area	0
		Former 1100 Area	0
		<b>Total</b>	<b>29</b>

### 10.3.2 Vegetation Control

*RC Roos and JM Rodriguez*

Vegetation control at the Hanford Site consists of cleaning up contaminated plants that can be a threat to site workers or the public, controlling or preventing the growth or regrowth of plants in contaminated or potentially contaminated areas onsite, and monitoring and removing unwanted (noxious) plant species.

Approximately 5,443 acres (2,203 hectares) were treated with herbicides in 2011 on radiological waste sites, around operations areas, and along roadways to keep them clean of deep-rooted noxious vegetation (e.g., Russian thistle, also known as tumbleweed). Follow-up treatments are included in the total treated acres; several areas received three or four treatments per year.

#### 10.3.2.1 Noxious Weed Control

*RC Roos*

Noxious weeds are 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 or Washington State Department of Agriculture). Noxious weeds are non-native, aggressively invasive, and hard to control. Noxious weeds plant communities degrade ecosystems unless control measures are taken. Control measures can be mechanical, chemical, cultural, or biological; approximately 34 acres (14 hectares) on the Hanford Site were treated in 2011 along roadways. The environmental assessment delineating noxious weed control by herbicides that was mandated in 2008 was undergoing DOE review in 2011 (DOE/EA-1728D).

Ten plant species are on a high-priority list for control at the Hanford Site. These species are described in the following paragraphs, along with a summary of 2011 control activities.

**Yellow Starthistle (*Centaurea solstitialis*).** Yellow starthistle represents the most rapidly expanding weed infestation in the western United States. Since 1995, yellow starthistle has been the highest priority weed for the Hanford Site noxious-weed control program because yellow starthistle has the potential to invade the entire site and have a dramatic impact on the ecology of the site and neighboring lands.

Control measures for yellow starthistle have included spot treatments and broadcast herbicide applications by ground equipment and aerial sprayers, biological control, and hand weeding in critical locations. Major populations near the Hanford town site have been reduced to scattered individual plants, mostly near live trees where aerial herbicide applications were not made. Control of the yellow starthistle in 2011 consisted of hand pulling individual plants as they were identified.

Yellow starthistle seeds are known to remain viable for 10 years in the soil. The small number of seedlings found over much of the area of infestation indicates the seed bank is being exhausted. Careful control efforts over the next few years at the Hanford Site should result in the yellow starthistle changing from a major infestation to a monitoring and eradication effort.

Biological control agents for yellow starthistle are widely distributed across the infested area and have been highly effective during the early part of the flowering season. However, the adult phase of the control agent's annual lifecycle is completed before the end of the flowering season. Consequently, flowers opening late in the season are largely spared the effects of insect predation.

**Rush Skeletonweed (*Chondrilla juncea*).** Rush skeletonweed is scattered over large areas at the Hanford Site. In the past, areas of dense rush skeletonweed infestation largely have been eliminated. Nevertheless, considerable rush skeletonweed remains as scattered individual plants. Populations of rush skeletonweed have increased in some areas burned by past wildfires. Reduction in active control efforts over the past few years while NEPA requirements have been evaluated has allowed some populations of skeletonweed to increase in both aerial extent and density.

The deep and extensive root system of rush skeletonweed makes it extremely difficult to eliminate. The area north of the HAMMER facility has been treated with herbicides in the past and will continue to be monitored for sprouts emerging from roots remaining in the ground. Additional aerial applications may be needed to reduce the population of rush skeletonweed to the level that ground applications will be able to control the infestation.

Biological control agents are commonly found in rush skeletonweed at the Hanford Site, but they have not significantly reduced plant populations.

**Babysbreath (*Gypsophila paniculata*).** Babysbreath is resistant to control by herbicides; however, the aboveground portion of the plant can be killed by certain herbicides. Using these herbicides, flowering and population growth can be prevented. These plants should be eradicated by continually removing the top portions through herbicide use. Herbicides were not used to control babysbreath in 2011 while NEPA authorization was being finalized. Active control of babysbreath in 2011 at the Hanford town site consisted of hand pulling individual plants to prevent seed production.

**Dalmatian Toadflax (*Linaria genistifolia* ssp. *Dalmatica*).** A small population of dalmatian toadflax plants was found growing in 2011 east of Energy Northwest at the Hanford Site. Sprouts and seedlings of the long-lived perennial plant will be eliminated as they are identified. No biological controls have been released at the Hanford Site for dalmatian toadflax. Toadflaxes growing along road shoulders were controlled using herbicides.

**Diffuse Knapweed (*Centaurea diffusa*).** Aerial applications for control of diffuse knapweed have been effective in the past. No areas in 2011 were sprayed aerially for control of diffuse knapweed. Spot treatment of scattered individuals continues. The population of diffuse knapweed near the high-water mark of the Columbia River has not been actively controlled by herbicides because of the biological sensitivity of the area. Biological controls are established and monitored to observe their effectiveness in controlling the weed.

**Medusahead (*Taeniatherum asperum*).** No medusahead plants were discovered in 2011. The Hanford Site will continue to be monitored for several years to verify the seed bank has been eradicated.

**Purple Loosestrife (*Lythrum salicaria*).** The Columbia River riverbank and islands along the Hanford Site are monitored for purple loosestrife. Populations are found on many islands and along the banks of the river. Individual plants and small populations are found along the south and west bank of the river. Under good ecological conditions, biological controls are effective for controlling purple loosestrife. However, rapidly fluctuating water levels along the Columbia River kill the control organisms overwinter on the ground in the weed populations. Winter mortality prevents an effective population of control agents from developing. Hanford Site personnel are working with neighboring land managers along the Columbia River to identify effective controls for purple loosestrife along the Hanford Reach. No control measures were applied in 2011 for purple loosestrife.



**Russian Knapweed (*Acroptilon repens*).** Biological controls for Russian knapweed are limited, and their success has been poor in the arid climate of the Hanford Site. Chemicals and other control techniques are being developed that promise to be effective with this difficult-to-control species.

**Saltcedar (*Tamarix* spp.).** Several individual plants of saltcedar are found at the Hanford Site. Most are the remainders from ornamental plantings near homes in the early part of the previous century. A few populations are the result of natural seed dispersal. Most individual plants south and west of the Columbia River have been eliminated. Those remaining alive continue to be treated with herbicide and will be monitored until they are eradicated; however, no active control measures in 2011 were performed.

**Spotted Knapweed (*Centaurea maculosa*).** Spotted knapweed at the Hanford Site has been controlled so that sprouts or seedlings are rare; therefore, in 2011 no sprouts or seedlings were found. The Hanford Site will continue to be monitored for several years to ensure viable seeds and roots have been eliminated from the soil. Cooperative efforts with neighboring landowners continue to eliminate spotted knapweed near the Hanford Site. *Cyphocleonus achates*, a root-feeding weevil has been released specifically for spotted knapweed. It is expected that the population of spotted knapweed at the Hanford Site is too small and scattered to sustain a biological control population. However, *Cyphocleonus* is known to use diffuse knapweed. It is hoped that a population of *Cyphocleonus* will establish in diffuse knapweed, and control spotted knapweed. Most biological controls for diffuse knapweed also are effective for spotted knapweed.

### 10.3.3 Waste Site Remediation and Revegetation

AR Johnson

Biobarrier®<sup>2</sup>, an engineered fabric impregnated with herbicide, is used to stop root penetration; it also can serve as a physical barrier to burrowing insects. Biobarrier® was not used on the Hanford Site in 2011 because more cost-effective means (e.g., herbicide applications) were used. Thirty-nine areas have been covered with Biobarrier® since 1999, comprising a total area of approximately 151,000 square feet (14,000 square meters).

Many waste sites are planted with perennial grass to inhibit the growth of deep-rooted noxious vegetation (e.g., tumbleweed) and control erosion. Native vegetation is replanted following a potential wildfire to control erosion and reestablish native vegetation to areas degraded by historical practices; however, in 2011 revegetation was not required.

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<sup>2</sup> Biobarrier is a registered trademark of Fiberweb Inc., Old Hickory, Tennessee.

## 11.0 Resource Protection

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### 11.1 Ecological Protection

*MR Sackschewsky, JW Wilde, CT Lindsey, JJ Nugent, PG Wagner, and RP Mueller*

The Hanford Site is a relatively undisturbed area of shrub steppe that supports a rich diversity of plant and animal species adapted to the semiarid environment of the Columbia Plateau. Ecological monitoring personnel collect ecological data and information needed to monitor, assess, and conserve resources; ensure RL is in compliance with legal and regulatory requirements for the biological resources; and protect sensitive resources and habitats found at the Hanford Site. Project personnel survey and monitor resources and key biota to assess the abundance, health, and distribution of populations and species at the Hanford Site. Data collection and analysis are integrated with environmental surveillance monitoring of biotic and abiotic media and analytical results are used to characterize any potential risk or impact to the biota. Ecological monitoring and ecological compliance support the Hanford Site's waste management and environmental restoration mission through the following activities:

- Ensure the Hanford Site's operational compliance with laws and regulations including the *Endangered Species Act of 1973*, the *Bald and Golden Eagle Protection Act*, and the *Migratory Bird Treaty Act*, as well as compliance with executive orders and DOE orders
- Provide data for environmental impact and ecological risk assessments
- Provide information and maps of the distribution and condition of biological resources at the Hanford Site
- Support Hanford Site land-use planning and stewardship.

Inventory and monitoring activities help protect natural resources within the DOE-operated portions of the Hanford Site including the DOE-managed portion of the Hanford Reach National Monument. Such activities also provide information useful to the Hanford Site natural resource stakeholders and the public on the status of some of the site's most highly valued biological resources.

The Hanford Site contains biologically diverse shrub-steppe plant communities that have been protected from most disturbances, except for fire, for more than 65 years. This protection has allowed plant and animal species to thrive at the Hanford Site that are displaced elsewhere in the Columbia Basin by agriculture and development. Population level surveys are conducted to monitor fish, wildlife, and plants in order to develop baseline information and monitor any changes resulting from Hanford Site operations.

#### 11.1.1 Rare Plant

Plant populations monitored at the Hanford Site include taxa classified by Washington State regulations as endangered, threatened, or sensitive species, and those species listed as Review Group 1 (i.e., taxa in need of additional field work before status can be determined). Rare plant monitoring for CY2011 focused on two species, Piper's daisy (*Erigeron piperianus*) and Columbia yellowcress (*Rorippa columbiae*).

Piper's daisy is a short-lived perennial species that is locally endemic to the Columbia Basin in Washington. Piper's daisy is considered sensitive in Washington State due to its limited range, habitat destruction, and isolation of remaining populations ([WNHP 2011](#)). The majority of known sites of this species that have been observed since 1980 are located on the Hanford Site, including a significant cluster of sites in the 200 Area Central Plateau. Surveys performed during 2011 focused on updating the existing database to represent extant populations, and determining locations where populations are no longer present. Field personnel surveyed 557

of the 580 previously known locations in the 200 Areas. Individual plants or patches of plants occurred at 217 of the 557 known sites, and seven new sites were located (Figure 11.1).

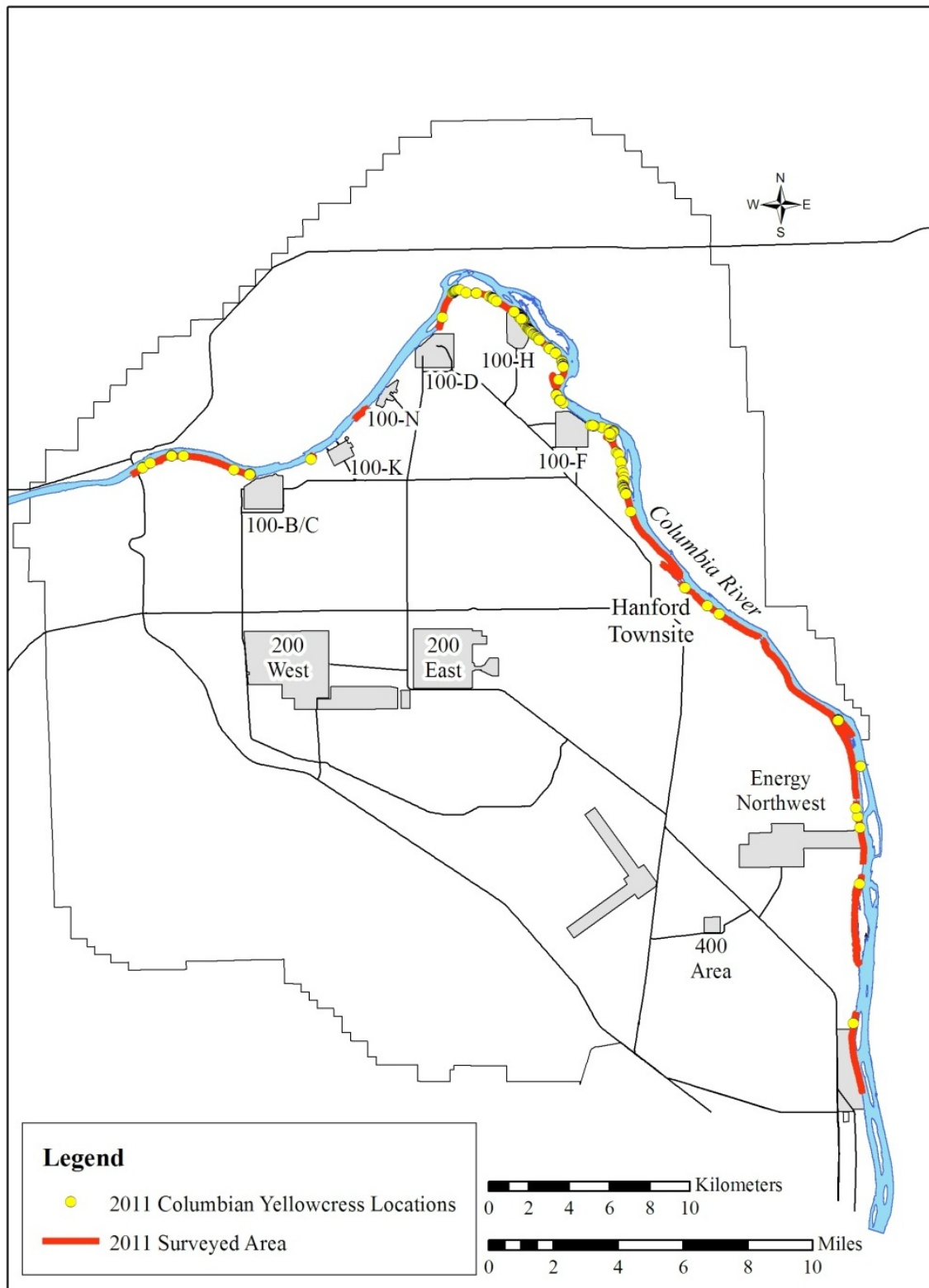
Monitoring of Piper's daisy remains important because the sensitive species occurs in such an active and changing portion of the Hanford Site (200 Areas). While the species is not uncommon in other areas of the Hanford Site, significant areas, especially on the Arid Lands Ecology (ALE) Reserve portion of the Hanford Reach National Monument, have been burned by wildfire and were subsequently treated with herbicides. The occurrences of this species in the 200 Areas should be reevaluated periodically to determine whether populations continue to persist. Population dynamics, together with the extent to which certain activities affect the species, should be evaluated.

Columbian yellowcress (*Rorippa columbiae*), also called persistentsepal yellowcress, is a rhizomatous perennial species that occurs along the shorelines of the Columbia River on the Hanford Site. It is endemic to Washington, Oregon, and California, is a federal species of concern in eastern Washington, and is listed as endangered by the Washington Natural Heritage Program. The extensive damming of the Columbia River has reduced its habitat, and the species is currently known from only two disjunctive locations in Washington: a relatively small population below the Bonneville Dam and an extensive population along the Hanford Reach. The objective of the 2011 inventory was to document the current distribution and vigor of Columbian yellowcress along the shoreline of the Columbia River on the Hanford Site. This included revisiting previously known locations for Columbian yellowcress, along with surveys of other areas with suitable habitat. Ecological monitoring personnel performed all surveys on foot.

A total of 43.7 miles (70.3 km) of Hanford shoreline was surveyed between late August and October 2011 (Figure 11.2) and all 101 previously recorded locations were visited. Columbian yellowcress was observed at 39 of the previously known locations and 196 additional locations were documented, for a total of 235-point locations (Figure 11.2). Patches greater than 98 feet (30 meters) from a previously documented point were considered new. Surveyors counted approximately 90,000 stems during the investigation and of these, 126 stems had flowers and/or flower buds during the initial surveys. Subsequent searches yielded no apparent fruiting.

Although some previous surveys for Columbian yellowcress indicated decreases in the number of Columbian yellowcress stems at specific locations along the Hanford Reach (e.g., [Simmons 2000](#), [Caplow 2003](#), [WNHP 2011](#)), others have documented high variability ([PNNL-20548](#)); however, during 2011 the species was relatively abundant and vigorous along the Hanford Site shoreline. Continued monitoring of Columbian yellowcress may include completing surveys in any areas not covered in 2011, including portions of the Hanford shoreline, several islands, and the opposing shoreline. Monitoring for successful seed production and recruitment could help to explain any potential impacts from the frequent inundations from upstream hydroelectric operations. Periodic surveys of the populations identified in 2011 would document trends in population size and location and provide insight into whether river flows are a potential driver for observed differences.

**Figure 11.1. 200 Areas Piper's Daisy Locations**

**Figure 11.2. Columbia Yellowcress (*Rorippa columbiae*) Locations**

### 11.1.2 Fish and Wildlife

This section provides inventory, monitoring, and survey information for species found at the Hanford Site during 2011, and presents this information in context with historical data and trend information. Four fish and wildlife species on the Hanford Site are usually monitored annually: fall Chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss*), bald eagles (*Haliaeetus leucocephalus*), and mule deer (*Odocoileus hemionus*). These species are of special interest to the public and to stakeholders, and in 2011 all but mule deer were monitored. Monitoring consisted of estimating numbers of fall Chinook salmon redds, surveying for steelhead redds, and assessing bald eagle nesting and night roosting activity. All of these species have the potential to be impacted by Hanford Site operations, and yearly monitoring provides baseline data for ecological assessments.

#### 11.1.2.1 Chinook Salmon

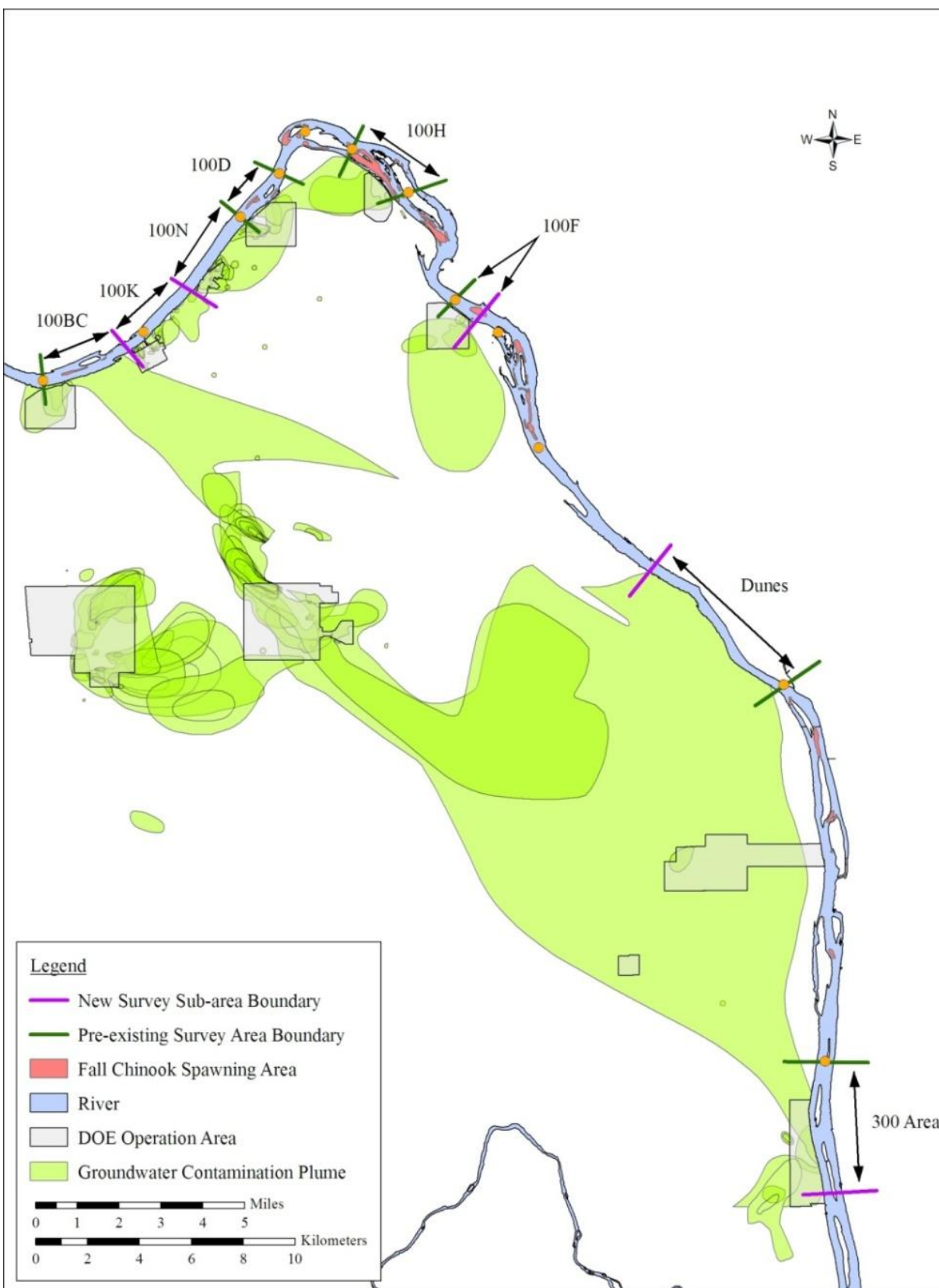
Chinook salmon (*Oncorhynchus tshawytscha*), commonly referred to as king salmon, are the largest of the Pacific salmon ([Myers et al. 1998](#), Netboy 1958). Adult fall Chinook salmon destined for the Hanford Reach enter the Columbia River in late summer and spawn from mid-October through November. Females fan out nests or redds in suitable gravel substrate and deposit eggs in an egg pocket while males simultaneously extrude milt to fertilize the eggs. Redds are readily identifiable at this time and appear as clean swept gravel patches amidst darker undisturbed substrate that is covered by algae (periphyton). Aerial counts of Chinook salmon redds have been conducted since 1948 at Hanford to provide an index of relative abundance among spawning areas and years. The counts also have been useful to document the onset of spawning, to locate spawning areas, and to determine intervals of peak spawning activity.

The Hanford Reach historically has been divided into 11 sections, with the number of redds being totaled by section. Eight additional sub-sections (100-B/C, 100-K, 100-N, 100-D, 100-H, 100-F, Dunes, 300 Area) were added in 2011 to monitor better the abundance and distribution of fall Chinook redds in areas of potential upwelling of contaminated groundwater (Figure 11.3).

Four aerial surveys were completed along the length of the Hanford Reach during the 2011 survey. The majority of the flights occurred on the weekends when outflows at Priest Rapids Dam were near 50,000 cubic feet (1,400 cubic meters) per second. The total number of redds is comprised of the maximum count from each survey area. The combined maximum count for 2011 totaled 8,915 (Table 11.1), which slightly surpassed that of 2010 (8,817), was less than the all-time highest count of 9,465 (year 2003), and was well in excess of the average for the past 10 years (6,972) (Figure 11.4).

As in past years, the 2011 redd count showed fair correlation with the 2011 adult fall Chinook escapement estimate for the Hanford Reach, which is generated annually by the Washington Department of Fish and Wildlife (WDFW), indicating overall consistency of the dataset. In addition, redds were observed to be located almost entirely in areas previously identified as 'historical spawning areas' indicating that the long-term preference of spawning Chinook for these areas was again captured in the 2011 surveys.

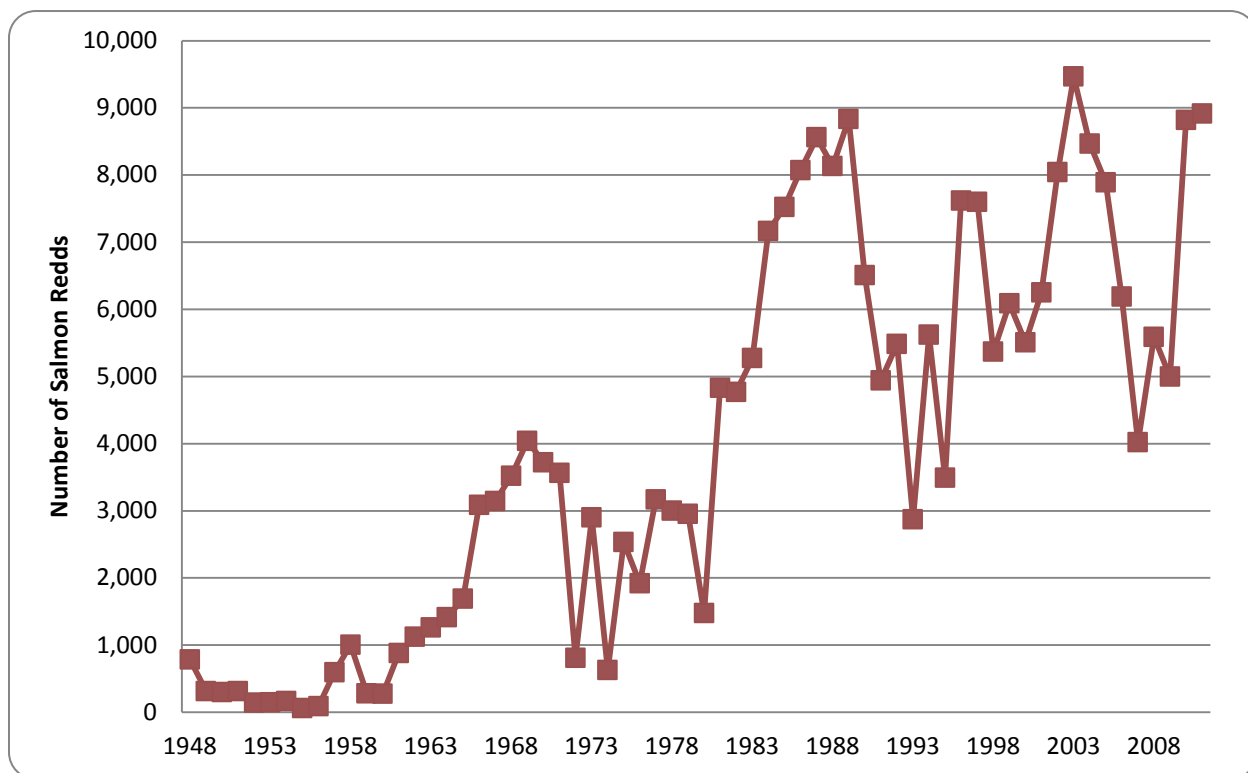
The historical areas where fall Chinook redds were observed in 2011 included locations of where contaminated groundwater upwellings may exist. However, more work would be necessary to confirm the actual presence of contaminated groundwater upwelling within spawning areas.

**Figure 11.3. Sub-Areas where Groundwater Upwelling's may contain Hanford Site Contamination**



**Table 11.1. Summary of Fall Chinook Salmon Redd Counts, Hanford Reach, Columbia River (2011 Aerial Surveys)**

Area	Description	10/16/2011	10/23/2011	11/5/2011	11/20/2011	Maximum Count
0	Islands 17-21 (Richland)	0	3	2	2	3
1	Islands 11-16	0	2	568	673	673
2	Islands 8-10	0	6	796	814	814
3	Island 7	0	0	670	630	670
4	Island 6 (lower half)	4	7	1,105	1,181	1,181
5	Island 4, 5 and upper 6	0	7	1,524	1,221	1,524
6	Island 3	0	3	520	525	525
7	Island 2	0	13	653	576	653
8	Island 1	0	2	202	295	295
9	Coyote Rapids	0	1	44	22	44
	Midway (China Bar)	0	0	40	67	67
10	Vernita Bar	5	23	2,410	2,463	2,463
11	Near Priest Rapids Dam	0	0	0	3	3
<b>TOTAL</b>		<b>9</b>	<b>67</b>	<b>8,534</b>	<b>8,472</b>	<b>8,915</b>

**Figure 11.4. Fall Chinook Salmon Redds in the Hanford Reach of the Columbia River (1948 through 2011)**

### 11.1.2.2 Steelhead

Steelhead within the Hanford Reach are considered part of the upper Columbia River Evolutionarily Significant Unit and are listed as endangered under the *Endangered Species Act of 1973*. In April 2011, two aerial observation flights were flown over the Hanford Reach from north Richland (river mile 340 [river kilometer 547]) to near the Vernita Bridge (river mile 388 [river kilometer 624]) to document the occurrence of any steelhead spawning along the shoreline regions. Flight environmental conditions were very good with clear skies and light winds for the initial flight. Water was slightly turbid for the second flight with sunny conditions and light winds. River flows were relatively high at over 130,000 cubic feet (3,680 cubic meters) per second during both flights. Areas in which steelhead redds were found in previous years were given high priority; several passes were made over these regions to check for the presence of any disturbance of the substrates, which would indicate the possibility of spawning fish. An area of potential redds was found along the Hanford shoreline near Islands 11-12. A follow-up boat video survey was conducted on April 23, 2011, but the regions were not determined to be spawning locations only lighter colored substrates (clay and sand patches). In summary, no steelhead redds were observed during either flight.

### 11.1.2.3 Bald Eagle

Bald eagles were removed from the federal endangered and threatened species list in July 2007 and were down-listed from threatened to sensitive by the WDFW in January 2008. Federal laws including the *Bald and Golden Eagle Protection Act of 1940* and the *Migratory Bird Treaty Act of 1918* still provide protection for eagles, their nest trees, and communal night roosts. The *Bald Eagle Management Plan for the Hanford Site, South-Central Washington* ([DOE/RL-94-150](#)) sets temporal and spatial restrictions on work activities on the Hanford Site to protect eagles and their habitats in accordance with current federal and state guidelines. Under the plan, communal night roosts and nest sites are protected with a 0.25 mile (400 m) buffer zone. Night roost buffers are enforced from November 15 until March 15, or until nest abandonment or fledging of young, whichever is later. Work-related access is allowed between 10 AM and 2 PM after notification of Hanford Site Ecological Compliance staff.

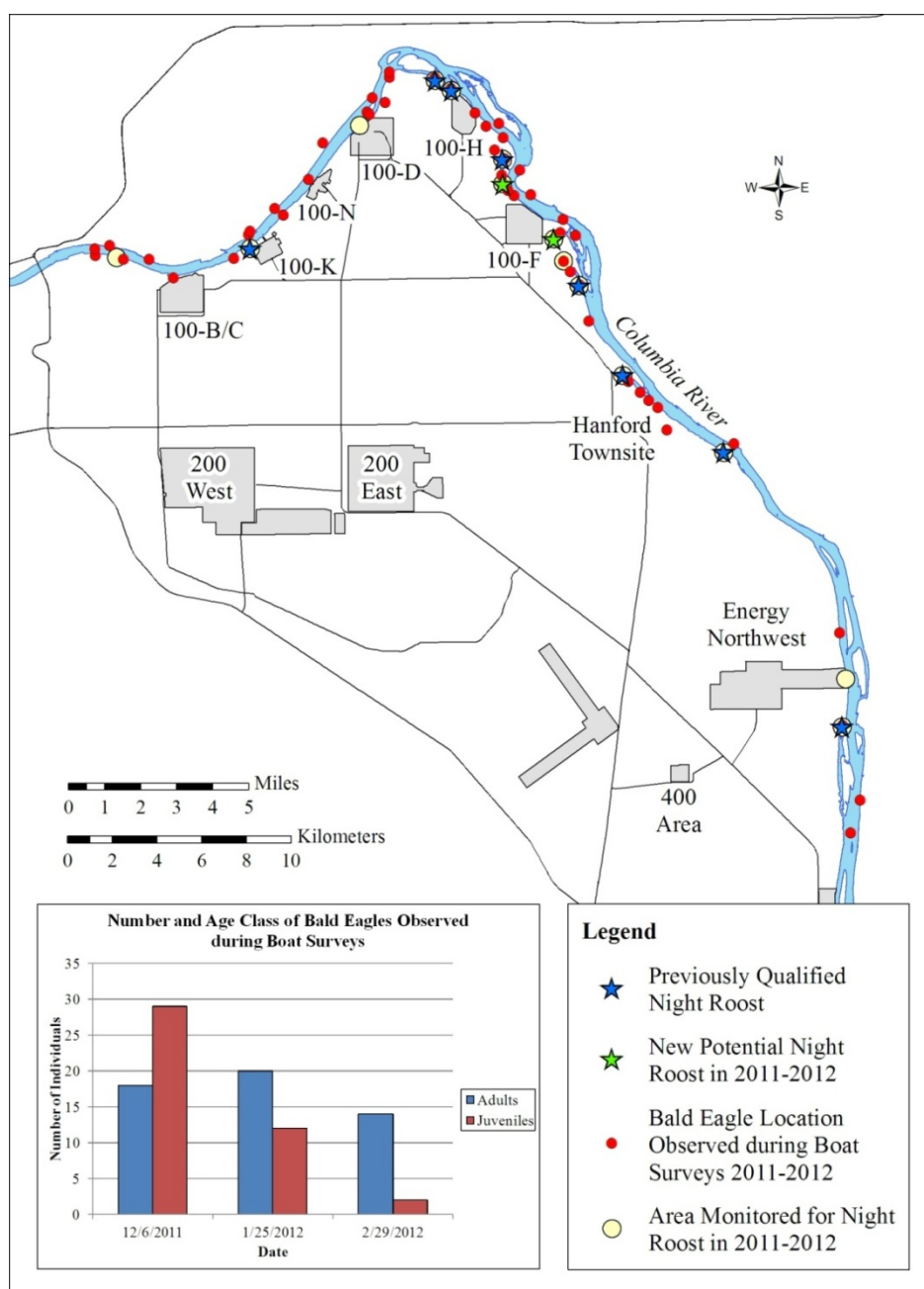
Monitoring of the bald eagle is essential to: 1) maintain current biological information about bald eagle abundance and distribution on the Hanford Site, 2) ensure compliance with protection regulations, and 3) inform future protection and management efforts. During the 2011-2012 season, 161 surveys were conducted including 150 night roost surveys, 3 boat surveys, and 8 nest site surveys.

WDFW defines a communal or night roost as “a tree or a group of trees in which at least 3 eagles roost for at least 2 nights and during more than one year”. Night roost surveys were conducted between half an hour of sunrise or sunset. On 22 separate days, 157 roost surveys were performed between mid-November 2011 and mid-March 2012. Surveys were conducted at 14 locations, including 8 historical roost sites, and 6 potential new roost areas (Figure 11.5). Two of the new roost areas (100-F Area and White Bluffs boat launch) had 3 or more eagles roosting for a least 2 nights during the 2011-2012 season.

The entire Hanford Reach was surveyed by boat three times during the 2011-2012 season (early December, late January, and late February). Boat surveys were used to determine the number, age class, and distribution of eagles present on the Hanford Reach (Figure 11.5). Portions of the boat surveys conducted within a half an hour of sunrise or sunset were used to confirm night roost status. Boat surveys also were used to identify additional potential night roosts and nest sites, and to identify the primary foraging areas along the Hanford Reach.

Nest site surveys were conducted in two historical locations; the White Bluffs Slough and upstream of 100-H Area, and at a potential new location at the Hanford Town site. Nest sites were monitored for nesting activities (e.g., a pair defending the nest from other eagles, nest tending, pair bonding behaviors, etc.). No nesting activities were observed at any of the nest sites during the 2011-2012 seasons, and thus, nests were determined to be unoccupied. The historical nest site at White Bluffs Slough was the most recent nest site to be occupied on the Hanford Site, but has not been occupied since the 2007-2008 season. Federal guidelines regard a bald eagle nest site as active for 5 years following occupation by a pair of eagles during the breeding season.

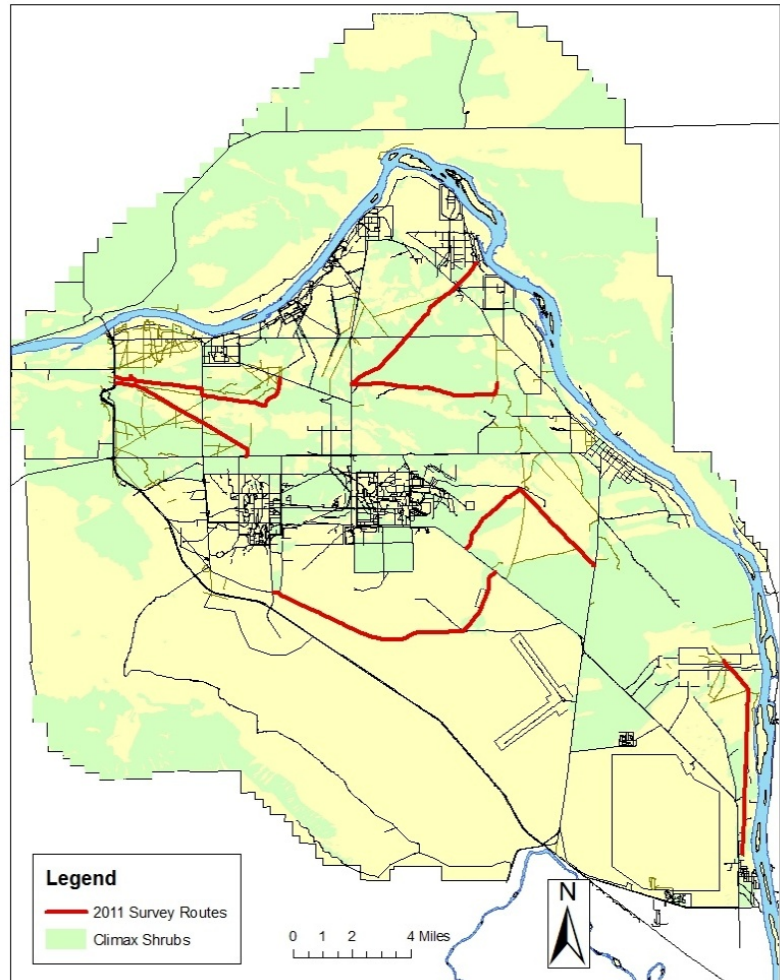
**Figure 11.5. Bald Eagle Night Roost Locations, Number, and Age Class Observed on the Hanford Reach**



#### 11.1.2.4 Jackrabbits

Recent evidence may suggest that populations of jackrabbits have not been seen at the historic levels on the Hanford Site. The WDFW currently lists the black-tailed jackrabbit (*Lepus californicus*) and white-tailed jackrabbit (*Lepus townsendii*) as 'candidate' species of concern (Table 11.2). Lack of recent monitoring or sightings on the Hanford Site has led some to believe the population is on a decline, while others believe that jackrabbits may follow a cyclical population density. Black-tailed jackrabbits play an important role in the ecosystem; and serve as a food source for large raptor and mammalian predators. An effort was made in December 2011 to perform spotlight surveys on transects similar to those which had been surveyed historically. A total of seven transects throughout the Hanford Site were surveyed using spotlights (Figure 11.6). Surveys were performed by driving the routes after sunset at approximately 10 miles

(16 kilometers) per hour with two individuals using spotlights to detect any wildlife activity. During the surveys, zero jackrabbits were documented using the spotlight method. The absence during the survey could be due to timing and method of survey. Springtime walking transects will be performed in 2012 in combination with a planned ground squirrel monitoring effort. Jackrabbit flushes during these transects will be documented and recorded as well as any continued spotlight survey efforts.



**Figure 11.6. Jackrabbit Spotlight Survey Routes (2011)**

## 11.2 Hanford Site Endangered and Threatened Species

*MR Sackschewsky*

This section describes federal and state endangered and threatened species, candidate or sensitive plant and animal species, and other species of concern potentially found at the Hanford Site. Endangered species are those in danger of extinction within all or a significant portion of their range. Threatened species are those likely to become endangered in the near future. Sensitive species are species that are vulnerable or declining and could become endangered or threatened without active management or removal of threats. The federal list of endangered and threatened species is maintained by the U.S. Fish and Wildlife Service in [50 CFR 17.11](#) and

[50 CFR 17.12](#). State lists are maintained by the Washington Natural Heritage Program ([WNHP 2011](#)) and WDFW ([WDFW 2011](#)).

The purposes of the *Endangered Species Act of 1973*, as amended, are to: 1) Provide a means to conserve critical ecosystems; 2) Provide a program for the conservation of endangered and threatened species; and 3) Ensure appropriate steps are taken to achieve the purposes of the treaties and conventions established under the Act. Washington State regulations also list species as endangered and threatened, but such a listing does not carry the protection of the federal *Endangered Species Act of 1973*. The National Oceanic and Atmospheric Administration's National Marine Fisheries Service ([NOAA 2008](#)) has the responsibility for federal listing of anadromous fish (i.e., fish that require both saltwater and freshwater to complete a lifecycle). The U.S. Fish and Wildlife Service is responsible for all other federally listed species at the Hanford Site. Table 11.2 lists the species of plants and animals that occur or potentially occur on the Hanford Site and are listed as endangered, threatened, sensitive, or candidate by either the federal or the state governments.

Two fish species (spring-run Chinook salmon [*Oncorhynchus tshawytscha*] and steelhead [*Oncorhynchus mykiss*]) on the federal list of endangered and threatened species are known to occur regularly on the Hanford Site (Table 11.2). One additional fish species (bull trout [*Salvelinus confluentus*]) was recorded at the Hanford Site but scientists believe this species is transient. No other plants or animals known to occur on the Hanford Site are currently on the federal list of endangered and threatened species ([50 CFR 17](#)), but two plant species have been proposed for listing, and one mammal species and one bird species are currently candidates for listing under the *Endangered Species Act of 1973* (Table 11.2). In addition, 13 plant species and 4 bird species have been listed as either endangered or threatened by Washington State. Numerous additional species of animals and plants are listed as candidate or sensitive species by Washington State. There are 32 state-level sensitive and candidate species of insects and animals and 14 sensitive plant species occurring or potentially occurring on the Hanford Site (Table 11.2).

Washington State officials maintain additional lower level lists of species, including a monitor list for animals ([WDFW 2011](#)) and review and watch lists for plants ([WNHP 2011](#)). Species on the state monitor, watch, and review lists are not considered species of concern, but are monitored for status and distribution. These species are managed as needed by the state to prevent them from becoming endangered, threatened, or sensitive; however, an abundance of these species may be indicative of an ecosystem with relatively high native diversity. Approximately 50 Washington State monitor list animal species occur or potentially occur on the Hanford Site (Table 11.3), and 23 watch or review list plant species are potentially found on the Hanford Site (Table 11.4).

**Table 11.2. Federal and Washington State Listed Endangered, Threatened, Sensitive, and Candidate Species Occurring or Potentially Occurring on the Hanford Site**

Common Name	Scientific Name	Federal Status <sup>(a)</sup>	State Status <sup>(a)</sup>
<b>Plants</b>			
Awned Halfchaff Sedge	Lipocarpha (= Hemicarpha) aristulata		Threatened
Beaked Spike-Rush	Eleocharis rostellata		Sensitive
Canadian St. John's Wort	Hypericum majus		Sensitive
Chaffweed	Anagallis (= Centunculus) minima		Threatened
Columbia Milkvetch	Astragalus columbianus	Species of concern	Sensitive
Columbia Yellowcress	Rorippa columbiae	Species of concern	Endangered
Coyote Tobacco	Nicotiana attenuata		Sensitive
Desert Cryptantha	Cryptantha scoparia		Sensitive
Desert Dodder	Cuscuta denticulata		Threatened
Desert Evening-Primrose	Oenothera caespitosa		Sensitive
Dwarf Evening Primrose	Camissonia (= Oenothera) pygmaea		Sensitive
Fuzzytongue Penstemon	Penstemon eriantherus whitedii		Sensitive
Geyer's Milkvetch	Astragalus geyeri		Threatened
Grand Redstem	Ammannia robusta		Threatened
Gray Cryptantha	Cryptantha leucophaea	Species of concern	Sensitive
Great Basin Gilia	Aliciella (= Gilia) leptomeria		Threatened
Hoover's Desert Parsley	Lomatium tuberosum	Species of concern	Sensitive
Loeflingia	Loeflingia squarrosa var. squarrosa		Threatened
Lowland Toothcup	Rotala ramosior		Threatened
Piper's Daisy	Erigeron piperianus		Sensitive
Rosy Pussypaws	Cistanthe (= Calyptridium) rosea		Threatened
Small-Flowered Evening-Primrose	Camissonia (= Oenothera) minor		Sensitive
Snake River Cryptantha	Cryptantha spiculifera (= C. interrupta)		Sensitive
Suksdorf's Monkey Flower	Mimulus suksdorfii		Sensitive
Umtanum Desert Buckwheat	Eriogonum codium	Proposed Threatened	Endangered
White Bluffs Bladderpod	Physaria (= Lesquerella) tuplashensis	Proposed Threatened	Threatened
White Eatonella	Eatonella nivea		Threatened
<b>Mollusks</b>			
California Floater	Anodonta californiensis	Species of concern	Candidate
Great Columbia River Spire Snail	Fluminicola columbiana	Species of concern	Candidate
Shortfaced Lanx	Fisherola nuttalli		Candidate
<b>Insects</b>			
Columbia River Tiger Beetle <sup>(b)</sup>	Cicindela columbica		Candidate
Silver-Bordered Fritillary	Boloria selene atrocostalis		Candidate



**Table 11.2. Federal and Washington State Listed Endangered, Threatened, Sensitive, and Candidate Species Occurring or Potentially Occurring on the Hanford Site**

Common Name	Scientific Name	Federal Status <sup>(a)</sup>	State Status <sup>(a)</sup>
<b>Fish</b>			
Bull Trout <sup>(c)</sup>	Salvelinus confluentus	Threatened	Candidate
Leopard Dace <sup>(c)</sup>	Rhinichthys flacatus		Candidate
Mountain Sucker <sup>(c)</sup>	Catostomus platyrhynchus		Candidate
River Lamprey <sup>(c)</sup>	Lampetra ayresi	Species of concern	Candidate
Spring-Run Chinook Salmon	Oncorhynchus tshawytscha	Endangered	Candidate
Steelhead	Oncorhynchus mykiss	Threatened	Candidate
<b>Amphibians and Reptiles</b>			
Sagebrush Lizard	Sceloporus graciosus	Species of concern	Candidate
Striped Whipsnake	Masticophis taeniatus		Candidate
Western Toad	Bufo boreas	Species of concern	Candidate
<b>Birds</b>			
American White Pelican	Pelecanus erythrorhynchos		Endangered
Bald Eagle	Haliaeetus leucocephalus	Species of concern	Sensitive
Burrowing Owl	Athene cunicularia	Species of concern	Candidate
Clark's Grebe	Aechmophorus clarkii		Candidate
Common Loon	Gavia immer		Sensitive
Ferruginous Hawk	Buteo regalis	Species of concern	Threatened
Flamulated Owl <sup>(c)</sup>	Otus flammeolus		Candidate
Golden Eagle	Aquila chrysaetos		Candidate
Greater Sage Grouse	Centrocercus urophasianus	Candidate	Threatened
Lewis's Woodpecker <sup>(c)</sup>	Melanerpes lewis		Candidate
Loggerhead Shrike	Lanius ludovicianus	Species of concern	Candidate
Northern Goshawk <sup>(c)</sup>	Accipiter gentilis	Species of concern	Candidate
Olive-Sided Flycatcher	Contopus cooperi	Species of concern	
Peregrine Falcon	Falco peregrinus	Species of concern	Sensitive
Sage Sparrow	Amphispiza belli		Candidate
Sage Thrasher	Oreoscoptes montanus		Candidate
Sandhill Crane	Grus canadensis		Endangered
Western Grebe	Aechmophorus occidentalis		Candidate
<b>Mammals</b>			
Black-Tailed Jackrabbit	Lepus californicus		Candidate
Merriam's Shrew	Sorex merriami		Candidate
Townsend's Ground Squirrel	Urocitellus townsendii	Species of concern	Candidate
Washington Ground Squirrel <sup>(c)</sup>	Urocitellus washingtoni	Candidate	Candidate
White-Tailed Jackrabbit	Lepus townsendii		Candidate

(a) Endangered - Species in danger of extinction within all or a significant portion of its range.

Threatened - Species likely to become endangered in the near future.

Candidate - Species that are believed to qualify for threatened or endangered species status, but for which listing proposals have not been prepared.

Sensitive - Taxa that are vulnerable or declining and could become endangered or threatened without active management or removal of threats.

Species of concern - Species that are not currently listed or candidates under the *Endangered Species Act of 1973*, but are of conservation concern within specific U.S. Fish and Wildlife Service regions.

(b) Probable, but not observed, on the Hanford Site.

(c) Reported, but seldom observed, on the Hanford Site.



**Table 11.3. Washington State Monitored Wildlife Species Occurring or Potentially Occurring on Hanford**

Common Name	Scientific Name
<b>Birds</b>	
Arctic Tern <sup>(a)</sup>	<i>Sterna paradisaea</i>
Ash-Throated Flycatcher <sup>(a)</sup>	<i>Myiarchus cinerascens</i>
Black Tern <sup>(a)</sup>	<i>Chlidonias niger</i>
Black-Crowned Night-Heron	<i>Nycticorax nycticorax</i>
Black-Necked Stilt	<i>Himantopus mexicanus</i>
Bobolink <sup>(A)</sup>	<i>Dolichonyx oryzivorus</i>
Caspian Tern	<i>Sterna caspia</i>
Forster's Tern	<i>Sterna forsteri</i>
Grasshopper Sparrow	<i>Ammodramus savannarum</i>
Gray Flycatcher	<i>Empidonax wrightii</i>
Great Blue Heron	<i>Ardea herodias</i>
Great Egret	<i>Ardea alba</i>
Gyr Falcon <sup>(a)</sup>	<i>Falco rusticolus</i>
Horned Grebe	<i>Podiceps auritus</i>
Lesser Goldfinch	<i>Spinus psaltria</i>
Long-Billed Curlew	<i>Numenius americanus</i>
Osprey	<i>Pandion haliaetus</i>
Prairie Falcon	<i>Falco mexicanus</i>
Red-Necked Grebe <sup>(a)</sup>	<i>Podiceps grisegena</i>
Snowy Owl	<i>Nyctea scandiaca</i>
Swainson's Hawk	<i>Buteo swainsoni</i>
Turkey Vulture <sup>(a)</sup>	<i>Cathartes aura</i>
Western Bluebird	<i>Sialia mexicana</i>
<b>Insects</b>	
Bonneville Skipper	<i>Ochlodes sylvanoides bonnevillae</i>
Juba Skipper	<i>Hesperia juba</i>
Nevada Skipper	<i>Hesperia nevada</i>
Pasco Pearl	<i>Phyciodes coccyta pascoensis</i>
Persius' Duskywing	<i>Erynnis persius</i>
Purplish Copper	<i>Lycaena helloides</i>
Ruddy Copper	<i>Lycaena rubida perkinsorum</i>
Viceroy	<i>Limenitis archippus lahontani</i>
<b>Mammals</b>	
Badger	<i>Taxidea taxus</i>
Long-Legged Myotis <sup>(b)</sup>	<i>Myotis volans</i>
Northern Grasshopper Mouse	<i>Onychomys leucogaster</i>
Pallid Bat	<i>Antrozous pallidus</i>
Sagebrush Vole	<i>Lagurus curtatus</i>
Small-Footed Myotis <sup>(b)</sup>	<i>Myotis ciliolabrum</i>
Western Pipistrelle	<i>Parastrellus hesperus</i>

Common Name	Scientific Name
<b>Fish</b>	
Pacific Lamprey <sup>(b)</sup>	<i>Lampetra tridentata</i>
Piute Sculpin	<i>Cottus beldingi</i>
Reticulate Sculpin	<i>Cottus perplexus</i>
Sand Roller	<i>Percopsis transmontana</i>
<b>Amphibians and Reptiles</b>	
Night Snake	<i>Hypsiglena torquata</i>
Racer	<i>Coluber constrictor</i>
Short-Horned Lizard	<i>Phrynosoma douglasii</i>
Tiger Salamander	<i>Ambystoma tigrinum</i>
Woodhouse's Toad	<i>Anaxyrus woodhousii</i>
<b>Mollusks</b>	
Oregon Floater	<i>Anodonta oregonensis</i>
Western Floater	<i>Anodonta kennerlyi</i>
Western Pearlshell	<i>Margaritifera falcata</i>

(a) Reported, but seldom observed on the Hanford Site.

(b) Federal species of concern.

**Table 11.4. Hanford Site Washington State Review and Watch list Plant Species**

Common Name	Scientific Name	State Listing <sup>(a)</sup>
annual paintbrush	Castilleja exilis	Watch list
annual sandwort	Minuartia pusilla var. pusilla	Review Group 1
basalt milkvetch	Astragalus conjunctus var. rickardii	Watch list
bristly combseed	Pectocarya setosa	Watch list
Columbia River mugwort	Artemisia lindleyana	Watch list
crouching milkvetch	Astragalus succumbens	Watch list
false pimpernel	Lindernia dubia var. anagallidea	Watch list
giant helleborine	Epipactis gigantea	Watch list
hedgehog cactus	Pediocactus simpsonii var. robustior =(P. nigrispinus)	Review Group 1
Kittitas larkspur	Delphinium multiplex	Watch list
medic milkvetch	Astragalus speirocarpus	Watch list
pigmy-weed	Crassula aquatica	Watch list
porcupine sedge	Carex hystericina	Watch list
Robinson's onion	Allium robinsonii	Watch list
rosy balsamroot	Balsamorhiza rosea	Watch list
scilla onion	Allium scilloides	Watch list
shining flatsedge	Cyperus bipartitus (rivularis)	Watch list
small-flowered nama	Nama densum var. parviflorum	Watch list
smooth cliffbrake	Pellaea glabella simplex	Watch list
southern mudwort	Limosella acaulis	Watch list
stalked-pod milkvetch	Astragalus sclerocarpus	Watch list
vanilla grass	Hierchloe odorata =(Anthoxanthum hirtum)	Review Group 1
winged combseed	Pectocarya penicillata	Watch list

(a) Review Group 1 - Taxa for which currently there are insufficient data available to support listing as threatened, endangered, or sensitive.

Watch list - Taxa that are more abundant and/or less threatened than previously assumed.

### 11.3 Cultural and Historic Resource Protection

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Cultural and historic resources monitoring at DOE-managed portions of the Hanford Site is conducted under the auspices of DOE's Cultural Resources Program to ensure site compliance with federal cultural resources laws and regulations ([Section 2.5](#)). Program activities in 2011 included the following:

- Performed cultural resource reviews for federal undertakings conducted at the Hanford Site in accordance with Section 106 of the *National Historic Preservation Act of 1966* and the *National Environmental Policy Act of 1969*
- Monitored cultural resources conditions to ensure important resources are protected
- Maintained a database of cultural resources site records, project records, and regional ethno history
- Maintained archaeological and historical collections
- Identified and evaluated new cultural resources to ensure they are appropriately managed
- Consulted with Native American tribes and other stakeholders to gather input on the identification, documentation, and management of cultural resources important to them.

DOE's Cultural Resources Program personnel oversee all cultural resource activities at the Hanford Site. Section 106 compliance work scope in 2011 was performed for DOE by archaeologists from CH2M HILL, MSA, PNNL, and WCH.

Having merged the Cultural Resources Program and Tribal Affairs Program to create the Tribal Affairs and Cultural Resources Program in 2010, DOE divided the programs again in 2011 to gain efficiency in administration, program identity, and function. The DOE Cultural Resources Program also schedules monthly meetings with all archaeological staff from the Hanford Site contractors to discuss and resolve issues relating to Cultural Resources Management (including survey procedures, site testing, site evaluation, consultations with external parties, etc.), with the objective of establishing and maintaining consistency among contractors.

### **11.3.1 Cultural Resources Reviews**

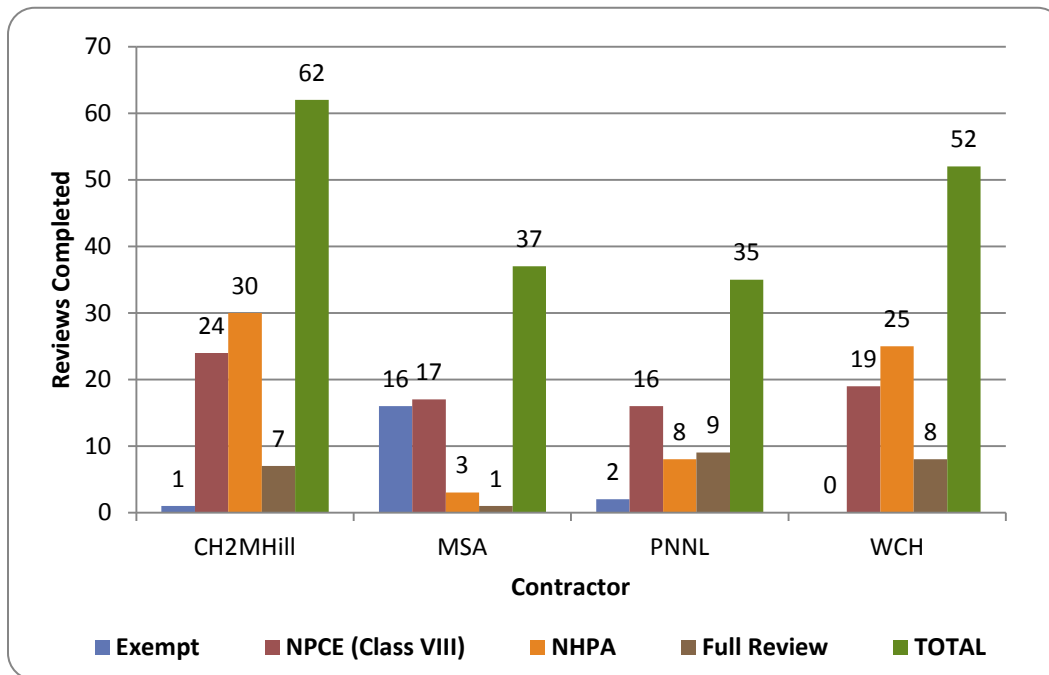
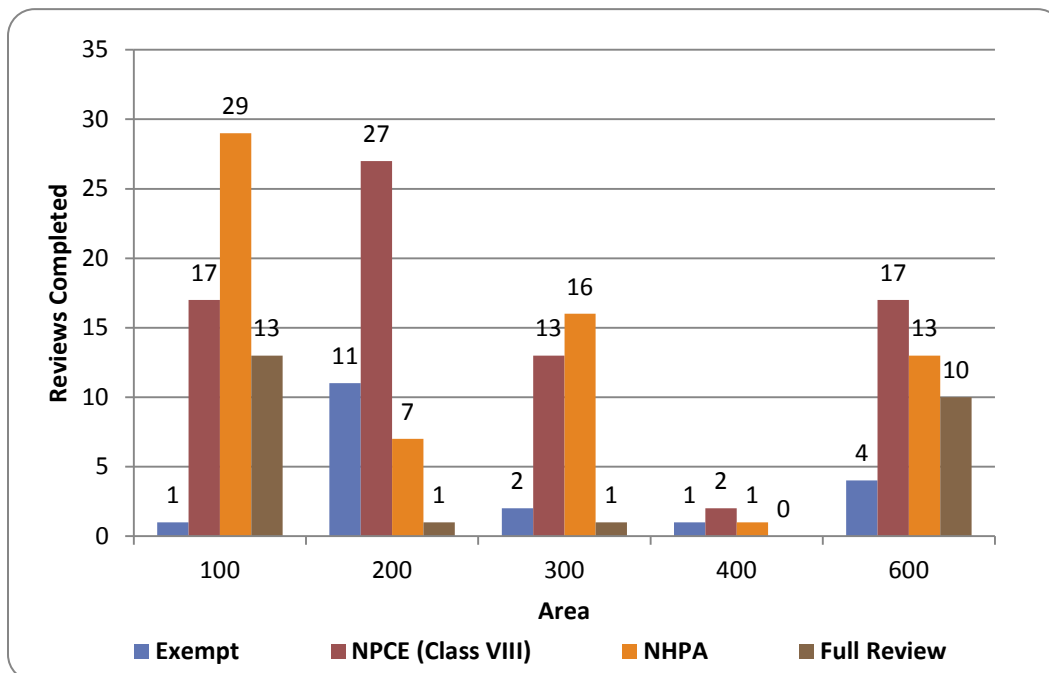
Pursuant to the *National Environmental Policy Act of 1969* and Section 106 of the *National Historic Preservation Act of 1966*, DOE conducts cultural resources reviews of federal undertakings at the Hanford Site. Section 106 reviews ensure that important cultural resources are identified and effects to those resources are evaluated so that mitigation measures can be conducted.

Section 106 reviews were completed for 186 undertakings in 2011 by Hanford Site archaeologists. CH2M HILL staff completed 62 Section 106 reviews; MSA staff completed 37 reviews; PNNL staff completed 35 reviews; and WCH staff completed 52 reviews. A total of 76 proposed projects were determined not to be the type to cause effects to cultural resources. Of these, CH2M HILL staff completed 24 reviews; MSA staff completed 17; PNNL staff completed 16; and WCH staff completed 19 (Figure 11.7). This type of undertaking is defined in the *Hanford Site Cultural Resources Management Plan* ([DOE/RL-98-10](#)) as a routine maintenance activity that occurs in areas away from culturally sensitive zones in areas previously disturbed by existing infrastructure. Most projects determined not to have the potential to cause effects to cultural resources occurred in the 200 Areas of the Hanford Site (Figure 11.8).

An additional 91 undertakings were reviewed in 2011 with the potential to affect cultural resources. Reviews included efforts to identify cultural resources that might be affected by project activity, assessment of potential impacts, and mitigation, if necessary<sup>(3)</sup>. CH2M HILL archaeologists completed 37 of these cultural reviews; MSA staff completed 4 reviews; PNNL staff completed 17; and WCH staff completed 33. Of the 91 undertakings, 66 were identified as *no historic properties affected*; 22 had *no adverse effects* to historic properties; and 3 resulted in *adverse effects*. Adverse effects were avoided by taking specific actions to minimize impacts, including avoidance, following treatment plan guidelines, and archaeological monitoring. The three undertakings resulting in adverse effects to historic properties required mitigation measures as documented in a project-specific Memorandum of Agreement. Approximately 1,689 acres (684 hectares) of new ground was surveyed for cultural resources because of 50 of the undertakings with the potential to affect cultural resources. In addition, some undertakings required *National Register of Historic Places* eligibility evaluations, including archaeological testing.

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<sup>(3)</sup> This number does not reflect all full cultural resources reviews initiated in 2011. Additional reviews initiated in 2011, but completed in 2012 are not included in this report.

**Figure 11.7. Hanford Site Section 106 Reviews by Archaeological Contractor (2011)****Figure 11.8. Hanford Site Section 106 Reviews by Area (2011)**

Exempt = no review required  
 NPCE = no potential to cause effect

NHPA = no historic properties affected  
 Full Review = potential to cause effects

Although the pace of work slowed somewhat in 2011, *American Recovery and Reinvestment Act of 2009* stimulus funding continued to accelerate cleanup on the Hanford Site, resulting in projects with more complex scopes than experienced under non- *American Recovery and Reinvestment Act of 2009* conditions.

### 11.3.2 Cultural Resources Protections

To ensure protection of the Hanford Site, cultural resources activities are conducted to comply with Section 110 of the *National Historic Preservation Act of 1966*, the *Native American Graves Protection and Repatriation Act of 1990*, and the *Archaeological Resources Protection Act of 1979*. A monitoring program has been in place since 1987 to assess effects of weathering and erosion and/or unauthorized excavation and collection of significant cultural resources at the Hanford Site. Activities include onsite inspections to monitor site conditions, assess impacts, and identify protective measures, if necessary. In 2011, 31 pre-contact archaeological sites were monitored. Site visits are conducted with the participation of tribal cultural resources personnel. Although no major impacts were noted at any sites inspected in 2011, minor impacts as a result of natural erosion, recreational activities, and/or animal disturbance were recorded. Additionally, three monitoring trips were made in 2011 to Locke Island within the Hanford Reach of the Columbia River. Water levels in 2011 were the highest in 20 years and a cause for concern. Examination of eroded areas on the periphery of Locke Island revealed two possible causal variables: high-water levels and water fluctuation.

One incident of unauthorized excavation in 2011 was noted within an archaeological site. Site 45BN920, an historic-archaeological site, was reportedly disturbed by unauthorized activity. Initial field reporting recorded disturbance of historic debris features. An in-depth impact assessment determined the impacts did not interfere either with the site's interpretive potential or the integrity of the features. There also was one unanticipated impact to an archaeological site in 2011 resulting from project activities. Spoils piles from remedial action excavation activities at the 100-K Area were dumped by heavy equipment in an area where lithic debris later was seen exposed on the surface. Project activities in this area were halted and a cultural resources impact assessment was completed.

#### 11.3.2.1 Identification and Evaluation Activities

Identification and evaluation activities are performed to comply with Sections 106 and 110 of the *National Historic Preservation Act of 1966*. Seventy-six new archaeological sites or isolated finds were recorded (Table 11.5). Of the 48 newly recorded sites, *National Register of Historic Places* evaluations were completed on 47; 3 of these sites were determined eligible for listing in the *National Register*. One of the newly recorded sites was not evaluated. Archaeological site forms for 25 previously recorded archaeological sites were updated, and 24 were evaluated for *National Register* eligibility. Of these, 10 sites were determined eligible for listing. Again, one site was not evaluated. Isolates generally are not evaluated for *National Register* eligibility.

**Table 11.5. Sites and Isolates Recorded or Updated (2011)**

	Eligible	Not Eligible	Unevaluated	TOTAL
Updates	10	14	1	25
New Sites	3	44	1	48
New Isolates	0	0	3	3
Historic Property Inventory Form	0	0	0	0
<b>TOTAL</b>	<b>13</b>	<b>58</b>	<b>5</b>	<b>76</b>

### 11.3.2.2 Data Recovery Activities

No data recovery excavations were conducted in 2011. However, lithic and faunal materials obtained through data recovery excavations in 1991 and 1992 were analyzed and documented in a 2011 report titled *Report of Findings: The Analysis of the Archaeological Materials Recovered from Site 45BN423 in 1991 and 1992, Benton County, Washington* (CHPRC 2011). This report concluded that: the lithic reduction strategy at 45BN423 focused on late-stage tool maintenance and reduction of previously prepared cores; the site experienced continuous occupation over an extended period of time beginning approximately 4,500 years ago rather than intermittent use; there was a fairly dense population at this site during its occupation; and the site likely functioned as a winter village. The findings contained in this report will guide future data recovery efforts, mitigation, and consultation at this location.

### 11.3.2.3 Artifact and Data Collections Management

Files for more than 1,500 cultural sites and curated archaeological collections from more than 80 sites were stored in an archive room at PNNL in early 2011. The transfer/move of these records and artifacts from PNNL to MSA was conducted on April 8, 2011, under the supervision of the U.S. Army Corps of Engineers, St. Louis District, Mandatory Center of Expertise for the Curation and Management of Archaeological Collections, and monitored by DOE Cultural Resources staff and tribal representatives. A bar code was affixed to each of the 150 boxes of artifacts and the 115 boxes of cultural resources reports, records, reference materials, photographs and maps, as well as the 17 file cabinets and 3 map cases removed from PNNL. Each box, file cabinet, and map case was electronically scanned and entered into an Excel tracking database as it was placed on the moving truck at PNNL, as it left the moving truck at the Washington State University Tri-Cities, Consolidated Information Center (WSU-CIC) artifact repository or the MSA library/archive room at 2430 Stevens Center, and again as it was placed in its final destination. The records and artifacts move was accomplished successfully, without any damage to or loss of materials. The only day access to these artifacts and records was not possible was the day of the move itself.

The cultural resources software applications, digital archives, digital photographs, and other electronic data are organized under three principal categories; i.e., Share Area Files and Databases, Records Management Information, and GIS Databases. A secure Hanford Information System Inventory work area/server was created by MSA Information Technology to independently track and store electronic data and software transferred from PNNL to MSA. The new MSA Cultural and Historic Resources Program (CHRP) server was placed under strict access control, with permission for access given only to qualified users by the MSA Principal Cultural Resources Specialist. To verify all electronic systems were functional and working properly, MSA CHPR staff developed data retrieval tests that PNNL Cultural staff performed at both PNNL and MSA to test the MSA system prior to MSA assumption of CHRP responsibilities. All MSA systems were demonstrated to be fully operational.

The Columbia River Exhibition of History, Science, and Technology (CREHST) museum staff manages the Hanford Site Manhattan Project and Cold War Era artifact collection. Efforts to generate additional items for the collections are conducted as stipulated in the Programmatic Agreement for the built (human-made) environment at the Hanford Site ([DOE/RL-96-77](#)), which directs DOE personnel to assess the contents of site historical buildings and structures prior to commencement of deactivation, decontamination, decommissioning, or demolition activities. Assessments identify and preserve any artifacts (e.g., control panels, signs, scale models, machinery) that may have value as interpretive or educational exhibits within national, state, or local museums. Eight assessments were conducted in 2011.

### 11.3.3 Cultural Resources Consultations and Public Involvement

DOE conducts formal consultations with the Washington State Historic Preservation Office, Native American tribes, and other interested parties for cultural resources reviews to comply with Section 106 of the *National Historic Preservation Act of 1966* and the *National Environmental Policy Act of 1969* ([Section 2.1.4](#)). DOE consulted with the Washington State Historic Preservation Office and Native American tribes on 91 cultural reviews.

DOE Cultural Resources Program staff held 11 meetings in 2011 with tribal cultural resources staff from the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes and Bands of the Yakama Nation, the Nez Perce Tribe, and the Wanapum. Discussions focused on the cultural resources reviews completed and initiated in 2011; proposed undertakings within traditional cultural property boundaries and view sheds; and approaches to protecting threatened archaeological sites and places containing Native American human remains.

DOE, archaeological contractors, Native American tribes, Washington State Historic Preservation Office, and the Advisory Council on Historic Preservation met in person and/or teleconference throughout 2011 to discuss the *Hanford Cultural Resources Management Plan*, No Potential to Cause Effect reviews ([DOE/RL-98-10](#)). The objectives were to document No Potential to Cause Effect application/decision-making through time, and develop a path forward for continued use of this type of review. The following steps were agreed to be taken towards final resolution of the issues raised:

1. Examine the criteria by which a No Potential to Cause Effect was identified.
2. Look at past classifications.
3. Identify how the Tribes can be involved in making the classification.
4. Educate Project Managers on the revised process.

Resolution was not reached in 2011, consequently discussions will continue in 2012.



## 12.0 Quality Assurance

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Quality assurance and quality control practices encompass all aspects of Hanford Site Environmental Monitoring and Surveillance Programs. This section provides information on specific measures taken in 2011 by the Hanford Site Environmental Monitoring and Surveillance Program staff to ensure quality and defensibility in project management, sample collection, and analytical results.

Environmental monitoring and surveillance at the Hanford Site comprehensively includes programs in groundwater, site-wide and offsite (far-field) environmental surveillance and monitoring, effluent monitoring, and near-facility environmental surveillance and monitoring. Due to the complexity of the Hanford Site groundwater program, quality assurance and quality control specifications for groundwater sampling and program management are reported independently in the *Hanford Site Groundwater Monitoring for 2011* ([DOE/RL-2011-118](#), Appendix D) and are not discussed further in this section. Quality assurance and quality control measures for the effluent, near-field and far-field environmental programs are described here.

The work scope for the Hanford Site Far-Field Environmental Monitoring Program was transitioned in May 2011 from the PNNL Surface Environmental Surveillance Program to MSA. During this transitional period and throughout the remainder of 2011, far-field program samples were collected according to approved and documented PNNL schedules and procedures (e.g., [PNNL-20121](#) and [PNL-MA-580](#)) and interim procedures developed by MSA (e.g., [MSC-MA-580](#)). Comprehensive quality assurance programs, including various quality control practices, were maintained to ensure the quality of data collected throughout the program transition.

The effluent, near field and far-field monitoring programs include quality assurance program plans that describe applicable quality assurance elements (e.g., [MSC-23333](#)). Sample analyses performed through laboratory contracts also are required to meet plan requirements. Suppliers were audited for equipment and services, which may have significantly affected project quality, before the contract awards were made.

### 12.1 Program Management

Site environmental monitoring and related activities are subject to an overall quality assurance program. This program implemented the requirements of DOE G 414.1-4, *Safety Software Guide for Use with 10 CFR 830 Subpart A, Quality Assurance Requirements*. The Hanford Site Environmental Monitoring and Surveillance Program also was subject to the quality assurance requirements specified in the *Hanford Analytical Services Quality Assurance Requirements Documents* (DOE/RL-96-68), and project-specific quality assurance plans and documentation (MSC-23333). Quality assurance programs complied with DOE G 414.1-4 using standards from the American Society of Mechanical Engineers (ASME NQA-1-2008) as their basis. The program also adhered to the guidelines and objectives in EPA *Requirements for Quality Assurance Project Plans for Environmental Data Operations* (EPA QA/R-5).

Record keeping is a vital part of the environmental monitoring program. Maintenance of environmental data is essential for quality assurance, regulatory compliance, trend analysis, and optimization purposes. Project documentation includes environmental sample logbooks, and as applicable, quarterly and annual occurrence reports.

## **12.2 Sample Collection Quality Assurance and Quality Control**

Samples for the Environmental Monitoring and Surveillance Programs were collected by personnel trained in accordance with approved procedures. Established sampling locations were accurately identified and documented to ensure continuity of data. Environmental monitoring and surveillance samples, collected by project staff, were submitted to the Waste Sampling and Characterization Facility (WSCF) located in the 200 Area of the Hanford Site, and the General Engineering Laboratories, LLC in Charleston, South Carolina, for chemical and radiochemical analyses. One high-efficiency particulate air filter sample was sent by the effluent monitoring program to Advanced Technologies and Laboratories International, Inc. for radiological analysis (Table 12.1).

### **12.2.1 Field Sample Collection Quality Assurance**

Personnel are trained to conduct sampling in accordance with approved schedules and procedures (e.g., [PNNL-20121](#), [PNL-MA-580](#), MSC-MA-580, and [MSC-23333](#)). Field duplicate samples were used to assess sampling and measurement precision. Continuity of all sampling location identities was maintained through careful documentation. Field duplicate samples collected and analyzed for far-field media in 2011 included 13 air samples, six Columbia River transect samples, two milk samples, two surface water samples, and six wine samples. Field duplicate samples for near-field locations and media collected in 2011 included air, soil, and vegetation samples. Near-field air filter samples were collected and analyzed bi-weekly from two locations, then composited semiannually, by location, for isotopic analysis. Nine soil and seven vegetation field duplicate samples were collected in 2011 for isotopic analysis.

Analytical results for routine samples and field duplicates were reviewed against the criterion that each result must be greater than the minimum detectable activity value or the method detection limit to be evaluated. The relative percentage difference of the routine sample and duplicate must be less than 30 percent to be an acceptable result. Of the 24 detected far-field media duplicate results evaluated, 80 percent of the duplicate results analyzed by General Engineering Laboratories, LLC for radiochemistry were acceptable (Table 12.2).

The concentration of a sample and the sample replicate were considered to be in agreement for the near-field media samples analyzed by the WSCF if one of the following criteria applied: 1) On a plot, the uncertainty error bars of the parent sample and its field duplicate overlap; 2) the lower uncertainty values for both the parent sample and its field duplicate extend below the minimum detectable concentration; or 3) the relative percentage difference was less than 30 percent or the percent significant difference was less than 15 percent. Near-field environmental media results (air, soil, vegetation) were acceptable for 94.7 percent of the duplicate results analyzed by WSCF (Table 12.3).

## **12.3 Media Audits and Comparisons**

The Washington State Department of Health routinely analyzed split samples of various environmental media during 2011 as part of the Hanford Environmental Radiation Oversight Program. Comparisons were conducted on several specific sample types. Media that were analyzed for radionuclides included irrigation water from 6 locations, surface water from 14 locations along and across the Columbia River, water from 10 Columbia River shoreline springs, and water from 2 onsite drinking water locations. Vegetation/foodstuff samples analyzed for radionuclides included two wine samples, two leafy vegetable samples, and three vegetation samples. Forty fish samples were obtained for whole organ and carcass analysis.

Split samples of various environmental media were submitted for radiological analysis during 2011 as part of the Hanford Environmental Radiation Oversight Program. No comparison data were available at the time this report was written; however, Washington State Department of Health publishes data summary reports for the Hanford Environmental Radiation Oversight Program annually online at <http://www.doh.wa.gov/CommunityandEnvironment/Radiation/Publications/EnvironmentalSciences.aspx>.

## **12.4 Laboratory Internal Quality Assurance Programs**

Analytical laboratories are required to maintain internal quality assurance and quality control programs. Contract laboratories used to perform environmental sample analysis in 2011 included General Engineering Laboratories, LLC, WSCF, and Advanced Technologies and Laboratories International, Inc. (Table 12.1). The internal quality control programs for contracted laboratories involved routine calibrations of counting instruments, yield determinations of radiochemical procedures, frequent radiation-check sources and background counts, replicate and spiked sample analyses, use of matrix and reagent blanks, and maintenance of control charts to indicate analytical deficiencies. Available calibration standards traceable to the National Institute of Standards and Technology were used for radiochemical calibrations. Calculation of minimum detectable concentrations involved using factors such as the average counting efficiencies and background counts for detection instruments, length of time for background and sample counts, sample volumes, radiochemical yields, and a pre-designated uncertainty multiplier ([EPA 520/1-80-012](#)).

Radiological counting room instruments were verified to perform within calibration limits through daily checks, and the results are stored in computer databases. Radiochemical standards used in analyses were measured regularly, and the results were reported and tracked. Formal, written laboratory procedures were followed to analyze samples. Analytical procedural control was ensured through administrative procedures. Chemical technologists at the laboratories were qualified to perform analyses through formal classroom and on-the-job training.

Periodically, inspections of services were performed, and conformance of the analytical facilities with their contractual requirements was documented. These inspections provided the framework for identifying and resolving potential performance problems. Responses to inspection findings were documented by written communication, and corrective actions were verified by follow-up audits and inspections.

## **12.5 Analytical Result Quality Assurance and Quality Control**

Analytical results for the Hanford Site Environmental Monitoring and Surveillance Program samples were provided by three laboratories (Table 12.1). Routine chemical analyses of soil, vegetation, air, water, and effluent for the Hanford Site Environmental Monitoring and Surveillance Program were performed by General Engineering Laboratories, LLC and the WSCF. One high-efficiency particulate air filter sample was submitted to Advanced Technologies and Laboratories International, Inc. (Table 12.1). These laboratories participated in managed quality assurance and quality control programs in 2011, including the DOE Consolidated Audit Program (DOECAP), the Mixed Analyte Performance Evaluation Program (MAPEP), EPA-compliant performance evaluation and proficiency testing studies, and laboratory performance intercomparison studies. These managed programs use standardized audit methods, processes, and procedures to ensure, on an annual basis, to assess the validity, reliability, and defensibility of data from the contract laboratories. These quality assurance and quality control programs are briefly described below.

General Engineering Laboratory, LLC participated in the DOECAP assessment, MAPEP Studies 24 and 25 (March 2011 and September 2011), and a number of Environmental Resource Associates proficiency studies for water, soil, filter, and vegetation matrices.

WSCF was evaluated in 2011 by its participation in the following laboratory performance intercomparison studies: EPA studies (i.e., soil, water pollution, and water tritium), DOE MAPEP studies, and the National Institute of Standards and Technology Radiochemistry Intercomparison Program study. Because the laboratory shutdown from early September to early December 2011, WSCF did not participate in the MAPEP Study 25, but participated in a makeup study (West 03-12-001) in water, soil, filter, and vegetation matrices.

Advanced Technologies and Laboratories International, Inc., the 222-S Laboratory Analytical Services and Testing Contractor in the 200-West Area of the Hanford Site, maintains accreditations from the American Industrial Hygiene Association and Ecology. Analytical performance was evaluated by its participation in six different laboratory proficiency testing studies in 2011, which included Environmental Resource Associates Water Pollution Studies 195 and 201; Environmental Resource Associates Soil Studies 73 and 76; Environmental Resource Associates MRAD™ Study 14 and a Quik™ Response Study; and MAPEP Studies 24 and 25. In addition, Advanced Technologies and Laboratories International, Inc. participated in the American Industrial Hygiene Association Industrial Hygiene Proficiency Analytical Testing and Beryllium Proficiency Analytical Testing programs to maintain its American Industrial Hygiene Association accreditation.

This section presents the results of the quality assurance and quality control programs performed for media audits and comparisons, consolidated audits, and analytical result proficiency testing for environmental samples for the near field, far-field, and effluent surveillance and monitoring programs.

### **12.5.1 U.S. Department of Energy Consolidated Audit Program**

An audit of General Engineering Laboratories, LLC was conducted in 2011 by the DOECAP. The objective of DOECAP is to ensure the application of consistent standards between the analytical laboratories supporting the DOE complex and its compliance programs. Audit objectives included assessing the ability of the laboratory to produce data of acceptable and documented quality through analytical operations that followed approved and technically sound methods, and the handling of DOE samples and associated waste in a manner that protected human health and the environment.

The scope of the DOECAP assessment of General Engineering Laboratories, LLC included the following specific functional areas:

- Quality assurance management systems and general laboratory practices
- Data quality for organic analyses
- Data quality for inorganic and wet chemistry analyses
- Data quality for radiochemistry analysis
- Laboratory information management systems/electronic data management
- Hazardous and radioactive materials management.

In addition, DOECAP assessments include verifying corrective action implementation from previous audit findings. One previous Priority II finding was closed in 2011 and none remained open.

Eight new Priority II findings (requiring some corrective action by the laboratory) and eight observations were noted during the 2011 DOECAP audit of General Engineering Laboratories, LLC. A Priority II finding is a factual statement issued from a DOECAP audit to document a deviation from a requirement.

The new Priority II findings are as follows:

- Permanent, bound laboratory logbooks with sequentially numbered pages are not in use in all areas of the laboratory
- No requirement or procedure addressing the screening solvents and reagents that are used during sample analysis in the analytical areas of the laboratory
- The mass spectrometer tune check was not evaluated for mass drift in accordance with the analytical standard operating procedure (SOP)
- General Engineering Laboratories, LLC failed to comply with the SOP requirement for semiannual participation in Environmental Resource Associates Water Pollution performance evaluation studies (in 2009)
- The corrective action for an unacceptable result on an Environmental Resource Associates Water Pollution performance evaluation study failed to meet Quality Systems for Analytical Services requirements
- Several inorganic method calibration standards are not traceable to the primary stock standards
- Shipping containers are not consistently opened under a ventilation hood
- Sample receiving personnel are not consistently screening all external surfaces of incoming containers for radiological contamination.

The eight new observations are as follows:

- Quality assurance management and general laboratory practices
  - ‡ Computer security awareness training was not included as annual training requirement
  - ‡ Project-specific sample receipt and review forms do not contain version numbers
  - ‡ Calibration certificates lacked documented evidence that out of tolerance conditions did not affect data quality.
- Data quality for organic analyses
  - ‡ Refrigerator #004 in the HE/MS/MS analytical laboratory was not labeled as a samples only refrigerator
  - ‡ The terms RL (reporting limit) and PQL (practical quantitation limit) were used interchangeably in the General Engineering Laboratories, LLC SOP. Either term may be technically correct for use in the SOP, but only one should be used consistently throughout the document, and defined in the SOP definitions
  - ‡ The terms CVS (calibration verification standard) and CCV (continuing calibration verification) were used interchangeably in the General Engineering Laboratories, LLC SOP. The SOP must supply a notation that these terms are identical in meaning.
- Data quality for radiochemistry analyses
  - ‡ The use of a lower order equation to fit gross alpha/beta analysis beta efficiency self-absorption calibration data may provide a smoother curve
- Laboratory information management systems (electronic data management)
  - ‡ Several offsite employees have not completed annual computer security awareness training.

Corrective actions for all the audit findings were accepted, and verification of the corrective actions will be performed in future audits.

The DOECAP audit concluded that General Engineering Laboratories, LLC *...demonstrated proficiency using a sound system for maintaining samples control and tracking to ensure proper disposal of samples and DOE samples and analysis derived wastes are managed in a manner that is protective of human health and the environment.* However, the DOECAP audit results noted that issues of concern and completed or planned corrective actions should be evaluated by DOE sites relative to their utilization of the laboratory.

### 12.5.2 Mixed Analyte Performance Evaluation Program

DOE's MAPEP provides critical quality assurance testing for environmental analytical services. Radiological and non-radiological (organic and inorganic) constituents were evaluated by performing semiannual proficiency testing of onsite DOE laboratories, other federal laboratories, state laboratories, commercial laboratories, and international laboratories. MAPEP proficiency tests help to ensure the accuracy of analytical results reported to DOE and other stakeholders, while also providing an efficient means for laboratories to demonstrate analytical proficiency. The validity and reliability of environmental data translates into more confident decision-making relative to environmental remediation cleanup projects, regulatory compliance, and protection of the public. Performance data for all matrices (soil, water, air filter, vegetation) from a MAPEP test session (i.e., Series) are reported to the DOE Headquarters' Program Offices, DOE Field Offices, Sample Management Offices or contractors, participating laboratories, and DOECAP audit personnel to support quality assurance oversight and quality improvement.

MAPEP studies were performed by the DOE Radiological and Environmental Sciences Laboratory in Idaho Falls, Idaho. Two MAPEP studies were performed: 1) MAPEP Study 24 was performed in March 2011; and 2) MAPEP Study 25 was performed in September 2011. MAPEP standard studies included gross alpha/beta analysis for air filters and water, radionuclides in air filters and vegetation, mixed analytes in soil and water, and semi-volatiles in soil and water. General Engineering Laboratories, LLC, WSCF, and Advanced Technologies and Laboratories International, Inc. participated in MAPEP studies in 2011. However, due to laboratory shutdown from early September to early December 2011, WSCF did not participate in the MAPEP Study 25, but participated in a makeup study (West 03-12-001) in water, soil, filter, and vegetation matrices.

Performance evaluation program results for General Engineering Laboratories, LLC analysis of radionuclides in water, soil, and vegetation were acceptable in 100 percent of MAPEP Study 24 and MAPEP Study 25 tests for routinely reported analytes. Performance evaluation results for air filters were deemed not acceptable for four radiological constituents (gross alpha, gross beta, plutonium-239/240, and uranium-238) due to result bias exceeding threshold criteria (Table 12.4). Performance evaluation program results for inorganic compounds met performance requirements for all water and soil analytes and methods with the exception of antimony in soil, which demonstrated bias in excess of 30 percent. Of the 74 organic analytes evaluated by the MAPEP Study 24 water study, only one organic constituent (1,4-dichlorobenzene) is routinely reported by the Hanford Site Environmental Monitoring and Surveillance Program. The proficiency test results for this compound in water were acceptable. Results of the MAPEP testing for General Engineering Laboratories, LLC concluded that 97 percent of the study results for routinely reported analytes in Hanford Site environmental media were acceptable.

Samples containing 336 different radionuclides and analytes were submitted to WSCF for the MAPEP Study 24 and West 03-12-001 Study analysis. Of the 336 reported radionuclide analytes, 318 results were acceptable while 18 were unacceptable, for a total acceptable rate of 95 percent for the WSCF (Table 12.5).

Advanced Technologies and Laboratories International, Inc. participated in MAPEP Studies 24 and 25 in 2011. For the two MAPEP Studies, 84 of 92 radionuclide results (including uranium isotopes and technetium-99 analyzed by inductively coupled plasma mass spectrometry) were acceptable, for an acceptable rate of 91.3 percent. Performance evaluation results are presented in Table 12.6.

### **12.5.3 Laboratory Performance Evaluation and Proficiency Testing**

Participation of Hanford Site analytical laboratories in DOE and EPA laboratory performance evaluation programs served to ensure data quality. Hanford Site environmental monitoring contract laboratories participated in a number of EPA-sanctioned proficiency test studies including those conducted by Environmental Resource Associates and the National Institute of Standards of Technology. Environmental Resource Associates, accredited National Environmental Laboratory Accreditation Conference (NELAC) Institute EL-V3-2011, provided certified reference materials and proficiency testing for water supply, water pollution, soil, air and emissions, effluent, MRAD™, and radiochemistry for contracted laboratories.

EPA Proficiency Testing studies for the General Engineering Laboratory, LLC were provided by Environmental Resource Associates in Arvada, Colorado. Proficiency testing included two WatR™ Supply studies (WS-175 and WS-180), two RadCheM™ studies (RAD-86, RAD-800), one WatR™ Pollution Study (WP-195), one soil study (SOIL-74), and one QuiK™ Response proficiency test for strontium-89 and strontium-90 in water (040511P). Results for all proficiency tests performed for the methods, analytes, and media reported by General Engineering Laboratory, LLC for the Hanford Site Environmental Monitoring and Surveillance Program were acceptable.

WSCF laboratory staff received and analyzed samples containing 471 different analytes and compounds during participation in Environmental Resource Associates Water Pollution Studies 192 and 198, and Soil Studies 73, 75, and *Quik™ Response* studies. Of the 471 reported analytes, 467 results were acceptable for a total acceptable rate of 99 percent. For the Environmental Resource Associates water tritium studies (RAD 84 and RAD 86, and a *Quik™ Response* Study), three tritium results were submitted and two were acceptable as shown in Table 12.5.

In the National Institute of Standards and Technology Radiochemistry Intercomparison Program Study, samples containing strontium-90, americium-241, isotopic plutonium, and isotopic uranium in filters and soils were submitted to the WSCF for different analyses (i.e., five samples of each radionuclide for each medium). All radionuclide results for both filters and soils were acceptable, for a total acceptance rate of 100 percent. The Radiochemistry Intercomparison Program Study performance evaluation results for WSCF are presented in Table 12.5.

Advanced Technologies and Laboratories International, Inc. reported 348 different analytes and compounds during participation in the Environmental Resource Associates water pollution studies in 2011. Of the 348 reported analytes, 338 results were acceptable and 10 were unacceptable, for a total acceptance rate of 97.1 percent. For the soil studies, 313 analytes were reported of which 310 analytes were acceptable, for an overall score of 99.0 percent. A combined 58 radionuclides were reported on the two MRAD™ studies, of which 54 were acceptable, for an overall score of 93.1 percent.



**Table 12.1. Summary of Laboratories Used and Types of Samples Analyzed for Effluent-Field Samples (2011)**

Analytical Laboratory	Effluent Monitoring Samples		Environmental Monitoring and Surveillance Samples		
	Air Filter	Water	Air Filter	Water	Other
General Engineering Laboratories, LLC			X	X	X
WSCF	X	X	X	X	
Advanced Technologies and Laboratories International, Inc.	X				

**Table 12.2. Summary of Field Duplicate Sample Results for Samples Submitted to General Engineering Laboratories, LLC in Charleston, South Carolina (2011)**

Media	Detected Analytes	Number of Detected Results Reported <sup>(a)</sup>	Results within Control Limits <sup>(b)</sup>
<b>Radionuclides</b>			
Air	Hydrogen-3 (tritium)	10	3
Water	Hydrogen-3 (tritium)	3	3
Water	Uranium-234	2	2
Water	Uranium-235	1	1
Water	Uranium-238	2	1
Biota-Milk	Hydrogen-3 (tritium)	2	2
Biota-Milk	Potassium-40	2	2
Foodstuffs-White Wine	Hydrogen-3 (tritium)	3	3
Foodstuffs-White Wine	Potassium-40	3	3
Foodstuffs-Red Wine	Hydrogen-3 (tritium)	3	3
Foodstuffs-Red Wine	Potassium-40	3	3
<b>Anions</b>			
Water	Chloride	2	2
	Fluoride	2	2
	NO <sub>3</sub> -N	2	2
	Sulfate	2	2

- (a) Number of reported results for radiological are those results greater than the minimum detectable activity. Number of reported results for chemistry are those results greater than or equal to the method detection limit.
- (b) Number of reported results within control limits for radiological analysis are those results with the relative percent difference value less than 30 percent, and the result is greater than the minimum detectable activity. Number of reported results within control limits for chemical analysis are those results with the relative percent difference value less than 30 percent, and the result is greater than or equal to the method detection limit.

**Table 12.3. Summary of Field Duplicate Sample Results for Samples Submitted to the Waste Sampling and Characterization Facility (2011)**

Detected Analytes	Number of Results Compared	Results within Control Limits <sup>(a)</sup>
<b>Air Filters</b>		
Tritium	14	14
Cobalt-60	2	2
Strontium-90	2	2
Ruthenium-106	2	2
Antimony-125	2	2
Cesium-134	2	2
Cesium-137	2	2
Europium-152	2	2
Europium-154	2	2
Europium-155	2	2
Uranium-234	2	2
Uranium-235	2	2
Uranium-238	2	2
Plutonium-238	2	2
Plutonium-239/240	2	2
gross $\alpha$	26	26
gross $\beta$	26	24
<b>Soil</b>		
Cobalt-60	9	9
Zinc-65	4	3
Strontium-90	9	9
Ruthenium-103	4	4
Ruthenium-106	9	9
Tin-113	4	4
Antimony-125	9	9
Cesium-134	9	9
Cesium-137	9	5
Cerium-144	4	4
Europium-152	9	9
Europium-154	9	9
Europium-155	9	5
Uranium-234	9	8
Uranium-235	7	6
Uranium-238	9	8
Plutonium-238	9	9
Plutonium-239/240	9	9

**Table 12.3. Summary of Field Duplicate Sample Results for Samples Submitted to the Waste Sampling and Characterization Facility (2011)**

Detected Analytes	Number of Results Compared	Results within Control Limits <sup>(a)</sup>
<b>Vegetation</b>		
Cobalt-60	7	7
Zinc-65	2	2
Strontium-90	7	7
Ruthenium-103	2	2
Ruthenium-106	7	7
Tin-113	2	2
Antimony-125	7	7
Cesium-134	7	7
Cesium-137	7	3
Cerium-144	2	2
Europium-152	7	7
Europium-154	7	7
Europium-155	7	7
Uranium-234	7	7
Uranium-235	7	7
Uranium-238	7	7
Plutonium-238	7	7
Plutonium-239/240	7	7

(a) Number of reported results within control limits for radiological analysis are those results with the relative percent difference value less than 30 percent, and the result is greater than the minimum detectable activity.

**Table 12.4. Summary of DOE Mixed Analyte Performance Evaluation Program Results for General Engineering Labs, LLC (2011)**

Environmental Sample Media and Analytes		MAPEP 24 Series (March 2011) <sup>(a)</sup>	MAPEP 25 Series (September 2011) <sup>(a)</sup>
<b>Radionuclides</b>			
<b>Air Filters</b>	Gross alpha, Gross beta, Americium-241, Cesium-134, Cesium-137, Cobalt-60, Strontium-90, Uranium-234, Uranium-238, Plutonium-238, Plutonium-239/240	Gross alpha <sup>(b)</sup>	Gross alpha <sup>(b)</sup> Gross beta <sup>(b)</sup> Plutonium-239/240 <sup>(c)</sup> Uranium-238 <sup>(c)</sup>
<b>Water</b>	Gross alpha, Gross beta, Americium-241, Cesium-134, Cesium-137, Cobalt-60, Potassium-40, Strontium-90, Uranium-234, Uranium-238, Technetium-99, Plutonium-238, Plutonium-239/240, Tritium	100 percent Acceptable	100 percent Acceptable
<b>Soil</b>	Cesium-134, Cesium-137, Cobalt-60, Potassium-40, Strontium-90, Uranium-234, Uranium-238, Plutonium-238, Plutonium-239/240, Technetium-99	100 percent Acceptable	100 percent Acceptable
<b>Vegetation</b>	Cesium-134, Cesium-137, Cobalt-60, Strontium-90, Uranium-234, Uranium-238	100 percent Acceptable	100 percent Acceptable
<b>Inorganic Compounds</b>			
<b>Water</b>	Antimony, Arsenic, Beryllium, Cadmium, Chromium, Copper, Lead, Nickel, Selenium, Thallium, Zinc, Mercury	100 percent Acceptable	100 percent Acceptable
<b>Soil</b>	Antimony, Arsenic, Beryllium, Cadmium, Chromium, Copper, Lead, Nickel, Selenium, Thallium, Zinc, Mercury	Antimony <sup>(c)</sup>	100 percent Acceptable
<b>Organic Compounds</b>			
<b>Water</b>	1,4-Dichlorobenzene	100 percent Acceptable	not tested

(a) Performance results 100 percent acceptable for all analytes unless otherwise noted.

(b) Result not acceptable, Bias &gt;+/- 50 percent or the reported result is not statistically positive at two standard deviations.

(c) Result not acceptable, Bias &gt; 30 percent.

**Table 12.5. Hanford Site Waste Sampling and Characterization Facility<sup>(a)</sup> Performance on RAD, DOE Mixed Analyte Performance Evaluation Program Samples, and National Institute of Standards and Technology Radiochemistry Inter-comparison Program Samples (2011)**

Media	Program	Radionuclide	Results Reported	Results within Control Limits
<b>Air filters</b>	MAPEP	Manganese-54, Cobalt-57, Cobalt-60, Zinc-65, Strontium-90, Cesium-134, Cesium-137, Uranium-233/234, Uranium-238, Plutonium-238, Plutonium-239/240, Americium-241, Gross Alpha, Gross Beta	26	26
	NRIP	Strontium-90, Uranium-233/234, Plutonium-238, Uranium-238, Plutonium-240, Americium-241	6	6
<b>Soil</b>	MAPEP	Potassium-40, Manganese-54, Cobalt-57, Cobalt-60, Zinc-65, Strontium-90, Technetium-99, Cesium-134, Cesium-137, Uranium-233/234, Plutonium-238, Uranium-238, Plutonium-239/240, Americium-241	28	19 <sup>(b)</sup>
	NRIP	Strontium-90, Uranium-233/234, Plutonium-238, Uranium-238, Plutonium-240, Americium-241	6	6
	MRAD <sup>TM(C)</sup>	Uranium-234, Uranium-238, Plutonium-238, Plutonium-239, Americium-241	5	5
<b>Vegetation</b>	MAPEP	Manganese-54, Cobalt-57, Cobalt-60, Zinc-65, Strontium-90, Cesium-134, Cesium-137, Uranium-233/234, Plutonium-238, Uranium-238, Plutonium-239/240, Americium-241	24	21 <sup>(d)</sup>
<b>Water</b>	MAPEP	Potassium-40, Manganese-54, Cobalt-57, Cobalt-60, Zinc-65, Strontium-90, Technetium-99, Cesium-134, Cesium-137, Uranium-233/234, Plutonium-238, Uranium-238, Plutonium-239/240, Americium-241, Gross Alpha, Gross Beta	32	32
<b>Water</b>	RAD	Hydrogen-3 (Tritium)	3	2 <sup>(e)</sup>

(a) Onsite laboratory operated by MSA (RJ Lee Group, Inc.).

(b) Failed americium-241 and isotopic uranium in Study 24 and West 03-12-MaS001, and failed isotopic plutonium in West 03-12-MaS001 soil samples, due to high organic matter in both soil samples. There was no impact on the Hanford Site sample; corrective action is ongoing to address high organic matter. Americium-241, plutonium-238, plutonium-239/240, uranium-234, and Uranium-238 results in NRIP and an ERA makeup sample (MRAD<sup>TM</sup> 030712B1) were acceptable. Due to laboratory shutdown from early September to early December 2011, WSCF did not participate in the MAPEP Study 25, but participated in a makeup study (West 03-12-001) in water, soil, filter, and vegetation matrices.

(c) MRAD<sup>TM</sup> 030712B1 (makeup performance evaluation sample for MAPEP Soil Study 22 and WEST 03-12-MaS001)

(d) Failed zinc-65 in MAPEP studies 24 and West 03-12-RdV001, and failed Cobalt-57 in West 03-12-RdV001 due to density difference between MAPEP vegetation samples and calibration standard.

(e) Failed hydrogen-3 in RAD 86. Hydrogen-3 result was acceptable in the Quik<sup>TM</sup> Response sample (090711I).

NRIP = National Institute of Standards and Technology Radiochemistry Intercomparison Program.

RAD= Radiochemistry Program provided by Environmental Resource Associates, Inc., a Waters Corporation.

**Table 12.6. Advanced Technologies and Laboratories International, Inc.'s Performance on DOE's Mixed Analyte Performance Evaluation Program Samples (2011)**

Media	MAPEP Study	Radionuclide	Number of Results Reported	Number of Results Within Control Limits
Air Filters	MAPEP-24	U-235, U-238, U-Total, Am-241, Cs-134, Cs-137, Co-57, Co-60, Mn-54, Pu-238, Pu-239/240, Sr-90, Zn-65, Gross alpha, Gross beta	15	13 <sup>(a)</sup>
	MAPEP-25	U-235, U-238, U-Total, Am-241, Cs-134, Cs-137, Co-57, Co-60, Mn-54, Pu-238, Pu-239/240, Sr-90, Zn-65, Gross alpha, Gross beta	15	15

(a) missed Am-241 (uncertainty too low for non-detect); Pu-239/240 (biased high)

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**Appendix A****Useful Information**

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## A. Useful Information

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The following information is provided to assist the reader in understanding this report. Included here is information on scientific notation, units of measure, radioactivity units, radiological dose units, chemical and elemental nomenclature, understanding data tables and data uncertainty, understanding graphs, and selected mathematical symbols. Definitions of technical terms can be found in Appendix B.

### A.1 Public Reading Rooms

University of Washington  
Government Publications Division,  
Suzzallo & Allen Libraries  
Box 352900  
Seattle, WA 98195-2900  
(206) 543-4164  
[www.catalog.kub.wa.edu](http://www.catalog.kub.wa.edu)

Portland State University  
Government Information  
Branford Price Millar Library  
1875 SW Park Avenue  
Portland, OR 97207-1151  
(503) 725-4542  
<http://library.pdx.edu/governmentinformationservice.html> and  
[http://library.pdx.edu/public\\_comment.html#hanf](http://library.pdx.edu/public_comment.html#hanf)

Washington State University, Tri-Cities  
US DOE Public Reading Room  
Consolidated Information Center, Room 101-L  
2770 University Drive  
Richland, WA 99352  
(509) 372-7443  
<http://reading-room.labworks.org>

Gonzaga University, Foley Center  
East 502 Boone  
Spokane, WA 99258-0001  
(509) 313-3847  
<http://www.gonzaga.edu/Academics/Libraries/Foley-Library/Departments/Special-Collections/default.asp>

Hanford Health Info Archive:  
<http://www.gonzaga.edu/Academics/Libraries/Foley-Library/Departments/Special-Collections/Collections/Hanford-Health-and-Information-Archives/default.asp>

### A.2 Documents and Reports Web Sites

BNI: <http://www.hanfordvitplant.com/>

CHPRC: <http://prc.rl.gov/rapidweb/Environmental/index.cfm?PageNum=36>

DOE: <http://www.hanford.gov/page.cfm/OfficialDocuments>

MSA: [http://msa.hanford.gov/msa/index.cfm/Environmental\\_Reports](http://msa.hanford.gov/msa/index.cfm/Environmental_Reports)

PNNL: <http://www.pnnl.gov/publications/results.asp>

WCH: <http://www.washingtonclosure.com/>

WRPS: <http://www.wrpstoc.com/resources/overview/>

### A.3 Scientific Notation

Scientific notation is used to express very large or very small numbers. For example, the number 1 billion could be written as 1,000,000,000 or, by using scientific or E notation, written as  $1 \times 10^9$  or 1.0E+09.

Translating from scientific notation to a more traditional number requires moving the decimal point either left or right from its current location. If the value given is  $2.0 \times 10^3$  (or 2.0E+03), the decimal point should be

moved three places to the **right** so that the number would then read 2,000. If the value given is  $2.0 \times 10^{-5}$  (or 2.0E-05), the decimal point should be moved five places to the **left** so that the result would be 0.00002.

## A.4 Units of Measure

The primary units of measure used in this report follow the International System of Units and are metric. Table A.1 summarizes and defines the terms and corresponding symbols (metric and non-metric). A conversion table is provided in Table A.2.

## A.5 Radioactivity Units

Much of this report provides data on levels of radioactivity in various environmental media. Radioactivity in this report is usually discussed in units of **curies (Ci)**, with conversions to **becquerels (Bq)**, the International System of Units measure (Table A.3). The curie is the basic unit used to describe the amount of activity present, and activities are generally expressed in terms of curies per mass or volume (e.g., picocuries per liter). One curie is equivalent to 37 billion disintegrations per second or is a quantity of any radionuclide that decays at the rate of 37 billion disintegrations per second. One becquerel is equivalent to one disintegration per second. Nuclear disintegrations produce spontaneous emissions of alpha or beta particles, gamma radiation, or combinations of these. Table A.4 includes selected conversions from curies to becquerels.

**Table A.1. Units of Measure**

Symbol	Name	Symbol	Name
<b>Temperature</b>		<b>Concentration</b>	
°C	degree Celsius	ppb	parts per billion
°F	degree Fahrenheit	ppm	parts per million
Time		ppmv	parts per million by volume
d	day	<b>Length</b>	
hr	hour	cm	centimeter ( $1 \times 10^{-2}$ m)
min	minute	ft	foot
sec	second	in.	inch
yr	year	km	kilometer ( $1 \times 10^3$ m)
<b>Rate</b>		m	meter
cfs (or ft <sup>3</sup> /sec)	cubic feet per second	mi	mile
cpm	counts per minute	mm	millimeter ( $1 \times 10^{-3}$ m)
gpm	gallon per minute	μm	micrometer ( $1 \times 10^{-6}$ m)
mph	mile per hour	<b>Area</b>	
mR/hr	milliroentgen per hour	ha	hectare ( $1 \times 10^4$ m <sup>2</sup> )
mrem/yr	millirem per year	km <sup>2</sup>	square kilometer
<b>Volume</b>		mi <sup>2</sup>	square mile
cm <sup>3</sup>	cubic centimeter	ft <sup>2</sup>	square foot
ft <sup>3</sup>	cubic foot	<b>Mass</b>	
gal	gallon	g	gram
L	liter	kg	kilogram ( $1 \times 10^3$ g)
m <sup>3</sup>	cubic meter	mg	milligram ( $1 \times 10^{-3}$ g)
mL	milliliter ( $1 \times 10^{-3}$ L)	μg	microgram ( $1 \times 10^{-6}$ g)
yd <sup>3</sup>	cubic yard	lb	pound



**Table A.2. Conversion Table**

Multiply	By	To Obtain
cm	0.394	in.
m	3.28	ft
km	0.621	mi
kg	2.205	lb
L	0.2642	gal
m <sup>2</sup>	10.76	ft <sup>2</sup>
ha	2.47	acre
km <sup>2</sup>	0.386	mi <sup>2</sup>
m <sup>3</sup>	35.31	ft <sup>3</sup>
m <sup>3</sup>	1.308	yd <sup>3</sup>
pCi	1,000	nCi
μCi/mL	109	pCi/L
Ci/m <sup>3</sup>	1012	pCi/m <sup>3</sup>
mCi/cm <sup>3</sup>	1015	pCi/m <sup>3</sup>
nCi/m <sup>2</sup>	1.0	mCi/km <sup>2</sup>
Ci	$3.7 \times 10^{10}$	Bq
pCi	0.037	Bq
rad	0.01	Gy
rem	0.01	Sv
ppm	1,000	ppb
°C	$(^{\circ}\text{C} \times 9/5) + 32$	°F
oz	28.349	g
ton	0.9078	tonne

Multiply	By	To Obtain
in.	2.54	cm
ft	0.305	m
mi	1.61	km
lb	0.454	kg
gal	3.785	L
ft <sup>2</sup>	0.093	m <sup>2</sup>
acre	0.405	ha
mi <sup>2</sup>	2.59	km <sup>2</sup>
ft <sup>3</sup>	0.0283	m <sup>3</sup>
yd <sup>3</sup>	0.7646	m <sup>3</sup>
nCi	0.001	pCi
pCi/L	10-9	μCi/mL
pCi/m <sup>3</sup>	10-12	Ci/m <sup>3</sup>
pCi/m <sup>3</sup>	10-15	mCi/cm <sup>3</sup>
mCi/km <sup>2</sup>	1.0	nCi/m <sup>2</sup>
Bq	$2.7 \times 10^{-11}$	Ci
Bq	27	pCi
Gy	100	rad
Sv	100	rem
ppb	0.001	ppm
°F	$(^{\circ}\text{F} - 32) \div 9/5$	°C
g	0.035	oz
tonne	1.1	ton

**Table A.3. Radioactivity Unit Conversions**

aCi	fCi	fCi	pCi	pCi	nCi	nCi	μCi	μCi	mCi	mCi	Ci	Ci	kCi
27	1	27	1	27	1	27	1	27	1	27	1	27	1
μBq	μBq	mBq	mBq	Bq	Bq	kBq	kBq	MBq	MBq	GBq	GBq	TBq	TBq

New unit of quantity = Becquerel (Bq) (formerly curie [Ci]) (1 Ci =  $3.7 \times 10^{10}$  dps).

1 Becquerel = 1 disintegrations/sec (dps).

**Table A.4. Radioactivity Units**

Symbol	Name
Ci	curie
mCi	millicurie ( $1 \times 10^{-3}$ Ci)
μCi	microcurie ( $1 \times 10^{-6}$ Ci)
nCi	nanocurie ( $1 \times 10^{-9}$ Ci)
pCi	picocurie ( $1 \times 10^{-12}$ Ci)
fCi	femtocurie ( $1 \times 10^{-15}$ Ci)
aCi	attocurie ( $1 \times 10^{-18}$ Ci)

Symbol	Name
Bq	becquerel ( $2.7 \times 10^{-11}$ Ci)
mBq	millibecquerel ( $1 \times 10^{-3}$ Bq)
kBq	kilobecquerel ( $1 \times 10^3$ Bq)
MBq	megabecquerel ( $1 \times 10^6$ Bq)
GBq	gigabecquerel ( $1 \times 10^9$ Bq)
TBq	terabecquerel ( $1 \times 10^{12}$ Bq)

## A.6 Radiological Dose Limits

Regulatory dose limits both public and occupational regulatory dose limits are set by federal [i.e., EPA, Nuclear Regulatory Commission (NRC), and DOE] and state agencies to limit cancer risk. Other radiation dose limits are applied to limit other potential biological effects with workers' skin and lens of the eye.

Annual Radiation Dose Limits	Agency
Radiation Worker - 5,000 mrem	NRC, occupationally exposed
General Public - 100 mrem	NRC, member of the public
General Public - 25 mrem	NRC, D&D all pathways
General Public - 10 mrem	EPA, air pathway
General Public - 4 mrem	EPA, drinking water pathway

## A.7 Radiological Dose Units

Radiological dose in this report is usually written in terms of total effective dose (equivalent) and reported numerically in units of millirem (mrem), with the metric units millisievert (mSv) or microsievert ( $\mu$ Sv) following in parenthesis or footnoted.

Millirem (millisievert) is a term that relates a given amount of absorbed radiation energy to its biological effectiveness or risk to humans. For perspective, a dose of 1.0 millirem (10 microsievert) would have a biological effect roughly the same as received from 1 day's exposure to natural background radiation. An acute (short-term) dose to the whole body of 100 rem (1 sievert) would likely cause temporary radiation sickness in some exposed individuals. An acute dose of over 500 rem (5 sievert) would soon result in death in approximately 50% of those exposed. Exposure to lower amounts of radiation (10 mrem [100  $\mu$ Sv] or less) produces no immediate observable effects, but long-term (delayed) effects are possible. The average person in the United States receives an annual dose from exposure to naturally produced radiation of approximately 310 mrem (3.1 mSv; National Council on Radiation Protection and Measurements 2009). Medical and dental x-rays and air travel add to this total. Table A.5 includes selected conversions from rem to sievert.

Also used in this report is the term **rad**, with the corresponding unit **gray (Gy)** in parenthesis or footnoted. The rad (gray) is a measure of the energy absorbed by any material, whereas a rem relates to both the amount of radiation energy absorbed by humans and its consequence. The gray can be converted to rad by multiplying by 100. The conversions in Table A.5 can also be used to convert grays to rads.

**Table A.5. Radiological Dose Units Conversions**

$\mu$ Sv	$\mu$ Sv	$\mu$ Sv	$\mu$ Sv	$\mu$ Sv	mSv	mSv	mSv	Sv
0.01	0.1	1	10	100	1	10	100	1
<hr/>								
1	10	100	1	10	100	1	10	100
$\mu$ rem	$\mu$ rem	$\mu$ rem	mrem	mrem	mrem	rem	rem	Rem

Unit of absorbed dose – Gray (Gy) (formerly rad).

Unit of dose equivalent – Sievert (Sv) (formerly rem).

Table also converts Gy to rad.

**Roentgen (R):** Measure of exposure to electromagnetic radiation (i.e., gamma and x-radiation). One roentgen is equivalent to a charge release of 258 microcoulombs per kilogram of air.

The names and symbols for units of radiation dose used in this report are listed in Table A.6.

**Table A.6. Radiation Dose or Exposure Units**

Symbol	Name
mrاد	millirad ( $1 \times 10^{-3}$ rad)
mrem	millirem ( $1 \times 10^{-3}$ rem)
μrem	microrem ( $1 \times 10^{-6}$ rem)
Sv	sievert (100 rem)
mSv	millisievert ( $1 \times 10^{-3}$ Sv)
μSv	microsievert ( $1 \times 10^{-6}$ Sv)
nSv	nanosievert ( $1 \times 10^{-9}$ Sv)
R	roentgen
mR	milliroentgen ( $1 \times 10^{-3}$ R)
μR	microroentgen ( $1 \times 10^{-6}$ R)
Gy	gray (100 rad)
mGy	milligray ( $1 \times 10^{-3}$ rad)

Additional information on radiation and dose terminology can be found in Appendix B. A list of the radionuclides discussed in this report, their symbols, and their half-lives are included in Table A.7.

**Table A.7. Radionuclides and Half-Lives<sup>(a)</sup>**

Symbol	Radionuclide	Half-Life	Symbol	Radionuclide	Half-Life
<sup>3</sup> H	tritium	12.35 yr	<sup>137</sup> mBa	barium-137m	2.552 min
<sup>7</sup> Be	beryllium-7	53.3 d	<sup>152</sup> Eu	europium-152	13.33 yr
<sup>14</sup> C	carbon-14	5,730 yr	<sup>154</sup> Eu	europium-154	8.8 yr
<sup>40</sup> K	potassium-40	$1.28 \times 10^9$ yr	<sup>155</sup> Eu	europium-155	4.96 yr
<sup>51</sup> Cr	chromium-51	27.704 d	<sup>212</sup> Pb	lead-212	10.64 hr
<sup>54</sup> Mn	manganese-54	312.5 d	<sup>220</sup> Rn	radon-220	55.6 sec
<sup>55</sup> Fe	iron-55	2.7 yr	<sup>222</sup> Rn	radon-222	3.8235 d
<sup>59</sup> Fe	iron-59	44.529 d	<sup>232</sup> Th	thorium-232	$1.405 \times 10^{10}$ yr
<sup>59</sup> Ni	nickel-59	$7.5 \times 10^4$ yr	U or uranium	natural uranium	$\sim 4.5 \times 10^{9(b)}$ yr
<sup>60</sup> Co	cobalt-60	5.271 yr	<sup>233</sup> U	uranium-233	$1.585 \times 10^5$ yr
<sup>63</sup> Ni	nickel-63	96 yr	<sup>234</sup> U	uranium-234	$2.445 \times 10^5$ yr
<sup>65</sup> Zn	zinc-65	243.9 d	<sup>235</sup> U	uranium-235	$7.038 \times 10^8$ yr
<sup>85</sup> Kr	krypton-85	10.72 yr	<sup>237</sup> Np	neptunium-237	$2.14 \times 10^6$ yr
<sup>90</sup> Sr	strontium-90	29.12 yr	<sup>238</sup> U	uranium-238	$4.468 \times 10^9$ yr
<sup>90</sup> Y	yttrium-90	64.0 hr	<sup>238</sup> Pu	plutonium-238	87.74 yr
<sup>95</sup> Zr	zirconium-95	63.98 d	<sup>239</sup> Pu	plutonium-239	$2.4065 \times 10^4$ yr
<sup>99</sup> Tc	technetium-99	$2.13 \times 10^5$ yr	<sup>240</sup> Pu	plutonium-240	$6.537 \times 10^3$ yr
<sup>103</sup> Ru	ruthenium-103	39.28 d	<sup>241</sup> Pu	plutonium-241	14.4 yr
<sup>106</sup> Ru	ruthenium-106	368.2 d	<sup>242</sup> Pu	plutonium-242	$3.763 \times 10^5$ yr
<sup>113</sup> Sn	tin-113	115.1 d	<sup>241</sup> Am	americium-241	432.2 yr
<sup>125</sup> Sb	antimony-125	2.77 yr	<sup>243</sup> Am	americium-243	7,380 yr
<sup>129</sup> I	iodine-129	$1.57 \times 10^7$ yr	<sup>243</sup> Cm	curium-243	28.5 yr
<sup>131</sup> I	iodine-131	8.04 d	<sup>244</sup> Cm	curium-244	18.11 yr
<sup>134</sup> Cs	cesium-134	2.062 yr	<sup>245</sup> Cm	curium-245	8,500 yr
<sup>137</sup> Cs	cesium-137	30.0 yr			

(a) From EPA 402-R-99-001.

(b) Natural uranium is a mixture dominated by uranium-238; thus, the half-life is  $\sim 4.5 \times 10^9$  years.

## A.8 Chemical and Elemental Nomenclature

Many of the chemical contaminants discussed in this report are listed in Table A.8 along with their chemical (or elemental) names and their corresponding symbols.

**Table A.8. Elemental and Chemical Constituent Nomenclature**

Symbol	Constituent	Symbol	Constituent
Ag	silver	K	potassium
Al	aluminum	LiF	lithium fluoride
As	arsenic	Mg	magnesium
B	boron	Mn	manganese
Ba	barium	Mo	molybdenum
Be	beryllium	NH <sub>3</sub>	ammonia
Br	bromine	NH <sub>4</sub> <sup>+</sup>	ammonium
C	carbon	N	nitrogen
Ca	calcium	Na	sodium
CaF <sub>2</sub>	calcium fluoride	Ni	nickel
CCl <sub>4</sub>	carbon tetrachloride	NO <sub>2</sub> <sup>-</sup>	nitrite
Cd	cadmium	NO <sub>3</sub> <sup>-</sup>	nitrate
CHCl <sub>3</sub>	trichloromethane	Pb	lead
Cl <sup>-</sup>	chloride	PO <sub>4</sub> <sup>-3</sup>	phosphate
CN <sup>-</sup>	cyanide	P	phosphorus
Cr <sup>+6</sup>	chromium (hexavalent)	Sb	antimony
Cr	chromium (total)	Se	selenium
CO <sub>3</sub> <sup>-2</sup>	carbonate	Si	silicon
Co	cobalt	Sr	strontium
Cu	copper	SO <sub>4</sub> <sup>-2</sup>	sulfate
F <sup>-</sup>	fluoride	Ti	titanium
Fe	iron	Tl	thallium
HCO <sub>3</sub> <sup>-</sup>	bicarbonate	V	vanadium
Hg	mercury		

## A.9 Understanding the Data Tables

Some degree of variability, or uncertainty, is associated with all analytical measurements. This uncertainty is the consequence of random or systematic inaccuracies related to collecting, preparing, and analyzing the samples. These inaccuracies could include errors associated with reading or recording the result, handling or processing the sample, calibrating the counting instrument, and numerical rounding. With radionuclides, inaccuracies can also result from the randomness of radioactive decay. In this report, the uncertainties used include standard deviation, total propagated analytical uncertainty, and standard error of the mean.

## A.10 Standard Deviation

The standard deviation (SD) of sample data relates to the variation around the mean of a set of individual sample results. If differences in analytical results occur among samples, then two times the standard deviation (or  $\pm 2$  SD) implies that 95% of the time, a re-count or re-analysis of the same sample would give a value somewhere between the mean result minus two times the standard deviation and the mean result plus two times the standard deviation.

### **A.11 Total Propagated Analytical Uncertainty**

For samples that are prepared or manipulated in the laboratory prior to counting (counting the rate of radioactive emissions from a sample), the total propagated analytical uncertainty includes both the counting uncertainty and the uncertainty associated with sample preparation and chemical separations. For samples that are not manipulated (e.g., ashed, dried, or chemically treated) in the laboratory before counting, the total propagated analytical uncertainty only accounts for the uncertainty associated with counting the sample. The uncertainty associated with samples that are analyzed but not counted (e.g., chemical or water quality measurements) includes only the analytical process uncertainty. In this situation, the total propagated analytical uncertainty is assumed the nominal detection limit.

### **A.12 Standard Error of the Mean**

Just as individual values are accompanied by counting uncertainties, the mean of mean values (averages) is accompanied by  $\pm 2$  times the standard error of the calculated mean. Two times the standard error of the mean implies that approximately 95% of the time the next calculated mean will fall somewhere between the reported value minus two times the standard error and the reported value plus two times the standard error.

### **A.13 Median, Maximum, and Minimum Values**

Median, maximum, and minimum values are reported in some sections of this report. A median value is the middle value of an odd numbered set and the average of the two central values in an even numbered set. For example, the median value in the odd numbered series of numbers — 1, 2, 3, 3, 4, 5, 5, 5, 6 is 4. The maximum value would be 6 and the minimum value would be 1. Median, maximum, and minimum values are reported when there are too few analytical results to accurately determine the average with a  $\pm$  statistical uncertainty or when the data do not follow a bell-shape (i.e., normal) distribution. Figure A.1 provides a graphical representation of median, maximum, and minimum values. The upper line is the maximum value, the center dot is the median value, and the lower line is the minimum value.

### **A.14 Negative Concentrations**

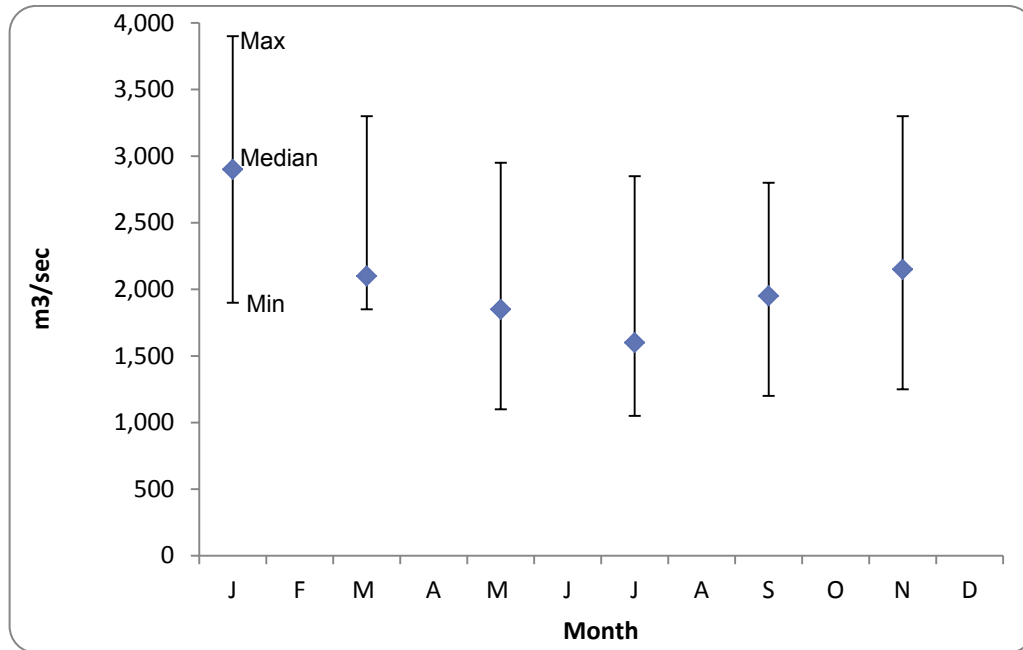
Instruments used in the laboratory to measure radioactivity in Hanford Site environmental samples are sensitive enough to measure natural, or background, radiation along with any contaminant radiation in a sample. To obtain a true measure of the contaminant level in a sample, the background radiation level must be subtracted from the total amount of radioactivity measured by an instrument. Because of the randomness of radioactive emissions, the very low activities of some contaminants, or the presence of undesirable materials, it is possible to obtain a background measurement that is larger than the actual contaminant measurement. When the larger background measurement is subtracted from the smaller contaminant measurement, a negative result is generated. The negative results are reported because they are essential when conducting statistical evaluations of the data.

### **A.15 Greater Than (>) or Less Than (<) Symbols**

Greater than (>) or less than (<) symbols are used to indicate that the actual value may either be larger than the number given or smaller than the number given. For example,  $>0.09$  would indicate that the actual value is greater than 0.09. A symbol pointed in the opposite direction ( $<0.09$ ) would indicate that the number is less

than the value presented. A symbol used with an underscore (< or >) indicates that the actual value is less than or equal to or greater than or equal to the number given, respectively.

**Figure A.1 Maximum, Median, and Minimum Values Graphical Representation**



## A.16 Understanding Graphs

Graphs are useful when comparing numbers collected at several locations or at one location over time. Graphs often make it easy to visualize differences in data where they exist. However, careful consideration should be given to the scale (linear or logarithmic) and units.

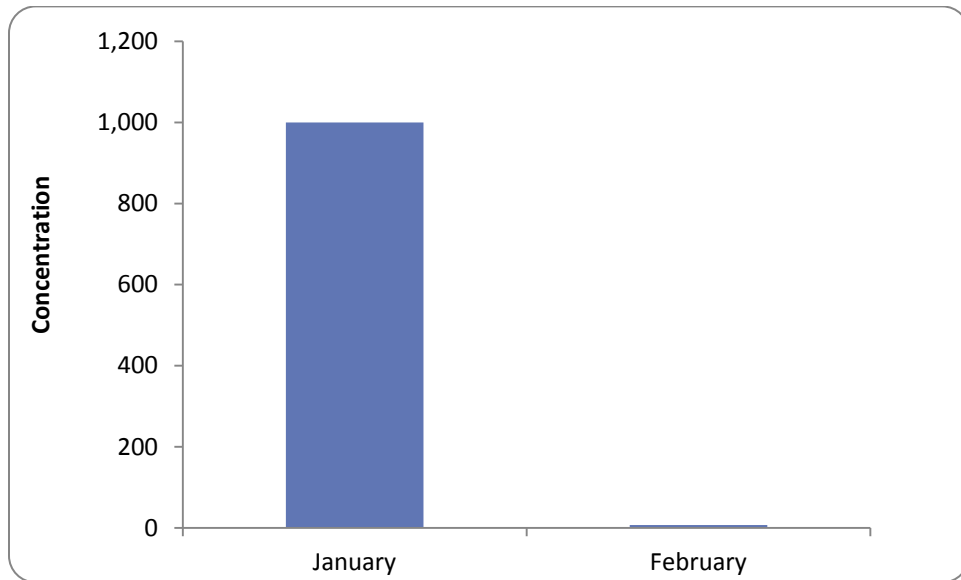
Some of the data graphed in this report may be plotted using logarithmic, or compressed, scales. Logarithmic scales are useful when plotting two or more numbers that differ greatly in size or are very close together. For example, a sample with a concentration of 5 grams per liter would get lost at the bottom of the graph if plotted on a linear scale with a sample having a concentration of 1,000 grams per liter (Figure A.2). A logarithmic plot of these same two numbers allows the reader to see both data points clearly (Figure A.3).

The mean (average) and median (defined earlier) values seen in graphics in this report have vertical lines extending above and below the data point. When used with a value, these lines (called error bars) indicate the amount of uncertainty (standard deviation, total propagated analytical uncertainty, or two standard error of the mean) in the reported value. The error bars in this report represent a 95 percent chance that the value is between the upper and lower ends of the error bar and a 5 percent chance that the true value is either lower or higher than the error bar.<sup>(a)</sup> For example, in Figure A.4, the first plotted value is  $2.0 \pm 1.1$ , so there is a 95 percent chance that the true value is between 0.9 and 3.1, a 2.5 percent chance that it is less than 0.9, and a 2.5 percent chance that it is greater than 3.1. Error bars are computed statistically, employing all of the information used to generate the value. These bars provide a quick, visual indication that one value may be statistically similar to or different from another value. If the error bars of two or more values overlap, as is the

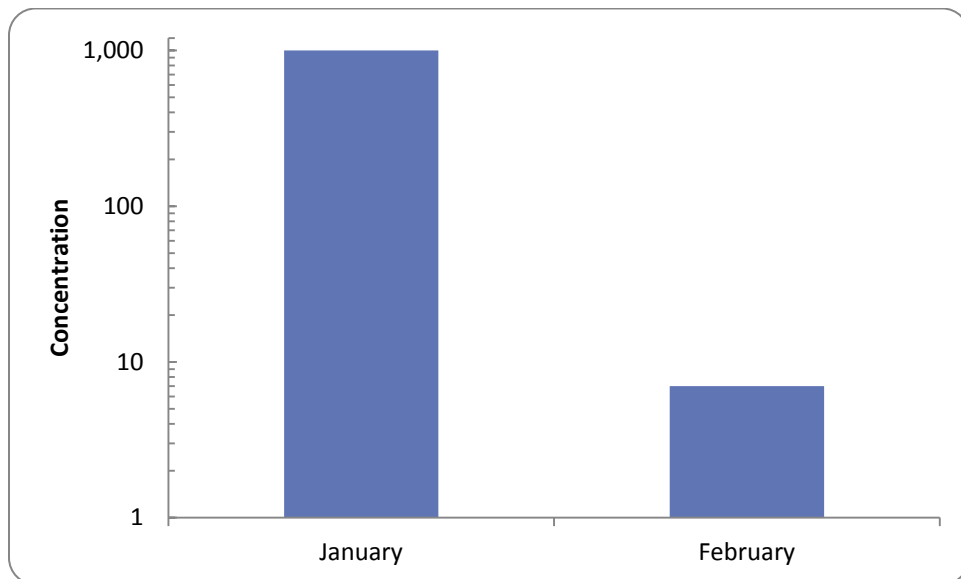
(a) Assuming the data are normally distributed.

case with values 1 and 3 and values 2 and 3, the values may be statistically similar. If the error bars do not overlap (values 1 and 2), the values may be statistically different. Values that appear to be very different visually (values 2 and 3) may actually be quite similar when compared statistically.

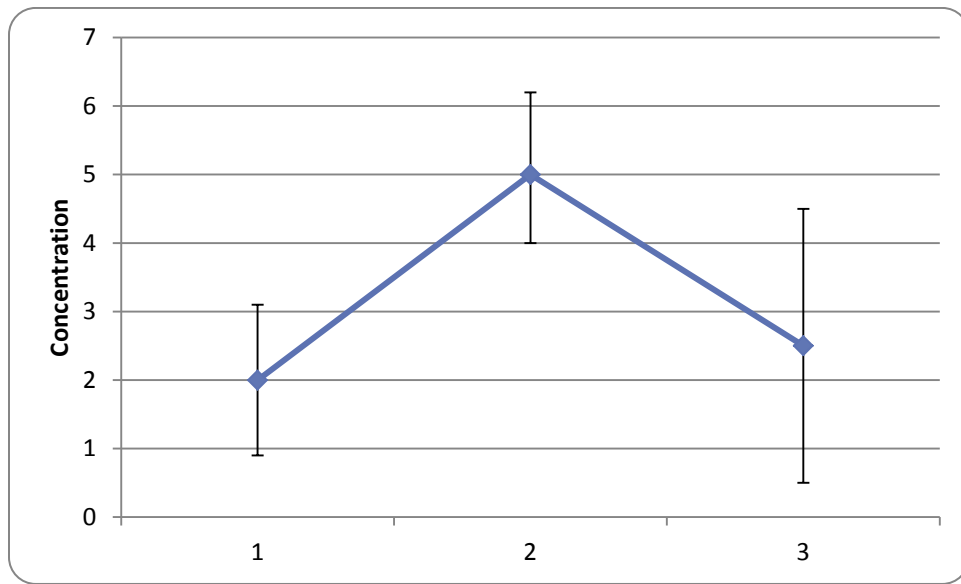
**Figure A.2 Data Plotted Using a Linear Scale**



**Figure A.3 Data Plotted Using a Logarithmic Scale**





**Figure A.4 Data with Error Bars Plotted Using a Linear Scale**

When vertical lines are used with median values, the lower end of each bar represents the minimum concentration measured; the upper end of each bar represents the maximum concentration measured (Figure A.1).

**Appendix B****Glossary**

<b>B. GLOSSARY .....</b>	<b>B.1</b>
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B .....	B.1
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I .....	B.4
L .....	B.5
M .....	B.5
N .....	B.6
O .....	B.6
P .....	B.6
Q .....	B.6
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T .....	B.8
U .....	B.8
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## B. Glossary

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This glossary contains selected words and phrases used in this report that may not be familiar to the reader. Words appearing in *italic* type within a definition are also defined in this glossary.

### A

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**absorbed dose** – Energy absorbed per unit mass from any kind of ionizing *radiation* in any kind of matter.

Units: *rad*, which is equal to the absorption of 100 ergs per gram of material irradiated, or *gray*, which is the International System of Units (SI) equivalent (1 *gray* = 100 *rad*).

**activation product** – Material made radioactive by *exposure to radiation*, principally by neutron radiation as in metals in a nuclear reactor (e.g., cobalt-60 from cobalt-59 in stainless steel).

**adsorption** – The accumulation of gases, liquids, or solutes on the surface of a solid or liquid.

**alpha particle** – A positively charged particle composed of two protons and two neutrons ejected spontaneously from the nuclei of some *radionuclides*. It has low penetrating power and short range. The most energetic alpha will generally fail to penetrate the skin. Alpha particles are hazardous when an alpha-emitting *isotope* is introduced into the body.

**anion** – A negatively charged ion.

**apatite** – A mineral that has the capability to capture and retain radioactive metal contaminants.

**aquifer** – Underground sediment or rock that stores and/or transmits water.

**aquifer tube** – A small-diameter, flexible plastic tube used to sample shallow *aquifers*, natural seepage areas, or springs.

### B

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**background radiation** – *Radiation* in the natural environment, including cosmic rays from space and *radiation* from naturally occurring radioactive elements in the air, in the earth, and in human bodies. It also includes *radiation* from worldwide *fallout* from historical atmospheric nuclear weapons testing. In the United States, the average person receives approximately 310 *millirem* of background radiation per year.

**bank storage** – Hydrologic term that describes river water that flows into and is retained in permeable stream banks during periods of high river stage. Flow is reversed during periods of low river stage.

**becquerel (Bq)** – Unit of activity or amount of a radioactive substance (also *radioactivity*) equal to one nuclear transformation per second (1 Bq = 1 disintegration per second). Another unit of *radioactivity*, the *curie*, is related to the becquerel: 1 Ci =  $3.7 \times 10^{10}$  Bq.

**beta particle** – A negatively charged particle (essentially an electron) emitted from a nucleus during radioactive *decay*. Large amounts of beta particles may cause skin burns and are harmful if they enter the body. Beta particles are easily stopped by a thin sheet of metal or plastic.

**biological half-life** – The time required for one-half of the amount of a *radionuclide* to be expelled from the body by natural metabolic processes, excluding radioactive *decay*, following ingestion, inhalation, or absorption.

**black cell** – A section of the Hanford Tank Waste Treatment and Immobilization Plant where high-level nuclear waste will be routed that will never be accessible to humans because of its high *radiation* levels.

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## C

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**cation** – A positively charged ion.

**clean closed** – A facility is classified as “clean closed” under *Resource Conservation and Recovery Act of 1976* regulations when all dangerous waste has been removed and *groundwater* monitoring is no longer required.

**collective total effective dose (equivalent)** (also referred to as “collective dose”) – Sum of the *total effective dose* for individuals comprising a defined population. Collective dose is expressed in units of *person-rem* or *person-sievert*.

**committed dose equivalent** – The *dose equivalent* to organs or tissues that will be received from an intake of radioactive material by an individual during the 50-year period following intake.

**committed effective dose equivalent** – The sum of the *committed dose equivalent* to various tissues in the body, each multiplied by the appropriate weighting factor.

**composite sample** – Sample formed by mixing discrete samples taken at different times or from different locations.

**confined aquifer** – An *aquifer* bounded above and below by less-permeable layers. *Groundwater* in the confined aquifer is under a pressure greater than atmospheric pressure.

**continuous sample** – Sample formed by the continuous collection of the medium or contaminants within the medium during the entire sampling period.

**cosmic radiation** – High-energy subatomic particles and electromagnetic *radiation* from outer space that bombard the earth. Cosmic radiation is part of natural *background radiation*.

**crib** – An underground structure designed to receive liquid waste that percolates into the soil directly or percolates into the soil after having traveled through a connected tile field. These structures are no longer used at the Hanford Site.

**curie (Ci)** – A unit of *radioactivity* equal to 37 billion ( $3.7 \times 10^{10}$ ) nuclear transformations per second (*becquerels*).

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## D

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**decay** – The decrease in the amount of any radioactive material (disintegration) with the passage of time. See *radioactivity*.

**decay product** – The atomic nucleus or nuclei that are left after radioactive transformation of a radioactive material. Decay products may be radioactive or non-radioactive (stable). They are informally referred to as daughter products. See *radioactivity*.

**deep-dose equivalent** – The *dose equivalent* at a tissue depth of 1 centimeter from *radiation* originating outside of the body.

**derived concentration guide (DCG)** – Concentrations of *radionuclides* in air and water that an individual could continuously consume, inhale, or be immersed in at average annual rates and not receive a *total effective dose (equivalent)* of greater than 100 *millirem* per year.

**desiccation** – A process whereby water or moisture is removed, resulting in dryness.

**detection level (or limit)** – Minimum amount of a substance that can be measured with a specified or implied confidence that the analytical result is greater than a specific value (e.g., zero).

**direct-push technology** – A cost-effective means of collecting subsurface samples; this technology uses a hydraulic hammer to drive a hollow rod into the soil either vertically or at an angle. Sensors can be deployed within the rod to detect radioactive contaminants, soil moisture, and other sampling criteria.

**dispersion** – Process whereby *effluent* or *emissions* are spread or mixed when they are transported by *groundwater*, surface water, or air.

**dose equivalent** – Product of the *absorbed dose*, a quality factor, and any other modifying factors. The dose equivalent is a quantity for comparing the biological effectiveness of different kinds of *radiation* on a common scale. The unit of dose equivalent is the *rem*.

**dose limits (regulatory)** – both public and occupational regulatory dose limits are set by federal [i.e., EPA, Nuclear Regulatory Commission (NRC), and DOE] and state agencies to limit cancer risk. Other radiation dose limits are applied to limit other potential biological effects with workers' skin and lens of the eye.

**dose rate** – The rate at which a dose is delivered over time (e.g., *dose equivalent* rate in *millirem* per hour [mrem/hr]).

**dosimeter** – Portable device for measuring the accumulated *exposure* or *absorbed dose* from specific types or energies of ionizing *radiation* fields.

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## E

**effective dose (equivalent)** – The sum of products of *dose equivalent* to selected tissues of the body and appropriate tissue weighting factors. The tissue weighting factors put doses to various tissues and organs on an equal basis in terms of health *risk*.

**effluent** – Liquid material released from a facility.

**effluent monitoring** – Sampling or measuring specific liquid *effluent* streams for the presence of pollutants.

**emission** – Gaseous stream released from a facility.

**exposure** – The interaction of an organism with a physical agent (e.g., *radiation*) or a chemical agent (e.g., arsenic) of interest. Also used as a term for quantifying x- and *gamma-radiation* fields. See *roentgen*.

**external radiation** – *Radiation* originating from a source outside the body.

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## F

**fallout** – Typically refers to radioactive materials that are released into the earth's atmosphere following a nuclear explosion or atmospheric release and that eventually fall to earth.

**field duplicate sample** – Replicate sample to determine the precision of the sampling and analytical measurement process by comparing results from identical samples collected at the same time and location. Matching field duplicates are stored in separate containers and are analyzed independently by the same laboratory.

**fission** – The splitting or breaking apart of a nucleus into at least two other nuclei, accompanied with a release of a relatively large amount of energy.

**fission products** – *Nuclides* formed from fissioning. Many fission products are radioactive.

**found fuel** – Incomplete pieces of spent nuclear fuel elements too small to have been located and removed during previous debris removal.

**fully institutionalized** – To incorporate into a formalized, structured system and be implemented and fully functional.

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## G

**gamma radiation** – High-energy electromagnetic *radiation (photons)* originating in the nucleus of decaying *radionuclides*. Gamma radiation is substantially more penetrating than *alpha* or *beta particles*.

**grab sample** – A short-duration sample (e.g., air, water, and soil) that is grabbed from the collection site.

**ground truth** – Direct physical observations that are used to test indirect interpretations.

**groundwater** – Subsurface water that is in the pores of sand and gravel or in the cracks of fractured rock.

**gray (Gy)** – Unit of *absorbed dose* in the International System of Units (SI) equal to the absorption of 1 joule per kilogram. The common unit of *absorbed dose*, the *rad*, is equal to 0.01 Gy.

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## H

**half-life** – Length of time in which a radioactive substance will lose one half of its *radioactivity* by *decay*. Half-lives range from a fraction of a second to billions of years, and each *radionuclide* has a unique half-life.

**high-activity waste** – See *high-level waste*.

**high-level waste** – Highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains *fission products* and other *radioisotopes* in sufficient concentrations to require permanent isolation.

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## I

**institutional controls** – Long-term actions or restrictions including *monitoring*, periodic sampling, access controls, and land-use restrictions designed to mitigate any *risks* posed by contamination following *remediation*. Institutional controls alone may be sufficient to reduce *risks* posed by low levels of contamination.

**internal radiation** – *Radiation* from radioactive material inside the body.

**ion exchange** – The reversible exchange of one species of ion for a different species of ion within a medium.

**ion exchange resin** – High molecular weight insoluble polymers containing functional groups that are capable of undergoing exchange reactions with ions in a solution with which it is in contact.

**irradiation** – *Exposure* to *radiation*.

**isotopes** – *Nuclides* of the same chemical element with the same number of protons but a differing number of neutrons.



**isotopic plutonium** – Any of two or more atoms of the chemical element *plutonium* with the same atomic number and position in the periodic table and nearly identical chemical behavior but with differing atomic mass number and different physical properties. Plutonium-239 is produced by neutron *irradiation* of uranium-238.

**isotopic uranium** – Any of two or more atoms of the chemical element uranium with the same atomic number and position in the periodic table and nearly identical chemical behavior but with differing atomic mass number and different physical properties. Uranium exists naturally as a mixture of three *isotopes* of mass 234, 235, and 238 in the proportions of 0.006%, 0.71%, and 99.27%, respectively.

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## L

**legacy waste** – Waste that was generated before the Hanford Site's nuclear materials production mission was terminated.

**low-activity waste** – See *low-level waste*.

**low-level waste** – Radioactive waste that is not high-level radioactive waste, spent nuclear fuel, *transuranic waste*, byproduct material, or naturally occurring radioactive material.

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## M

**material at risk** – The inventory of radioactive material that could potentially be released to the environment from an accident.

**maximally exposed individual** – A hypothetical member of the public residing near the Hanford Site who, by virtue of location and living habits, would reasonably receive the highest possible *radiation* dose from materials originating from the site.

**mean (or average)** – Average value of a series of measurements. The mean is computed using the following equation:

$$\text{mean} = \frac{\sum x}{n}$$

where  $n$  is the number of measurements, and  $\sum x$  is the sum of all measurements.

**median** – Middle value in an odd-numbered set of results when the data are ranked in increasing or decreasing order or the *average* of two central values in an even number set of results.

**millirem** – A unit of *radiation dose equivalent* that is equal to one one-thousandth (1/1000) of a *rem*.

**minimum detectable amount or concentration** – Smallest amount or concentration of a chemical or radioactive material that can be reliably detected in a sample.

**mitigation** – Prevention or reduction of expected *risks* to workers, the public, or the environment.

**mixed waste** – A U.S. Environmental Protection Agency or state-designated dangerous, extremely hazardous, or acutely hazardous waste that contains both a nonradioactive hazardous component and a radioactive component.

**monitoring** – As defined in DOE Order 5400.5, Chg 2, the collection and analysis of samples or measurements of liquid *effluent* and gaseous *emissions* for purposes of characterizing and quantifying contaminants, assessing *radiation exposure* to the public, and demonstrating compliance with regulatory standards.

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**N**

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**noble gas** – Any of a group of chemically and biologically inert gases that includes argon, krypton, radon, and xenon. These gases are not retained in the body following inhalation. The principal *exposure* pathway for radioactive noble gases is direct external dose from the surrounding air.

**nuclide** – A particular combination of neutrons and protons. A *radionuclide* is a radioactive nuclide.

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**O**

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**offsite locations** – Sampling and measurement locations outside the Hanford Site boundary.

**onsite locations** – Sampling and measurement locations within the Hanford Site boundary.

**operable unit** – A discrete area for which an incremental step can be taken toward comprehensively addressing site problems. The cleanup of a site can be divided into a number of operable units, depending on the complexity of the problems associated with the site.

**outfall** – End of a drain or pipe that carries wastewater or other *effluent* into a ditch, pond, or river.

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**P**

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**person-rem or person-sievert (person-Sv)** – Unit of *collective total effective dose (equivalent)*. 1 person-Sv = 100 person-rem.

**photon** – A quantum of radiant energy. *Gamma radiation* and x-radiation (x-rays) are both composed of photons of varying energy.

**phytoremediation** – Use of plants to degrade or immobilize pollutants or toxins from the environment.

**plume** – The cloud of a pollutant in air, surface water, or *groundwater* formed after the pollutant is released from a source.

**plutonium** – A heavy, radioactive, metallic element consisting of several *isotopes*. One important *isotope* is plutonium-239, which is produced by the *irradiation* of uranium-238. Routine analysis cannot distinguish between the plutonium-239 and plutonium-240 *isotopes*; hence, the term plutonium-239/240 as used in this report is symbolic of the presence of one or both of these *isotopes* in the analytical results.

**primordial radionuclide** – A radioactive material in the earth's crust that has a very long *half-life* and has existed since the beginning of the planet.

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**Q**

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**quality assurance** – Actions that provide confidence that an item or process meets or exceeds a user's requirements and expectations.

**quality control** – Comprises all those actions necessary to control and verify the features and characteristics of a material, process, product, or service to specified requirements. Quality control is an element of *quality assurance*.

**R**

**rad** – The unit of *absorbed dose*. 1 rad = 0.01 gray (Gy).

**radiation** – The energy emitted in the form of *photons* or particles (e.g., *alpha* and *beta particles*) such as that from transforming *radionuclides*. For this report, radiation refers to ionizing types of radiation; not radiowaves, microwaves, radiant light, or other types of non-ionizing radiation.

**radioactivity** – Property possessed by *radioisotopes* emitting *radiation* (such as *alpha* or *beta particles*, or high-energy *photons*) spontaneously in their *decay* process; also, the *radiation* emitted.

**radioisotope** – An unstable *isotope* of an element that *decays* or disintegrates spontaneously, emitting *radiation* (Shleien 1992).

**radiologically controlled area** – An area to which access is controlled to protect individuals from exposure to *radiation* or radioactive materials.

**radionuclide** – A species of atoms having a particular number of protons (Z), a particular number of neutrons (A), and a particular atomic weight (N = Z + A) that happens to emit *radiation*. Carbon-14 is a radionuclide but carbon-12, which is not radioactive, is referred to simply as a *nuclide*.

**recruitment** – Survival from one life form or stage to the next or from one age class to the next.

**redox** – A chemical reaction involving 
$$\text{RPD} = \left( \frac{|S - D|}{\left( \frac{S + D}{2} \right)} \right) \times 100$$
 reduction.

**refractory** – A material that has a high  $\left( \frac{S + D}{2} \right)$  e., heat resistant).

**refugium (refugia)** – An area that has not experienced ecological changes that have affected surrounding regions, providing a habitat for species that were once more widespread.

**rem** – A unit of dose equivalent and total effective dose (equivalent).

**remediation** – Reduction (or cleanup) of known *risks* to the public and environment to an agreed-upon level.

**risk** – The probability that a detrimental health effect will occur.

**risk-based disposal approval** – A written application to the EPA intended to manage and dispose of *Toxic Substances Control Act*-regulated polychlorinated biphenyl waste not addressed suitably within the regulations. The risk-based disposal approval process applies to any person wishing to sample, clean up, or dispose of waste in a manner other than as prescribed in 40 CFR 761. For polychlorinated biphenyl *remediation* waste, the requirements for a risk-based disposal approval are specified in 40 CFR 761.61(c). A written approval from the U.S. Environmental Protection Agency is required before waste management activities are performed.

**roentgen (R)** – The unit of *x-ray* or gamma *photon exposure* as measured in air, historically used to describe *external radiation* levels. An *exposure* of 1 roentgen typically causes an *effective dose* of 1 *rem*.

**relative percent difference (RPD)** – A measure of the precision of the measurement of a sample (S) and its duplicate (D). The formula is:

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**S**

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**shrub-steppe** – A drought-resistant shrub and grassland ecosystem.

**sievert (Sv)** – The unit of *dose equivalent* and its variants in the International System of Units (SI). The common unit for *dose equivalent* and its variants, the *rem*, is equal to 0.01 Sv.

**special case waste** – Waste for which there is an undetermined disposal path because of high levels of *radioactivity* and difficulties in characterization, classification, and packaging.

**specific retention facilities** – Historical structures consisting of *cribs*, ditches, trenches, or holes in the ground that received relatively small volumes of high concentration liquid radioactive waste. The small volume of liquid waste was designed to prevent flushing of the contaminants through the soil column to the *groundwater*.

**spent fuel** – Uranium metal or oxide and its metal container that have been used to power a nuclear reactor and for one reason or another has reached the end of its useful life. It is highly radioactive and typically contains *fission products*, *plutonium*, and residual uranium.

**standard error of the mean** – A measure of the precision of a *mean* of observed values; that is, an estimate of how close a *mean* of observed values is expected to be to the true *mean*.

**surveillance** – As defined in DOE Order 5400.5, Chg 2, the collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media, and the measurement of *external radiation* for purposes of demonstrating compliance with applicable standards, assessing *exposures* to the public, and assessing effects, if any, on the local environment.

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**T**

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**tank farm** – A group of underground waste storage tanks.

**thermoluminescent dosimeter** – A device containing a material that, after being exposed to beta and/or *gamma radiation*, emits light when heated. The amount of light emitted is proportional to the *absorbed dose* to the thermoluminescent dosimeter.

**total effective dose (equivalent)** – The sum of *committed effective dose equivalent* from the intake of radioactive material and dose equivalent from *exposure* to *external radiation*. Unit: *rem* or *sievert*.

**total uranium** – The sum of concentrations of the *isotopes* uranium-234, uranium-235, and uranium-238.

**transuranic element** – An element with an atomic number greater than 92 (92 is the atomic number of uranium).

**transuranic waste** – Waste containing more than 100 nanocuries ( $10^{-9}$  *curies*) per gram of alpha-emitting transuranic *isotopes* (*half-lives* greater than 20 years).

**tritium** – The heaviest radioactive *isotope* of hydrogen (hydrogen-3) with a 12.3-year half life.

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**U**

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**unconfined aquifer** – An *aquifer* containing groundwater that is not confined above by relatively impermeable rocks. The pressure at the top of the unconfined aquifer is equal to that of the atmosphere. At the Hanford Site, the unconfined *aquifer* is the uppermost aquifer and is most susceptible to contamination from site operations.

**V**

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**vadose zone** – Underground area from the ground surface to the top of the *water table* or *aquifer*.

**volatile organic compounds** – Lightweight organic compounds that vaporize easily; used in solvents and degreasing compounds as raw materials.

**W**

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**water table** – The top of the *unconfined aquifer*.

**wind rose** – A diagram showing how often winds of various speeds blow from different directions, usually based on yearly averages.

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## C. Additional Monitoring Results

This appendix contains additional information on 2011 monitoring results, supplementing data summarized in the main body of the report. More detailed information is available upon request (see Preface for contact information).

**Table C.1 Radionuclide Concentrations Measured in Sediment from West Lake (2006 – 2011)**

Radionuclide	2011				Samples	2006-2010					
	Samples	Concentration, pCi/g <sup>(a)</sup>				Average <sup>(c)</sup>	Concentration, pCi/g <sup>(a)</sup>				
		Result <sup>(b)</sup>					Maximum <sup>(b)</sup>				
ALPHA	1	10	±	2.6	11	7.3	±	6.2	12	±	4.8
BETA	1	27	±	3.0	11	22	±	11	31	±	5.4
Potassium-40	1	17	±	1.9	11	16	±	5.8	19	±	2.0
Strontium-90	1	0.27	±	0.068	11	0.32	±	0.40	0.65	±	0.11
Cesium-134	1	- <sup>(d)</sup>			11	0.035	±	0.027	0.063	±	0.028 <sup>(e)</sup>
Cesium-137	1	0.96	±	0.091	11	1.1	±	0.98	1.9	±	0.24
Uranium-234	1	2.1	±	0.41	13	1.9	±	3.6	6.4	±	0.87
Uranium-235	1	0.13	±	0.063	11	0.10	±	0.20	0.36	±	0.07
Uranium-238	1	2.0	±	0.39	11	2.0	±	3.5	6.1	±	0.83
Antimony-125	1	0.035	±	0.044 <sup>(e)</sup>	11	0.012	±	0.033	0.038	±	0.038 <sup>(e)</sup>
Europium-152	1	-0.004	±	0.047 <sup>(e)</sup>	11	-0.002	±	0.018	0.015	±	0.052 <sup>(e)</sup>
Europium-154	1	0.047	±	0.060 <sup>(e)</sup>	11	-0.019	±	0.069	0.039	±	0.041 <sup>(e)</sup>
Europium-155	1	0.041	±	0.047 <sup>(e)</sup>	11	0.046	±	0.051	0.094	±	0.032
Cobalt-60	1	-0.005	±	0.017 <sup>(e)</sup>	11	-0.0001	±	0.012	0.009	±	0.017 <sup>(e)</sup>
Beryllium-7	1	-0.007	±	0.21 <sup>(e)</sup>	11	-0.29	±	2.1	0.24	±	0.10 <sup>(e)</sup>
Ruthenium-106	1	-0.095	±	0.14 <sup>(e)</sup>	11	-0.0004	±	0.14	0.12	±	0.15 <sup>(e)</sup>
Technetium-99	1	-0.47	±	0.50 <sup>(e)</sup>	11	0.16	±	0.73	0.92	±	0.41

(a) To convert to the International System of Units, multiply pCi/g by 0.037 to obtain Bq/g. All values are dry weight.

(b) Result and maximum values are ± total propagated analytical uncertainty.

(c) Averages are ±2 standard deviations of the mean.

(d) Dashes indicate no result available.

(e) Below detection limit.

**Table C.2. Radionuclide Concentrations Measured in Water Samples Collected from West Lake (2011, and 1997 - 2001)**

Radionuclide	2011			1997 - 2001		DOE-Derived Concentration Guides	Washington State Ambient Surface Water Quality Standard <sup>(d)</sup> Concentration, pCi/L <sup>(a)</sup>
	Samples	Average <sup>(b)</sup>	Maximum <sup>(c)</sup>	Concentration, pCi/L <sup>(a)</sup>	Maximum <sup>(c)</sup>		
Tritium	3	146 ± 137	220 ± 172	171 ± 214	358 ± 140	2,000,000	20,000 <sup>(d,e)</sup>
Uranium-234	3	526 ± 1,222	1,200 ± 282	905 ± 1,854	2,650 ± 460	500	
Uranium-235	3	26 ± 61	60 ± 19	32 ± 77	132 ± 23	600	
Uranium-238	3	514 ± 1,205	1,180 ± 278	1,035 ± 2,390	4,590 ± 2,700	600	
Alpha		No Analysis		1,573 ± 3,775	7,060 ± 2,100		15
Antimony-125		No Analysis		0.25 ± 34 <sup>(f)</sup>	46 ± 71 <sup>(f)</sup>	50,000	300
Beta		No Analysis		3,195 ± 6,887	9,860 ± 1,600		50
Cobalt-60		No Analysis		0.15 ± 16 <sup>(f)</sup>	15 ± 29 <sup>(f)</sup>	5,000	100
Cesium-134		No Analysis		-4.0 ± 20 <sup>(f)</sup>	9.4 ± 23 <sup>(f)</sup>	2,000	
Cesium-137		No Analysis		6.9 ± 19	31 ± 11	3,000	200
Europium-154		No Analysis		2.3 ± 27 <sup>(f)</sup>	29 ± 79 <sup>(f)</sup>	20,000	
Europium-155		No Analysis		3.0 ± 56 <sup>(f)</sup>	97 ± 89 <sup>(f)</sup>	100,000	
Ruthenium-106		No Analysis		17 ± 115 <sup>(f)</sup>	206 ± 320 <sup>(f)</sup>	6,000	30
Strontium-90		No Analysis		5.9 ± 18	26 ± 4.7	1,000	8
Technetium-99		No Analysis		205 ± 741	1,400 ± 96	100,000	900 <sup>(d)</sup>

a) To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.

(b) Averages are ±2 standard deviations of the mean.

(c) Maximum values are ± total propagated analytical uncertainty.

(d) WAC 246-290, 40 CFR 141.

(e) WAC 173-201A-250 and EPA-570/9-76-003.

(f) Value below the laboratory-reported detection limit.

Table C.3. Concentrations of Selected Radionuclides (pCi/m3)(a) in Near-Facility Air Samples (2006 - 2011)

Radionuclide	Location	2011					2006 - 2010				
		Samples	Detections <sup>(b)</sup>	Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	Sampler	Samples	Detections <sup>(b)</sup>	Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	EPA Table 2 <sup>(e,f)</sup>
<b>gross α</b>	100-D FR	104	94	1.1E-03	4.6E-03	N514	404	366	1.1E-03	3.4E-03	2.0E-02
	100-F FR	72	61	1.2E-03	3.1E-03	N519	327	289	1.2E-03	4.6E-03	
	100-H FR	102	90	1.2E-03	3.6E-03	N510	252	231	1.2E-03	3.0E-03	
	100-K KBC	155	134	1.1E-03	4.0E-03	N575	1021	933	1.4E-03	2.0E-02	
	100-N	78	73	1.1E-03	2.8E-03	N102	393	372	1.2E-03	3.3E-03	
	118-K-1 FR	77	65	1.0E-03	2.8E-03	N534	328	293	1.2E-03	9.4E-03	
	200-East	544	488	1.2E-03	3.8E-03	N957	2731	2543	1.2E-03	5.0E-03	
	200-North	68	54	9.3E-04	6.4E-03	N564	206	182	1.2E-03	3.7E-03	
	200-West	628	572	1.2E-03	1.4E-02	N441	3160	2893	1.3E-03	1.2E-02	
	300 FR & D4	52	46	1.1E-03	2.6E-03	N130	262	247	1.2E-03	3.3E-03	
	618-10 FR	87	70	1.3E-03	1.6E-02	N548	36	32	8.7E-04	1.9E-03	
	BCCA	109	95	1.0E-03	3.8E-03	N957	521	454	1.1E-03	4.7E-03	
	ERDF	129	110	1.0E-03	4.0E-03	N518	659	588	1.2E-03	7.4E-03	
	U Canyon	155	136	1.2E-03	3.8E-03	N963	707	652	1.3E-03	7.4E-03	
	100-D FR	104	104	1.7E-02	7.3E-02	N514	404	404	1.7E-02	4.9E-02	9.0E+00
<b>gross β</b>	100-F FR	72	72	1.6E-02	5.1E-02	N519	327	327	1.7E-02	5.6E-02	
	100-H FR	102	102	1.7E-02	6.0E-02	N574	252	250	1.9E-02	5.3E-02	
	100-K KBC	155	155	1.6E-02	6.3E-02	N575	1021	1021	2.6E-02	1.2E+00	
	100-N	78	78	1.7E-02	5.4E-02	N102	393	393	1.7E-02	4.4E-02	
	118-K-1 FR	77	77	1.6E-02	4.4E-02	N534	328	328	2.4E-02	5.3E-01	
	200-East	544	544	1.7E-02	7.0E-02	N481	2731	2731	1.7E-02	9.6E-02	
	200-North	68	68	1.4E-02	5.8E-02	N564	206	206	1.6E-02	5.2E-02	
	200-West	628	628	1.6E-02	7.4E-02	N964	3160	3157	1.7E-02	1.7E-01	
	300 FR & D4	52	52	1.7E-02	5.0E-02	N130	262	262	1.7E-02	5.2E-02	
	618-10 FR	87	86	1.6E-02	9.0E-02	N548	36	36	1.2E-02	2.3E-02	
	BCCA	109	109	1.7E-02	6.7E-02	N920	521	520	1.7E-02	5.1E-02	
	ERDF	129	129	1.5E-02	4.8E-02	N517	659	657	1.6E-02	9.6E-02	
	U Canyon	155	155	1.7E-02	4.9E-02	N168	707	707	1.7E-02	9.6E-02	
	100-D FR	8	0	5.2E-06	1.7E-05	N467	24	15	7.3E-06	1.4E-05	1.9E-03
	100-H FR	8	1	6.7E-06	1.1E-05	N508	12	6	8.8E-06	1.6E-05	
<b><sup>241</sup>Am</b>	100-K KBC	12	8	1.9E-05	7.3E-05	N403	81	62	9.9E-05	1.2E-03	
	100-N	6	3	1.1E-05	1.9E-05	N102	30	13	8.0E-06	3.9E-05	
	118-K-1 FR	6	4	2.9E-05	7.3E-05	N403	10	10	2.7E-04	1.2E-03	
	200-East	4	0	2.7E-06	4.6E-06	N480	20	8	5.7E-06	1.0E-05	
	200-West	2	2	5.1E-05	6.4E-05	N165	6	5	8.5E-05	3.1E-04	
	618-10 FR	8	6	5.2E-05	2.4E-04	N548	0	0	ND	ND	
	BCCA	5	0	-4.0E-04	8.4E-04	N920	12	2	-2.1E-05	4.3E-04	

Table C.3. Concentrations of Selected Radionuclides (pCi/m3)(a) in Near-Facility Air Samples (2006 - 2011)

Radionuclide	Location	2011					2006 - 2010				
		Samples	Detections <sup>(b)</sup>	Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	Sampler	Number of		Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	EPA Table 2 <sup>(e,f)</sup>
							Samples	Detections <sup>(b)</sup>			
<sup>134</sup> Cs	100-D FR	8	4	1.2E-04	2.4E-04	N468	32	0	3.3E-05	4.0E-04	2.7E-02
	100-F FR	6	3	5.9E-05	3.0E-04	N521	28	0	6.3E-05	7.9E-04	
	100-H FR	8	3	9.4E-05	2.3E-04	N510	20	0	8.8E-07	3.1E-04	
	100-K KBC	12	6	1.1E-04	2.6E-04	N575	81	0	7.8E-06	3.2E-04	
	100-N	6	3	8.4E-05	3.3E-04	N103	30	0	3.7E-06	2.1E-04	
	118-K-1 FR	6	2	4.5E-05	2.1E-04	N403	26	0	-2.1E-05	9.1E-05	
	200-East	42	18	1.0E-04	3.2E-04	N532	210	1	4.1E-06	4.1E-04	
	200-North	8	3	-1.1E-05	3.0E-04	N564	20	0	3.1E-05	2.6E-04	
	200-West	50	22	7.3E-05	4.8E-04	N155	243	1	2.0E-06	5.2E-04	
	300 FR & D4	6	1	6.4E-05	3.7E-04	N557	30	0	3.9E-05	4.8E-04	
	618-10 FR	8	3	8.2E-05	6.8E-04	N579	8	0	-2.2E-04	6.7E-05	
	BCCA	13	4	7.9E-05	3.3E-04	N572	53	0	5.9E-05	5.5E-04	
	ERDF	10	2	1.8E-05	2.3E-04	N963	50	0	1.8E-05	5.8E-04	
	U Canyon	12	6	6.9E-05	2.4E-04	N956	54	0	1.1E-05	5.2E-04	1.9E-02
<sup>137</sup> Cs	100-D FR	8	5	2.5E-04	4.5E-04	N468	32	0	1.8E-05	9.6E-05	
	100-F FR	6	3	1.9E-04	3.6E-04	N520	28	0	-5.4E-06	1.1E-04	
	100-H FR	8	4	2.1E-04	5.1E-04	N510	20	0	1.7E-05	9.4E-05	
	100-K KBC	12	8	3.0E-04	1.2E-03	N403	81	31	6.5E-03	1.2E-01	
	100-N	6	6	8.9E-04	1.9E-03	N106	30	3	3.6E-05	2.4E-04	
	118-K-1 FR	6	5	4.1E-04	1.2E-03	N403	26	11	6.1E-03	7.5E-02	
	200-East	42	24	2.4E-04	1.7E-03	N019	210	24	6.2E-05	2.3E-03	
	200-North	8	4	1.9E-04	5.7E-04	N563	20	0	4.4E-05	1.5E-04	
	200-West	50	24	1.7E-04	7.6E-04	N155	243	18	3.5E-05	3.2E-04	
	300 FR & D4	6	3	2.0E-04	5.3E-04	N557	30	0	1.1E-05	1.0E-04	
	618-10 FR	8	4	3.6E-04	1.2E-03	N579	8	0	2.3E-05	1.6E-04	
	BCCA	13	4	1.0E-04	4.8E-04	N572	53	4	8.6E-05	2.5E-03	
	ERDF	10	5	1.7E-04	4.1E-04	N550	50	7	6.3E-05	3.8E-04	
	U Canyon	12	6	1.9E-04	4.4E-04	N551	54	9	5.4E-05	3.2E-04	

Table C.3. Concentrations of Selected Radionuclides (pCi/m3)(a) in Near-Facility Air Samples (2006 - 2011)

2011							2006 - 2010				
Radionuclide	Location	Number of			Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	Sampler	Number of		Maximum <sup>(d)</sup>	EPA Table 2 <sup>(e,f)</sup>
		Samples	Detections <sup>(b)</sup>					Samples	Detections <sup>(b)</sup>		
<sup>238</sup> Pu	100-D FR	8	0	1.1E-06	3.9E-06	N514	32	0	5.1E-07	1.8E-05	2.1E-03
	100-F FR	6	2	1.2E-05	2.3E-05	N519	28	1	1.1E-06	1.4E-05	
	100-H FR	8	0	-5.2E-07	4.2E-06	N510	20	1	-1.3E-06	1.1E-05	
	100-K KBC	12	0	4.0E-06	1.6E-05	N403	81	10	1.1E-05	1.5E-04	
	100-N	6	0	1.8E-06	4.1E-06	N103	30	0	2.2E-06	1.9E-05	
	118-K-1 FR	6	0	6.3E-06	1.6E-05	N403	26	2	1.1E-05	1.1E-04	
	200-East	42	2	7.6E-07	1.3E-05	N985	209	2	2.0E-06	1.9E-04	
	200-North	8	1	2.9E-06	1.2E-05	N567	20	1	-8.2E-08	1.8E-05	
	200-West	50	2	2.1E-06	2.1E-05	N433	243	7	1.9E-06	3.4E-05	
	300 FR & D4	6	1	1.6E-07	1.2E-05	N557	30	3	3.4E-06	5.5E-05	
	618-10 FR	8	0	2.2E-06	1.3E-05	N549	8	0	-9.5E-08	7.0E-06	
	BCCA	13	0	2.8E-06	1.5E-05	N573	50	2	1.5E-01	7.6E+00	
	ERDF	10	0	7.4E-08	8.5E-06	N517	50	1	1.5E-06	1.6E-05	
	U Canyon	12	1	2.0E-06	1.6E-05	N975	54	3	2.4E-06	1.6E-05	
	100-D FR	8	2	3.4E-06	1.0E-05	N467	32	3	2.3E-06	5.9E-06	2.0E-03
	100-F FR	6	1	4.0E-06	1.9E-05	N519	28	2	1.4E-06	8.6E-06	
	100-H FR	8	1	2.6E-06	5.5E-06	N508	20	6	2.9E-06	2.6E-05	
	100-K KBC	12	6	2.1E-05	8.8E-05	N403	81	42	8.8E-05	1.2E-03	
	<sup>239/240</sup> Pu	100-N	6	4	7.2E-06	1.1E-05	N106	30	11	5.1E-06	3.3E-05
118-K-1 FR		6	3	3.1E-05	8.8E-05	N403	26	12	8.3E-05	9.4E-04	
200-East		42	4	1.7E-06	1.2E-05	N970	210	17	1.0E-05	1.8E-03	
200-North		8	2	3.9E-06	1.9E-05	N564	20	4	2.8E-06	1.2E-05	
200-West		50	23	2.6E-05	4.5E-04	N165	243	93	2.1E-05	7.1E-04	
300 FR & D4		6	0	2.4E-06	1.2E-05	N557	30	2	3.6E-06	3.1E-05	
618-10 FR		8	5	1.3E-04	6.8E-04	N548	8	0	1.1E-06	6.0E-06	
BCCA		13	0	-1.4E-07	2.5E-06	N957	48	1	1.1E-01	5.3E+00	
ERDF		10	5	4.5E-06	9.1E-06	N482	50	20	4.9E-06	2.8E-05	
U Canyon		12	7	1.1E-05	6.6E-05	N975	54	26	8.8E-06	9.1E-05	
100-K KBC		12	0	-1.5E-04	3.4E-04	N578	81	15	7.7E-04	9.2E-03	1.9E-03
118-K-1 FR		6	0	-1.5E-04	5.4E-05	N403	10	4	1.4E-03	5.8E-03	
200-East		4	0	-1.3E-04	-1.4E-05	N481	20	1	3.0E-05	1.0E-03	
200-West	2	1	1.9E-04	7.3E-04	N165	6	2	8.0E-04	1.7E-03		

Table C.3. Concentrations of Selected Radionuclides (pCi/m3)(a) in Near-Facility Air Samples (2006 - 2011)

2011							2006 - 2010					
Radionuclide	Location	Number of			Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	Sampler	Number of		Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	EPA Table 2 <sup>(e,f)</sup>
		Samples	Detections <sup>(b)</sup>					Samples	Detections <sup>(b)</sup>			
<sup>90</sup> Sr	100-D FR	8	2	1.5E-04	3.0E-04	N514	32	1	-1.1E-04	2.9E-04	1.9E-02	
	100-F FR	6	0	-8.5E-05	2.1E-05	N521	28	1	-1.3E-04	2.7E-04		
	100-H FR	8	0	2.9E-05	1.7E-04	N509	20	0	-1.5E-04	2.3E-04		
	100-K KBC	12	2	1.1E-05	2.2E-04	N403	81	15	7.3E-04	1.5E-02		
	100-N	6	2	1.7E-04	3.2E-04	N106	30	1	-1.2E-04	2.0E-04		
	118-K-1 FR	6	1	6.8E-05	2.2E-04	N403	26	4	6.0E-04	7.7E-03		
	200-East	42	5	4.5E-05	4.5E-04	N978	210	5	-1.1E-04	4.7E-04		
	200-North	8	0	-4.7E-06	9.6E-05	N563	20	0	-3.7E-04	1.0E-04		
	200-West	50	4	6.0E-06	5.0E-04	N155	243	4	-1.3E-04	6.2E-04		
	300 FR & D4	6	0	-2.2E-05	7.6E-05	N130	30	0	-2.4E-04	1.9E-04		
<sup>228</sup> Th	618-10 FR	8	2	1.1E-04	3.7E-04	N579	8	0	-3.6E-04	2.1E-04		
	BCCA	13	3	-2.1E-05	4.5E-04	N978	52	2	-6.0E-05	7.8E-04		
	ERDF	10	1	4.9E-06	2.4E-04	N518	50	1	-1.0E-04	6.7E-04		
	U Canyon	12	1	-3.1E-06	2.2E-04	N975	54	1	-1.4E-04	1.7E-04		
	100-F FR	6	3	1.5E-05	5.7E-05	N521	3	0	5.2E-04	8.2E-04	3.1E-03	
	100-F FR	6	6	5.5E-05	7.2E-05	N520	3	0	2.0E-04	2.2E-04	3.4E-03	
	100-F FR	6	6	1.9E-05	5.7E-05	N521	3	0	1.6E-05	2.0E-05	6.2E-04	
	100-D FR	8	7	1.1E-05	2.0E-05	N468	32	28	1.1E-05	1.8E-05	7.7E-03	
	100-F FR	6	5	1.4E-05	2.8E-05	N519	28	22	1.2E-05	2.0E-05		
	100-H FR	8	6	1.1E-05	1.8E-05	N508	20	16	1.3E-05	4.0E-05		
<sup>230</sup> Th	100-K KBC	12	11	1.3E-05	2.1E-05	N577	81	70	1.2E-05	4.7E-05		
	100-N	6	6	1.1E-05	1.4E-05	N103	30	28	1.2E-05	2.2E-05		
	118-K-1 FR	6	6	1.2E-05	1.4E-05	N535	26	21	1.2E-05	3.1E-05		
	200-East	42	41	1.1E-05	2.2E-05	N976	210	194	1.2E-05	4.4E-05		
	200-North	8	8	1.2E-05	1.9E-05	N563	20	19	1.6E-05	5.4E-05		
	200-West	50	48	1.2E-05	3.0E-05	N551	243	222	2.6E-05	2.2E-03		
	300 FR & D4	6	5	2.2E-05	3.4E-05	N557	30	27	1.9E-05	4.0E-05		
	618-10 FR	8	8	1.7E-05	2.4E-05	N548	8	5	1.9E-05	2.7E-05		
	BCCA	13	13	2.6E-05	4.8E-05	N920	52	41	1.4E-01	7.2E+00		
	<sup>232</sup> Th	ERDF	10	10	2.0E-05	4.2E-05	N518	50	49	3.4E-05	4.7E-04	
U Canyon		12	11	1.4E-05	3.0E-05	N551	54	51	7.4E-05	2.2E-03		



Table C.3. Concentrations of Selected Radionuclides (pCi/m3)(a) in Near-Facility Air Samples (2006 - 2011)

2011							2006 - 2010						
Radionuclide	Location	Number of		Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	Sampler	Samples	Detections <sup>(b)</sup>	Number of	Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	EPA Table 2 <sup>(e,f)</sup>	
<sup>235</sup> U	100-D FR	8	3	3.2E-06	6.8E-06	N467	32	5	2.2E-06	6.2E-06	7.1E-03		
	100-F FR	6	1	3.2E-06	6.2E-06	N519	28	4	2.7E-06	8.2E-06			
	100-H FR	8	2	3.1E-06	6.7E-06	N574	20	1	2.1E-06	5.6E-06			
	100-K KBC	12	2	2.1E-06	5.9E-06	N476	80	14	2.9E-06	2.6E-05			
	100-N	6	0	1.4E-06	3.1E-06	N106	30	8	2.6E-06	8.2E-06			
	118-K-1 FR	6	0	1.0E-06	3.0E-06	N534	26	3	2.6E-06	5.3E-06			
	200-East	42	3	2.2E-06	6.0E-06	N976	210	39	2.4E-06	1.4E-05			
	200-North	8	0	2.8E-06	5.2E-06	N564	20	6	4.8E-06	2.1E-05			
	200-West	49	6	2.6E-06	1.0E-05	N155	243	50	4.2E-06	2.1E-04			
	300 FR & D4	6	2	6.4E-06	1.0E-05	N130	30	3	3.4E-06	8.8E-06			
	618-10 FR	8	2	4.0E-06	8.4E-06	N580	8	0	3.7E-06	1.0E-05			
	BCCA	13	3	4.3E-06	2.7E-05	N572	52	6	2.7E-06	9.5E-06			
	ERDF	10	1	2.5E-06	5.8E-06	N518	50	14	4.3E-06	3.7E-05			
	U Canyon	12	0	2.4E-06	4.1E-06	N550	54	17	8.8E-06	2.1E-04			
	100-D FR	8	7	9.0E-06	1.3E-05	N515	32	28	8.6E-06	1.5E-05	8.3E-03		
	100-F FR	6	4	1.2E-05	2.1E-05	N520	28	23	9.5E-06	1.8E-05			
	100-H FR	8	6	9.6E-06	1.5E-05	N574	20	16	1.0E-05	2.4E-05			
<sup>238</sup> U	100-K KBC	12	11	1.1E-05	1.9E-05	N576	81	69	9.1E-06	2.7E-05			
	100-N	6	6	9.2E-06	1.6E-05	N106	30	26	8.5E-06	1.7E-05			
	118-K-1 FR	6	6	1.3E-05	1.9E-05	N535	26	21	1.1E-05	2.4E-05			
	200-East	42	35	8.7E-06	1.9E-05	N976	210	185	8.3E-06	2.0E-05			
	200-North	8	6	9.8E-06	2.0E-05	N567	20	14	1.0E-05	1.7E-05			
	200-West	50	47	1.0E-05	2.1E-05	N554	243	213	2.2E-05	1.9E-03			
	300 FR & D4	6	4	1.4E-05	2.0E-05	N557	30	25	1.4E-05	3.6E-05			
	618-10 FR	8	5	1.0E-05	1.9E-05	N580	8	6	1.7E-05	2.7E-05			
	BCCA	13	13	2.5E-05	5.0E-05	N920	52	43	1.6E-05	6.2E-05			
	ERDF	10	10	1.9E-05	3.3E-05	N517	50	48	3.0E-05	4.3E-04			
	U Canyon	12	12	1.3E-05	1.9E-05	N551	54	52	6.5E-05	1.9E-03			
	<div><div><div>a) 1 pCi = 0.037 Bq.</div><div>b) Number of samples with measurable concentrations of contaminant.</div><div>c) Average ± two standard deviations of all samples analyzed.</div><div>d) Maximum ± analytical uncertainty</div><div>e) DOE derived concentration guides are shown for gross alpha and gross beta</div><div>f) EPA values are based on an effective dose equivalent of 10 mrem/year (40 CFR 61, Appendix F, Table 2).</div></div><div><div>BCCA = BC Controlled Area</div><div>D&amp;D = Decontamination and Decommissioning</div><div>DOE = U.S. Department of Energy</div><div>ERDF = Environmental Restoration Disposal Facility</div><div>FR = Field Remediation project</div><div>KRC =K Basins Closure</div></div></div>												

(a) 1 pCi = 0.037 Bq.

(b) Number of samples with measurable concentrations of contaminant.

(c) Average ± two standard deviations of all samples analyzed.

(d) Maximum ± analytical uncertainty

(e) DOE derived concentration guides are shown for gross alpha and gross beta

(f) EPA values are based on an effective dose equivalent of 10 mrem/year (40 CFR 61, Appendix E, Table 2).

BCCA = BC Controlled Area

D&amp;D = Decommissioning and Decommissioning

DOE = U.S. Department of Energy

ERDF = Environmental Restoration Disposal Facility

FR = Field Remediation project

KBC = K Basins Closure

**Table C.4. Radionuclide Concentrations in Columbia River Water Samples Collected at Priest Rapids Dam, Washington (2011 - 2006)**

2011				2006 – 2010				Washington State Ambient Surface Water Quality Standard Concentration (pCi/ L)
Radionuclide <sup>(a)</sup>	Samples	Maximum	Concentration <sup>(b)</sup> (pCi/L)	Samples	Maximum	Concentration <sup>(b)</sup> (pCi/L)	Average	
Composite System								
Tritium	12	26 ± 8.6	18 ± 12	61	55 ± 26	24	± 18	
Alpha (gross)	12	1.7 ± 1.32 <sup>(d)</sup>	0.49 ± 1.29 <sup>(d)</sup>	63	2.3 ± 1.6	0.52	± 1.4	
Beta (gross)	12	9.4 ± 2.6	1.67 ± 5.31	63	6.8 ± 1.6	1.4	± 2.8	
Strontium-90	12	0.04 ± 0.04	0.01 ± 0.05	63	0.13 ± 0.05	0.04	± 0.05	
Technetium-99	12	0.42 ± 0.42	0.03 ± 0.46 <sup>(d)</sup>	63	1.1 ± 0.43	0.09	± 0.57	
Uranium-234	12	0.27 ± 0.07	0.22 ± 0.05	63	0.30 ± 0.10	0.23	± 0.08	
Uranium-235	12	0.02 ± 0.02	0.01 ± 0.01	63	0.03 ± 0.033 <sup>(d)</sup>	0.01	± 0.02	
Uranium-238	12	0.22 ± 0.05	0.18 ± 0.05	63	0.27 ± 0.07	0.18	± 0.06	
Continuous System								
Cesium-137	P 12	1.4E-03 ± 3.2E-03 <sup>(d)</sup>	2.5E-04 ± 1.4E-03 <sup>(d)</sup>	60	8.9E-03 ± 6.0E-03 <sup>(d)</sup>	6.6E-04	± 3.1E-03	
	D 12	1.9E-03 ± 5.2E-03 <sup>(d)</sup>	1.2E-04 ± 2.3E-03 <sup>(d)</sup>	60	7.8E-03 ± 7.0E-03 <sup>(d)</sup>	8.1E-04	± 4.5E-04	
Plutonium-238	P 4	7.5E-06 ± 1.5E-05 <sup>(d)</sup>	-1.0E-05 ± 3.0E-05 <sup>(d)</sup>	20	7.3E-05 ± 1.2E-04	6.1E-06	± 5.5E-05	
	D 4	7.2E-04 ± 6.0E-04 <sup>(d)</sup>	1.2E-04 ± 1.9E-03 <sup>(d)</sup>	20	2.3E-04 ± 4.1E-04 <sup>(d)</sup>	-7.8E-05	± 4.5E-04	
Plutonium-239/240	P 4	2.0E-05 ± 4.2E-05 <sup>(d)</sup>	3.9E-06 ± 2.9E-05 <sup>(d)</sup>	20	1.1E-04 ± 1.0E-04	2.2E-05	± 6.3E-05	
	D 4	7.2E-04 ± 2.5E-04 <sup>(d)</sup>	2.4E-04 ± 6.6E-04 <sup>(d)</sup>	20	3.2E-04 ± 4.4E-04 <sup>(d)</sup>	3.4E-05	± 1.7E-04	

2006 – 2010								Washington State Ambient Surface Water Quality Standard Concentration (pCi/ L)
Concentration <sup>(b)</sup> (pCi/L)								
Samples	Maximum	Average						
Composite System								
61	55 ± 26	24	± 18	20,000 <sup>(c)</sup>				
63	2.3 ± 1.6	0.52	± 1.4	15 <sup>(e,f)</sup>				
63	6.8 ± 1.6	1.4	± 2.8	50 <sup>(e,f)</sup>				
63	0.13 ± 0.05	0.04	± 0.05	8 <sup>(e,f)</sup>				
63	1.1 ± 0.43	0.09	± 0.57	900 <sup>(c)</sup>				
63	0.30 ± 0.10	0.23	± 0.08	— <sup>(g)</sup>				
63	0.03 ± 0.033 <sup>(d)</sup>	0.01	± 0.02	—				
63	0.27 ± 0.07	0.18	± 0.06	—				
Continuous System								
60	8.9E-03 ± 6.0E-03 <sup>(d)</sup>	6.6E-04	± 3.1E-03	200 <sup>(c)</sup>				
60	7.8E-03 ± 7.0E-03 <sup>(d)</sup>	8.1E-04	± 4.5E-04					
20	7.3E-05 ± 1.2E-04	6.1E-06	± 5.5E-05	600 <sup>(c)</sup>				
20	2.3E-04 ± 4.1E-04 <sup>(d)</sup>	-7.8E-05	± 4.5E-04					
20	1.1E-04 ± 1.0E-04	2.2E-05	± 6.3E-05					
20	3.2E-04 ± 4.4E-04 <sup>(d)</sup>	3.4E-05	± 1.7E-04					

(a) Radionuclides measured using the continuous system show the particulate (P) and dissolved (D) fractions separately. Other radionuclides are based on unfiltered samples collected by the composite system (see Section 7).

(b) Maximum values are ± total propagated analytical uncertainty (2 sigma). Averages are ±2 standard deviations of the mean. To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.

(c) WAC 173-201A-250 and EPA-570/9-76-003.

(d) Less than the laboratory reported detection limit.

(e) WAC 246-290.

(f) 40 CFR 141.

(g) Dashes indicate no concentration guides available.

**Table C.5. Radionuclide Concentrations in Columbia River Water Samples Collected at Richland, Washington (2006 – 2011)**

Radionuclide <sup>(a)</sup>	Composite System	Samples	2011			2006 – 2010			Washington State	
			Concentration <sup>(b)</sup> (pCi/L)			Concentration <sup>(b)</sup> (pCi/L)			Ambient Surface Water Quality Standard Concentration(pCi/L)	
			Maximum	Average		Maximum	Average			
Composite System	Tritium	12	108 ± 17	38 ± 50		136 ± 32	45 ± 45		20,000 <sup>(c)</sup>	
	Alpha (gross)	12	1.4 ± 1.6	0.72 ± 0.91		3.6 ± 1.9	0.57 ± 1.3		15 <sup>(e,f)</sup>	
	Beta (gross)	12	4.2 ± 2.5	1.9 ± 2.3		5.4 ± 2.6	1.7 ± 2.7		50 <sup>(e,f)</sup>	
	Strontium-90	12	0.06 ± 0.04 <sup>(d)</sup>	0.03 ± 0.04 <sup>(d)</sup>		0.08 ± 0.03	0.03 ± 0.04		8 <sup>(e,f)</sup>	
	Technetium-99	12	0.56 ± 0.45 <sup>(d)</sup>	0.08 ± 0.64 <sup>(d)</sup>		0.81 ± 0.39	0.11 ± 0.61		900 <sup>(c)</sup>	
	Uranium-234	12	0.31 ± 0.07	0.26 ± 0.06		0.35 ± 0.07	0.26 ± 0.07		— <sup>(g)</sup>	
Continuous System	Uranium-235	12	0.04 ± 0.02	0.01 ± 0.02		0.05 ± 0.04	0.01 ± 0.02		—	
	Uranium-238	12	0.25 ± 0.06	0.21 ± 0.06		0.30 ± 0.12	0.21 ± 0.07		—	
	Cesium-137	P 11	1.1E-03 ± 1.8E-03 <sup>(d)</sup>	3.3E-04 ± 1.5E-03 <sup>(d)</sup>		9.1E-03 ± 4.8E-03 <sup>(d)</sup>	3.3E-04 ± 3.2E-03 <sup>(d)</sup>		200 <sup>(c)</sup>	
		D 11	5.5E-03 ± 6.6E-03 <sup>(d)</sup>	2.0E-03 ± 5.2E-03 <sup>(d)</sup>		7.9E-03 ± 5.6E-03 <sup>(d)</sup>	3.4E-04 ± 5.1E-03 <sup>(d)</sup>			
	Plutonium-238	P 4	3.0E-05 ± 3.2E-05 <sup>(d)</sup>	9.9E-06 ± 3.5E-05 <sup>(d)</sup>		9.5E-05 ± 9.4E-05 <sup>(d)</sup>	7.3E-06 ± 6.4E-05 <sup>(d)</sup>		600 <sup>(c)</sup>	
		D 4	1.5E-04 ± 1.3E-04	6.1E-05 ± 1.4E-04		3.3E-04 ± 9.6E-04 <sup>(d)</sup>	-1.2E-04 ± 5.3E-04 <sup>(d)</sup>			
Plutonium-239/240		P 4	2.4E-05 ± 2.9E-05 <sup>(d)</sup>	-1.6E-05 ± 5.7E-05 <sup>(d)</sup>		9.5E-05 ± 8.6E-05 <sup>(d)</sup>	1.9E-07 ± 1.6E-04 <sup>(d)</sup>			
		D 4	4.1E-04 ± 2.2E-04 <sup>(d)</sup>	1.2E-04 ± 4.1E-04 <sup>(d)</sup>		1.6E-04 ± 1.4E-04	3.8E-05 ± 1.1E-04			

(a) Radionuclides measured using the continuous system show the particulate (P) and dissolved (D) fractions separately. Other radionuclides are based on unfiltered samples collected by the composite system (see Section 7).

(b) Maximum values are ± total propagated analytical uncertainty (2 sigma). Averages are ± standard deviations of the mean. To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.

(c) WAC 173-201A-250 and EPA-570/9-76-003.

(d) Less than the laboratory reported detection limit.

(e) WAC 246-290.

(f) 40 CFR 141.

(g) Dashes indicate no concentration guides available.

**Table C.6. Radionuclide Concentrations Measured in Columbia River Water Samples Collected Along Transects of the Hanford Reach (2011)**

Transect/Radionuclide	Samples	Concentration <sup>(a)</sup> , pCi/L	
		Maximum	Minimum
Vernita Bridge (HRM 0.3)			
Tritium	8	29 ± 6.9	15 ± 6.4
Strontium-90	8	0.033 ± 0.036	-0.026 ± 0.020
Uranium (total)	8	0.46 ± 0.14	0.32 ± 0.13
100-N Area (HRM 9.5)			
Tritium	6	53 ± 11	16 ± 7.0
Strontium-90	6	0.049 ± 0.037	-0.006 ± 0.031
Uranium (total)	6	0.96 ± 0.21	0.35 ± 0.12
Hanford Town Site (HRM 28.7)			
Tritium	6	642 ± 275	10 ± 6.1
Strontium-90	6	0.036 ± 0.038	-0.023 ± 0.028
Uranium (total)	6	1.2 ± 0.13	0.34 ± 0.10
300 Area (HRM 43.1)			
Tritium	6	39 ± 13	19 ± 7.2
Strontium-90	6	0.031 ± 0.036	-0.030 ± 0.031
Uranium (total)	6	0.55 ± 0.13	0.41 ± 0.12
Richland (HRM 46.4)			
Tritium	18	30 ± 6.2	15 ± 4.7
Strontium-90	17	0.045 ± 0.038	-0.051 ± 0.033
Uranium (total)	17	0.75 ± 0.16	0.34 ± 0.10

(a) Maximum and minimum values are ± total propagated analytical uncertainty (2 sigma). To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.

(b) Less than the laboratory-reported detection limit.

HRM = Hanford river marker.

**Table C.7. Radionuclide Concentrations Measured in Columbia River Water Samples Collected at Near-Shore Locations in the Hanford Reach (2011)**

Near-Shore/Radionuclide	Samples	Concentration <sup>(a)</sup> , pCi/L	
		Maximum	Minimum
100-N Area (HRM 9.5)			
Tritium	6	56 ± 11	17 ± 7.4
Strontium-90	6	0.051 ± 0.033	-0.028 ± 0.030
Uranium (total)	6	0.96 ± 0.21	0.35 ± 0.12
100-N Area (HRM 9.5)			
Tritium	6	56 ± 11	17 ± 7.4
Strontium-90	6	0.051 ± 0.033	-0.028 ± 0.030
Uranium (total)	6	0.96 ± 0.21	0.35 ± 0.12
Hanford Town Site (HRM 28.7)			
Tritium	6	854 ± 303	19 ± 7.6
Strontium-90	6	0.031 ± 0.030	-0.023 ± 0.028
Uranium (total)	6	0.48 ± 0.151	0.34 ± 0.15
300 Area (HRM 43.1)			
Tritium	6	3160 ± 663	24 ± 9.2
Strontium-90	6	0.048 ± 0.036	-0.016 ± 0.033
Uranium (total)	6	16 ± 2.4	0.32 ± 0.12
Richland (HRM 46.4)			
Tritium	15	41 ± 11	18 ± 11
Strontium-90	15	0.044 ± 0.039	-0.033 ± 0.033
Uranium (total)	15	16 ± 2.4	0.359 ± 0.115

(a) Maximum and minimum values are ± total propagated analytical uncertainty (2 sigma). To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.

(b) Less than the laboratory-reported detection limit.

HRM = Hanford river marker.

**Table C.8. Concentrations (µg/L) of Dissolved Metals in Columbia River Transect and Near-Shore Water Samples Collected near the Hanford Site (September 2011)**

Location	Metal Detected	Detections	Samples	Detected Values	Maximum	Washington State Ambient Surface Water Quality Chronic Toxicity Level <sup>(a)</sup>
<b>Vernita Bridge</b>		0	4			
<b>100-N Area</b>	Arsenic	3	10	5.5	5.7	190
				5.7		190
				5.4		190
	Selenium	1	10	7.1		5
<b>Hanford Town Site</b>	Zinc	1	10	4.0 <sup>(b)</sup>		55
<b>300 Area</b>	Antimony	2	10	5.4	5.6	
				5.6		
	Chromium	1	10	1.2 <sup>(c)</sup>		96
	Lead	1	10	3.4 <sup>(d)</sup>		1.1
	Selenium	3	10	7.5	7.5	5
				7.1		5
				7.4		5
	Zinc	2	10	22	22	55
				11		55
	Antimony	1	10	5.1		
<b>Richland</b>	Lead	3	10	3.4	5.5	1.1
				5.5		1.1
				3.7		1.1
	Zinc	1	10	3.5		55

(a) WAC 173-201A-240, for hardness-dependent criteria, the minimum value of 47 mg CaCO<sub>3</sub>/L for 1992-2000 water samples collected near Vernita Bridge by the U.S. Geological Survey is used. Parts per million (ppm) values are equivalent to the reported micrograms per liter (µg/L) concentrations shown. Dashes indicate no concentration guides available.

(b)  $(0.986) \exp(0.8473[\ln(\text{hardness})] + 0.7614)$ .

(c)  $(0.860) \exp(0.8190[\ln(\text{hardness})] + 1.561)$ .

(d)  $(1.4620 / [\ln(\text{hardness})] + 0.1457) \exp(1.273 [\ln(\text{hardness})] / 4.705)$ .

**Table C.9. Radionuclide and Total Organic Carbon Concentrations in Sediment from Columbia River near the Hanford Site (2006 - 2011)**

Location and Total Organic Carbon Concentrations (2011 TOC Value)	2011				2006-2010			
	Radionuclide	Samples	Average <sup>(b)</sup>	Maximum <sup>(c)</sup>	Concentration, pCi/g <sup>(a)</sup>	Samples	Average <sup>(b)</sup>	Maximum <sup>(c)</sup>
<b>Priest Rapids Dam</b> (24,200-27,800 mg/kg)	Cobalt-60	2	-0.014 ±	0.031 ±	-0.026 ± 0.054	10	0.003 ±	0.012 ± 0.016
	Strontium-90	2	0.003 ±	0.027 ±	0.013 ± 0.027	10	0.005 ±	0.04 ± 0.028
	Cesium-137	2	0.277 ±	0.041 ±	0.29 ± 0.087	10	0.29 ±	0.062 ± 0.038
	Europium-152	2	0.034 ±	0.156 ±	0.089 ± 0.136	10	-0.022 ±	0.073 ± 0.038
	Europium-155	2	0.088 ±	0.075 ±	0.114 ± 0.124	10	0.07 ±	0.04 ± 0.051
	Uranium-234	2	1.2 ±	0.41 ±	1.4 ± 0.25	12	1.0 ±	0.34 ± 0.2
	Uranium-235	2	0.049 ±	0.002 ±	0.050 ± 0.033	10	0.052 ±	0.052 ± 0.026
	Uranium-238	2	1.1 ±	0.30 ±	1.2 ± 0.23	11	0.94 ±	0.42 ± 0.43
<b>White Bluffs Slough</b> (15,000mg/kg)	Plutonium-239/240	2	0.010 ±	0.003 ±	0.011 ± 0.004	10	0.009 ±	0.003 ± 0.004
	Cobalt-60	1			-0.01 ± 0.046	5	0.015 ±	0.014 ± 0.026
	Strontium-90	1			0.04 ± 0.031	5	-0.003 ±	0.029 ± 0.014
	Cesium-137	1			0.47 ± 0.111	5	0.54 ±	0.27 ± 0.09
	Europium-152	1			0.008 ± 0.111	5	0.15 ±	0.13 ± 0.06
	Europium-155	1			0.079 ± 0.098	5	0.064 ±	0.064 ± 0.068
	Uranium-234	1			1.0 ± 0.18	6	0.62 ±	0.34 ± 0.122
	Uranium-235	1			0.053 ± 0.04	5	0.032 ±	0.042 ± 0.02
<b>McNary Dam</b> (12,400-16,400 mg/kg)	Uranium-238	1			1.0 ± 0.18	5	0.53 ±	0.33 ± 0.115
	Plutonium-239/240	1			0.003 ± 0.001	5	0.004 ±	0.003 ± 0.003
	Cobalt-60	2	0.002 ±	0.023 ±	0.01 ± 0.05	11	0.009 ±	0.02 ± 0.015
	Strontium-90	2	0.013 ±	0.002 ±	0.013 ± 0.024	11	-0.0020 ±	0.027 ± 0.024
	Cesium-137	2	0.232 ±	0.008 ±	0.235 ± 0.092	11	0.24 ±	0.165 ± 0.054
	Europium-152	2	0.064 ±	0.093 ±	0.097 ± 0.157	11	0.058 ±	0.14 ± 0.068
	Europium-155	2	0.1 ±	0.003 ±	0.101 ± 0.104	11	0.053 ±	0.05 ± 0.073
	Uranium-234	2	1.6 ±	0.31 ±	1.7 ± 0.31	13	1.2 ±	0.55 ± 0.23
	Uranium-235	2	0.081 ±	0.024 ±	0.090 ± 0.049	11	0.059 ±	0.055 ± 0.03
	Uranium-238	2	1.3 ±	0.07 ±	1.3 ± 0.25	11	0.97 ±	0.54 ± 0.23
	Plutonium-239/240	2	0.010 ±	0.005 ±	0.011 ± 0.004	11	0.007 ±	0.005 ± 0.003

(a) To convert to the International System of Units, multiply pCi/g by 0.037 to obtain Bq/g. All values are dry weight.

(b) Average values are not provided when only one sample was analyzed.

(c) Values are ± total propagated analytical uncertainty (2 sigma).

TOC = Total organic carbon.



**Table C.10. Range of Metal Concentrations (mg/kg dry wt.) in Sediment Samples Collected from the Columbia River near the Hanford Site (2011)**

	n=2	n=1	n=2	n=3
<b>Metal</b>	<b>Priest Rapids Dam</b>	<b>Hanford Reach<sup>(a)</sup></b>	<b>McNary Dam</b>	<b>Shoreline Springs(b)</b>
Antimony	0.83 - 0.84	0.58	0.72 - 0.77	0.39 - 0.41
Arsenic	7.3 - 11	5.4	6.6 - 6.9	2.2 - 6.5
Beryllium	2.8 - 3.2	1.1	3.1 - 3.8	0.31 - 1.4
Cadmium	3.1 - 8.1	1.2	1.0 - 1.6	0.13 - 0.64
Chromium	39 - 40	19	23 - 26	18 - 31
Copper	45 - 60	19	25 - 32	8 - 20
Lead	34 - 43	24	16 - 17	5.9 - 23
Mercury	0.11 - 0.14	0.031	0.091 - 0.11	0.0044 - 0.009
Nickel	41 - 43	11	20 - 23	11 - 15
Selenium	3.5 - 3.7	1.8	2.4 - 3.3	0.60 - 1.0
Silver	1.4 - 1.5	0.57	1.4 - 1.8	0.12 - 0.82
Thallium	2.3 - 3.5	1.1	2.3 - 3.2	0.60 - 2.4
Zinc	391 - 631	234	193 - 244	53 - 122

(a) White Bluffs Slough (n=1)

(b) 100-B Area (n=1), 100-K Area (n=1), and 100-H Area(n=1)

n = Number of samples

**Table C.11. Radionuclide Concentrations in Columbia River Water Samples Collected from Shoreline Springs along the Hanford Site (2006 - 2011)**

Location/Radionuclide	2011		2006-2010		Washington State Ambient Surface Water Quality Standard Concentration pCi/L	
	Sample s	Concentration <sup>(a)</sup> , pCi/L	Sample s	Concentration <sup>(a)</sup> , pCi/L		
		Result		Maximum		Average
100-B Area						
Alpha (gross)	1	3.3 ± 2.1	10	14 ± 5.6	3.7 ± 8.2	15
Beta (gross)	1	4.1 ± 2.6	10	23 ± 5.1	10 ± 12	50
Strontium-90	1	0.030 ± 0.0282 <sup>(c)</sup>	10	2.84 ± 0.42	1.1 ± 2.3	8
Technetium-99	1	2.4 ± 0.90	10	7.8 ± 1.02	3.5 ± 5.0	900 <sup>(d)</sup>
Tritium	1	1340 ± 321	10	2840 ± 180	2201 ± 990	20,000
100-K Area						
Alpha (gross)	1	2.3 ± 1.89 <sup>(c)</sup>	7	13 ± 4.8	3.4 ± 8.6	15
Beta (gross)	1	9.4 ± 3.1	7	19 ± 5.2	9.8 ± 11	50
Strontium-90	1	-0.017 ± 0.0279 <sup>(c)</sup>	7	1.91 ± 0.29	0.65 ± 1.6	8
Tritium	1	1090 ± 277	7	4200 ± 370	1374 ± 3405	20,000
100-N Area						
Alpha (gross)	1	1.7 ± 1.44 <sup>(c)</sup>	5	10 ± 4.0	3.2 ± 8.1	15
Beta (gross)	1	0.999 ± 0.18 <sup>(c)</sup>	5	18 ± 3.8	7.2 ± 12	50
Strontium-90	1	0.023 ± 0.0353 <sup>(c)</sup>	5	0.048 ± 0.032	0.02 ± 0.033 <sup>(c)</sup>	8
Tritium	1	492 ± 178	5	8860 ± 390	6046 ± 4620	20,000
100-D Area						
Alpha (gross)	1	1.74 ± 1.58 <sup>(c)</sup>	8	4.8 ± 2.0	1.4 ± 3.1	15
Beta (gross)	1	4.4 ± 2.35	8	6.1 ± 2.8	4.3 ± 3.1	50
Strontium-90	1	0.00749 ± 0.0281 <sup>(c)</sup>	8	1.3 ± 0.24	0.33 ± 0.81	8
Tritium	1	1840 ± 415	8	6230 ± 1310	959 ± 4311	20,000
100-H Area						
Alpha (gross)	1	3.2 ± 1.98 <sup>(c)</sup>	10	3.8 ± 2.6	2.1 ± 2.7	15
Beta (gross)	1	8.5 ± 2.8	10	22 ± 3.0	9.9 ± 15	50
Strontium-90	1	2.9E-03 ± 0.032 <sup>(c)</sup>	10	6.8 ± 1.1	2.6 ± 5.9	8
Technetium-99	1	0.075 ± 0.32 <sup>(c)</sup>	10	3.7 ± 0.66	0.75 ± 2.3	900 <sup>(d)</sup>
Tritium	1	299 ± 159	10	2370 ± 270	1099 ± 1629	20,000
Uranium (total)	1	4.7 ± 0.99	10	5.0 ± 0.84	1.4 ± 2.8	— <sup>(e)</sup>

(a) Maximum values are ± total propagated analytical uncertainty. Averages are ±2 standard deviations of the mean.

To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.

(b) WAC 246-290, 40 CFR 141, and Appendix D, Table D.4.

Table C.12. Radionuclide Concentrations in Columbia River Shoreline Sediment (2006 - 2011)

Location	Radionuclide	Samples	2011		2006-2010	
			Concentration, pCi/g		Concentration, pCi/g <sup>(a)</sup>	
			Result		Average <sup>(b)</sup>	Maximum <sup>(c)</sup>
100-B Spring	Cobalt-60	1	7.2E-03 ± 1.1E-02		4.0E-03 ± 1.8E-02	1.4E-02 ± 2.1E-02
	Strontium-90	1	-1.4E-03 ± 2.1E-02		3.2E-03 ± 8.3E-03	8.0E-03 ± 2.0E-02
	Cesium-137	1	4.5E-02 ± 1.5E-02		5.4E-02 ± 2.7E-02	7.7E-02 ± 3.2E-02
	Europium-152	1	-2.0E-02 ± 3.3E-02		-1.9E-02 ± 4.1E-02	1.1E-02 ± 4.6E-02
	Europium-155	1	3.4E-02 ± 3.4E-02		8.3E-02 ± 3.2E-02	1.1E-01 ± 7.7E-02
	Uranium-234	1	7.3E-01 ± 1.3E-01		4.6E-01 ± 4.7E-01	8.3E-01 ± 1.0E-01
	Uranium-235	1	5.1E-02 ± 2.8E-02		2.4E-02 ± 3.5E-02	4.0E-02 ± 2.2E-02
100-K Spring	Uranium-238	1	7.3E-01 ± 1.3E-01		3.9E-01 ± 4.0E-01	6.1E-01 ± 1.2E-01
	Cobalt-60	1	3.0E-03 ± 1.1E-02		3.9E-03 ± 1.6E-02	1.3E-02 ± 8.5E-03
	Strontium-90	1	3.3E-02 ± 2.8E-02		-5.0E-04 ± 6.9E-03	2.7E-03 ± 4.5E-03
	Cesium-137	1	2.7E-02 ± 1.6E-02		1.0E-01 ± 2.2E-02	1.1E-01 ± 2.5E-02
	Europium-152	1	-1.6E-03 ± 2.4E-02		1.9E-02 ± 6.8E-02	4.9E-02 ± 4.5E-02
	Europium-155	1	7.5E-02 ± 3.5E-02		4.7E-02 ± 1.8E-02	5.7E-02 ± 3.5E-02
	Uranium-234	1	7.2E-01 ± 1.4E-01		6.8E-01 ± 9.2E-01	1.3E+00 ± 1.7E-01
100-H Spring	Uranium-235	1	4.9E-02 ± 2.9E-02		5.4E-02 ± 1.1E-01	1.2E-01 ± 3.1E-02
	Uranium-238	1	6.9E-01 ± 1.3E-01		6.6E-01 ± 1.2E+00	1.3E+00 ± 1.7E-01
	Cobalt-60	1	1.5E-02 ± 1.4E-02		7.4E-03 ± 1.7E-02	1.9E-02 ± 2.1E-02
	Strontium-90	1	4.0E-02 ± 3.0E-02		3.7E-02 ± 7.6E-02	1.0E-01 ± 1.7E-02
	Cesium-137	1	6.8E-02 ± 2.1E-02		1.5E-01 ± 6.7E-02	1.8E-01 ± 2.7E-02
	Europium-152	1	3.6E-03 ± 2.9E-02		3.0E-02 ± 5.5E-02	6.6E-02 ± 3.7E-02
	Europium-155	1	5.5E-02 ± 4.5E-02		4.6E-02 ± 3.6E-02	7.4E-02 ± 3.4E-02
	Uranium-234	1	8.8E-01 ± 1.6E-01		6.2E-01 ± 5.8E-01	1.0E+00 ± 1.4E-01
	Uranium-235	1	4.0E-02 ± 2.5E-02		2.4E-02 ± 4.9E-02	6.7E-02 ± 2.5E-02
	Uranium-238	1	7.5E-01 ± 1.4E-01		5.3E-01 ± 5.7E-01	9.3E-01 ± 1.3E-01

(a) To convert to the International System of Units, multiply pCi/g by 0.037 to obtain Bq/g. All values are dry weight.

(b) Averages are ±2 standard deviations of the mean. Average values are not provided when only one sample was analyzed.

(c) Values are ± total propagated analytical uncertainty (2 Sigma).

(d) Below detection limit.

**Appendix D****Dose Calculations**

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## D.0 Dose Calculations

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### *R Perona and RT Ryti*

Dose calculations based on measured and/or estimated releases from stack emissions, liquid effluents, and contaminated soils were conducted for the public and biota. These dose calculations are summarized in Section 4.2. Details of the methods and assumptions used for modeling individual and population dose for the public are provided in Section D.1. Methods and assumptions related to the calculation of biota dose are provided in Section D.2.

### D.1 Supporting Information for Calculation of Public Doses

The radiological dose that the public could have received in 2011 from the Hanford Site was calculated in terms of the *total effective dose*. The total effective dose is the sum of the effective dose equivalent from external sources and the committed effective dose equivalent for internal exposure. The effective dose equivalent is the sum of doses to organs and tissues that is weighted to account for the sensitivity of the organ or tissue to the effects of radiation and for the biological effectiveness of the type of radiation causing the dose. It is expressed in units of rem (sievert), or more typically the sub-unit millirem (millisievert)<sup>a</sup> for individuals, and in units of person-rem (person-sievert) for the collective dose received by the total population within an 50-mile (80-kilometer) radius of the site operations areas. This appendix describes how the doses described in Section 4.2 of this report were calculated.

Calculation of the effective dose equivalent takes into account the long-term (50 years) internal exposure from radionuclides absorbed into the body during the current year. The effective dose equivalent is the sum of individual committed (50 years) organ doses multiplied by tissue weighting factors ([ICRP 1991](#)) that represent the contribution to a person's total health risk that each organ or tissue contributes following uniform irradiation of the whole body. Internal organs may also be irradiated from external sources of radiation. The external exposure received during the current year is added to the committed internal dose to obtain the total effective dose.

Releases of radionuclides from Hanford Site facilities are usually too small for their concentrations to be accurately measured in many of the offsite environmental media of interest. Therefore, environmental radionuclide concentrations were estimated from effluent measurements by using environmental transport models. The air dose calculations employ environmental transport modeling based on measurements made at the point of release (stacks and vents). The water pathway dose calculations are based on measurements of releases to the Columbia River (from the 100 Areas) and the difference in detectable radionuclide concentrations measured upstream and downstream of the site.

The transport of radionuclides in the environment to points of exposure is predicted using mathematical models of the physical processes underlying the various exposure pathways. These models are used to calculate radionuclide levels in air, water, soil, and foods at offsite locations. Long-lived radionuclides deposited on the ground become possible sources for long-term external exposure and uptake by agricultural products. Radionuclides taken into the body by inhalation or ingestion may be distributed among different organs and tissues and retained in the body for various lengths of times. Agricultural, behavioral, and dosimetric models were applied to calculate radionuclide intakes and radiological doses to the public from annual-average radionuclide concentrations in the exposure media. Computer programs were used to

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<sup>a</sup> 1 rem (0.01 sievert) = 1,000 millirem (10 millisievert).

implement these mathematical models using Hanford Site-specific dispersion and uptake parameters. These programs are incorporated in a master code—*GENII - The Hanford Environmental Radiation Dosimetry Software System, Version 2.10* ([PNNL-14583](#), [PNNL-14584](#), [PNNL-19168](#))—which employs the internal dosimetry methodology described in International Commission on Radiological Protection Publication 60 ([ICRP 1991](#)) and external dose coefficients described in Federal Guidance Report 12 ([EPA 1993](#)). GENII Version 1.485 (PNL-6584), which incorporated internal dosimetry methods of *International Commission on Radiological Protection Publication 30* (1979a, 1979b, 1980, 1981a, 1981b, 1982a, 1982b, 1988) was used for dose calculations through 2008. GENII Version 2.10 is a Microsoft Windows®-based version that also incorporates some environmental modeling improvements (e.g., plume depletion during atmospheric transport) relative to Version 1.485. The modeling assumptions and radionuclide release data used in the GENII calculations are the primary focus of Section D.1. The ingestion and inhalation dose coefficients ([ICRP 1991](#)) and external dose coefficients ([EPA 1993](#)) used for the pathway dose calculations are described further in [PNNL-14584](#) and are not reproduced here.

The computer program, CAP88-PC (also known as CAP-88), was used to calculate an air pathway dose to a maximally exposed individual for compliance with *Clean Air Act* standards, as required by the U.S. Environmental Protection Agency (EPA) through 40 CFR 61, Subpart H from airborne radionuclide effluent (other than radon) released at U.S. Department of Energy (DOE) facilities. Technical details of the CAP88-PC calculations are provided in the 2011 air emissions report ([DOE/RL-2012-19](#)).

Calculations of radiological doses to the public from radionuclides released into the environment are performed to demonstrate compliance with applicable standards and regulations. DOE O 458.1, Chg. 2, provides requirements for demonstrating compliance with the public dose limit of 100 mrem (1 millisievert) total effective dose in a year. Relevant requirements include:

- Compliance may be demonstrated by calculating dose to the representative person or to the maximally exposed individual.
- Collective dose for members of the public should be calculated, and may be truncated by distance (e.g., 50 miles).
- The representative person or maximally exposed individual must include members of the public outside of controlled areas on DOE sites and offsite.
- Analytical models used to calculate dose must be codified or approved by DOE and must consider likely exposure pathways including external radiation from air and soil, inhalation, and ingestion of water and terrestrial and/or aquatic foods.
- Calculations of doses to the public from exposures resulting from both routine and unplanned activities must be performed using DOE-approved dose conversion factors.
- Values of default or site-specific parameters used in the dose modeling must be included to document the calculations.

A summary of how the offsite maximally exposed individual was identified, and information on modeling assumptions and inputs to the GENII computer code used to conduct the maximally exposed individual dose calculations, is provided in Section D.1.1. Information supporting the calculation of collective offsite dose using the GENII computer code is provided in Section D.1.2. Dose calculations related to members of the public outside of controlled areas on DOE sites (specifically, onsite drinking water dose) are described in Section D.1.3.



**D.1.1 Maximally Exposed Individual Dose**

The maximally exposed individual is a hypothetical member of the public who lives at a location and has a lifestyle that makes it unlikely other individuals would receive higher doses. The location of the maximally exposed individual can vary from year to year, depending on the relative contributions of the different operational areas to radioactive emissions released to the air and of effluent released to the Columbia River from Hanford Site facilities. Regardless of location, all the following potentially significant exposure pathways for this hypothetical individual are considered (see also Figure 4.2.2):

- Inhalation of airborne radionuclides
- External exposure from submersion in airborne radionuclides
- Ingestion of foodstuffs contaminated by radionuclides deposited on vegetation and the ground by both airborne deposition and irrigation water drawn from the Columbia River
- Incidental ingestion of soil and external exposure to ground contaminated by both airborne deposition and irrigation water
- Consumption of fish from the Hanford Reach of the Columbia River
- Recreation along the Hanford Reach of the Columbia River, including fishing, boating, swimming, and exposure to sediments during shoreline activities.

**Determination of the Location of the Maximally Exposed Individual.** Based on experience since 1990 from environmental transport modeling and environmental surveillance monitoring, three separate locations (Figure 4.2.1) have been used to assess the dose to the maximally exposed individual. The distinguishing characteristics of these three locations are described in the following paragraphs.

Ringold Maximally Exposed Individual. The Ringold area is along the east shoreline of the Columbia River 26 kilometers (16 miles) east of separations facilities in the 200 Areas. Because of its location, an individual in the Ringold area has the potential to receive the maximum exposure to airborne emissions from the 200 Areas. In addition, it is assumed that some individuals in the Ringold area may irrigate their crops with water from the Columbia River downstream of where contaminated groundwater originating from the 100 and 200-East Areas enters the river. Domestic drinking water at Ringold is not obtained from the Columbia River so this exposure pathway is incomplete.

Riverview Maximally Exposed Individual. The Riverview area is across the Columbia River from the city of Richland. Because of its location, an individual in the Riverview area has the potential to receive the maximum exposure to waterborne effluent from Hanford Site facilities. The Riverview location is where a small population of West Pasco residents obtain their drinking water from the river via a community water system. Therefore, the domestic drinking water pathway is applied to this location. Columbia River water from just downstream of the Hanford Site is also withdrawn for irrigation of small gardens and farms at Riverview.

Sagemoor Maximally Exposed Individual. An individual in the Sagemoor area, located approximately 1.4 kilometers (0.87 mile) directly across the Columbia River from the 300 Area, receives the maximum exposure to airborne emissions from the 300 Area. However, domestic water at this location comes from wells rather than from the river, and wells in this region are not directly contaminated by radionuclides of Hanford Site origin (EPS-87-367A). Because the farms located across from the 300 Area obtain irrigation water from the Columbia River upstream of the Hanford Site, irrigation-related exposure pathways are likely incomplete at this location. However, researchers conservatively assumed that the diet of the Sagemoor area maximally

exposed individual consisted entirely of food purchased from an affected area such as Riverview. The added contribution of radionuclides in the Riverview area irrigation water maximizes the calculated dose from the air and water pathways combined.

During the period of plutonium production, Ringold was the location of the maximally exposed individual. Because of the shift in Hanford Site operations from nuclear weapons production to the current mission of managing waste products, cleaning up legacy waste, and researching new ideas and technologies for waste disposal and cleanup, the significance of air emissions from production facilities in the 200 Areas has decreased compared to emissions from research facilities in the 300 Area. For the past decade, the hypothetical, maximally exposed individual has been located across the Columbia River from the 300 Area at Sagemoor (Figure 4.2.1).

Because the hypothetical, maximally exposed individual at all three locations is assumed to consume foods raised using Columbia River irrigation water, the identification of the location of the maximally exposed individual is based on the highest projected dose among the following location-specific pathways:

- Air pathways dose at Ringold (200 Area sources);
- Air pathways dose at Sagemoor (300 Area sources); and,
- Drinking water pathway dose at Riverview.

For 2011, air pathways dose calculations conducted using CAP-88PC in support of *Clean Air Act* requirements identified Sagemoor as the location with the highest maximally exposed individual dose (0.024 mrem) from stack emissions (DOE/RL-2012-19). At Riverview, the comparable air pathways dose was 0.0028 mrem (Sandra Snyder, PNNL, personal communication). Drinking water dose in 2011 for the Riverview maximally exposed individual from 100 Area sources ( $3.7 \times 10^{-14}$  mrem) and 200 Area sources (0.0066 mrem) when summed with the air pathways dose of 0.0028 mrem is below the Sagemoor dose of 0.024 mrem. Therefore, Sagemoor was identified as the location of the hypothetical, maximally exposed individual in 2011 for the GENII calculations. A water ingestion rate of 2 L/day for 365 days was assumed for the drinking water dose calculation.

The coordinates of the Sagemoor location relative to each of the Hanford Site operating areas are entered in the GENII computer code to specify the location of the maximally exposed individual for the air pathways dose calculations. These coordinates are:

100 Area: 26.874 km Easting, -30.064 km Northing;  
200 Area: 24.954 km Easting, -20.814 km Northing;  
300 Area: 1.35 km Easting, 0.26 km Northing; and,  
400 Area: 7.909 km Easting, -6.739 km Northing.

**Water and Air Release Inputs Used In GENII Version 2.10.** As discussed in Section 4.2, the environmental data needed to perform the GENII dose calculations for the water pathways include measured upstream and downstream differences in radionuclide concentrations in the Columbia River (assigned to the 200 Area) and measured effluent releases from the 1908-K Outfall (100 Areas). Measured emissions of radionuclides in stack releases are used in the GENII air pathways dose calculations. These data must be processed for input to the GENII computer code. For both water and air pathways, GENII accepts inputs for environmental releases using dimensions of activity (e.g., Ci or Bq) per time.

Direct liquid effluent releases in the 100 Areas in 2011 were limited to the 1908-K Outfall in the 100-K Area. This outfall ceased operations at the end of March 2011. Therefore, annual releases in 2011 from the 100

Areas are based on measured radionuclide activities and outfall flow rates for only January, February, and March. Radionuclide measurements for the 1908-K Outfall in 2011 were based on grab samples collected on the last day of each month with analyses of strontium-90, cesium-137, plutonium-238, and plutonium-239/240. Only strontium-90 and plutonium-239/240 were detected in any of the three samples. 100 Area liquid effluent data and calculated releases for the 100 Areas GENII water pathways dose calculations are summarized in Table D.1.

**Table D.1. 1908-K Outfall Liquid Effluent Radionuclide Releases for GENII Calculations**

	Jan	Feb	Mar	Annual Total
<b>Outfall flow and radionuclide activity data</b>				
Outfall flow (Lpm)	47.3	433.7	657.1	NA
Strontium-90 (pCi/L)	0 <sup>(a)</sup>	0 <sup>(a)</sup>	1.7E+00	NA
Plutonium-239/240 (pCi/L)	3.9E-03	4.7E-03	3.8E-02	NA
<b>Calculated radionuclide releases <sup>(b)</sup></b>				
Plutonium-239/240 (Ci)	8.2E-09	8.5E-08	1.1E-06	1.2E-06
Strontium-90 (Ci)	0.0E+00	0.0E+00	5.0E-05	5.0E-05
Yttrium-90 (Ci) <sup>(c)</sup>	0.0E+00	0.0E+00	5.0E-05	5.0E-05

(a) A negative value was reported.

(b) Calculated as the product of the monthly outfall flow and the measured radionuclide activity.

(c) This short-lived progeny of Sr-90 was protectively assumed to be in secular equilibrium at the time of discharge. Refer to Section 7.0 for information on sampling for liquid effluent releases.

Lpm: liters per minute.

NA: Not applicable; flow and concentration data are recorded monthly.

Liquid effluent discharges related to historical Hanford operations are known to enter the Columbia River by groundwater discharge at certain locations along the site shoreline from the 100-B/C Area downstream to the 300 Area. The impact of these discharges was evaluated as the difference between near-shore river water radionuclide concentrations downstream of the Hanford Site (monthly samples collected at the Richland Pumphouse, sampling location label RICH.PMPHS HRM46.4) and upstream samples collected below the Priest Rapids Dam (monthly samples collected at sampling location label PRIEST RAPIDS-RIVER). A two-tailed paired t-test was used to determine whether average downstream sample concentrations were statistically greater than upstream average concentrations, using a p-value of 0.05 as the threshold of statistical significance. Cesium-137, tritium, uranium-234, and uranium-238 were identified as Hanford-related contaminants to include in the 2011 dose assessment based on this statistical test. Because uranium-235 would co-occur with both uranium-234 and uranium-238, uranium-235 was also identified for inclusion in the dose assessment. These liquid effluent releases were associated with the 200 Area for reporting purposes. Table D.2, summarizes the mean annual differences in downstream and upstream concentrations, and calculated annual releases for the 200 Areas GENII water pathways dose calculations.

**Table D.2. 200 Area Liquid Effluent Radionuclide Releases for GENII Calculations**

Radionuclide	Upstream	Downstream	Difference
<b>Columbia River Radionuclide Concentrations (pCi/L)</b>			
Cesium-137	5.7E-04	2.9E-03	2.3E-03
Tritium	1.8E+01	3.8E+01	2.0E+01
Uranium-234	2.2E-01	2.6E-01	3.5E-02
Uranium-235	1.1E-02	1.4E-02	2.8E-03
Uranium-238	1.8E-01	2.1E-01	2.4E-02
<b>Calculated Radionuclide Releases (Ci/year)<sup>(a)</sup></b>			
Cesium-137	NA	NA	3.0E-01
Barium-137m <sup>(b)</sup>	NA	NA	3.0E-01
Tritium	NA	NA	2.7E+03
Uranium-234	NA	NA	4.6E+00
Uranium-235	NA	NA	3.7E-01
Thorium-231 <sup>(c)</sup>	NA	NA	3.7E-01
Uranium-238	NA	NA	3.1E+00
Thorium-234 <sup>(d)</sup>	NA	NA	3.1E+00
Protactinium-234m <sup>(d)</sup>	NA	NA	3.1E+00

(a) Calculated as the product of the difference in downstream and upstream radionuclide concentrations and the annual-average river flow rate of 4201 m<sup>3</sup>/sec at Priest Rapids Dam.

(b) This short-lived progeny of cesium-137 was protectively assumed to be in secular equilibrium at the time of discharge.

(c) This short-lived progeny of uranium-235 was protectively assumed to be in secular equilibrium at the time of discharge.

(d) These short-lived progeny of uranium-238 were protectively assumed to be in secular equilibrium at the time of discharge.

Refer to Section 7.0 for information on Columbia River surface water sampling.

NA: Not applicable; radionuclide releases are calculated based on the difference between annual-average downstream and upstream concentrations.

Radioactive air emissions based on monitoring of stacks in the 100, 200, 300, and 400 Areas were used as the basis for the GENII air pathways dose calculations. Stack emissions are measured for specific radionuclides related to the operations at each emissions point. During the dispersion time from the stack to an offsite exposure location there is opportunity for ingrowth short-lived radioactive progeny that are included in the GENII radionuclide inventory. A protective upper-bound dispersion time of 15 hours was estimated based on the longest dispersion distance in the collective dose calculations (80 km) and an assumed 1.5 m/s average wind speed. Concentrations of short-lived progeny after a 15-hr ingrowth period were included in the GENII air emissions inventory for the air pathways dose calculations. In addition to measurement of specific radionuclides, gross alpha and gross beta measurements are also made on emissions from each operating area. Following the precedent of [DOE/RL-2012-19](#), measurements of gross alpha and gross beta radiation in stack emissions were protectively added to the measured emissions of plutonium-239/240 and strontium-90, respectively, to ensure that contributions from any unmeasured operations-related radionuclides are incorporated in the estimated doses. These specific radionuclides were selected based on their historical association with releases in these operating areas and because of the relatively large values of their dose conversion factors. Air releases for the GENII air pathways dose calculations are summarized in Table D.3.

**Exposure Parameter Values Used in GENII Version 2.10.** GENII Version 2.10 requires input values for numerous parameters used in the environmental transport and human exposure models. Important parameters affecting the movement of radionuclides within agricultural exposure pathways such as animal dietary

parameters, irrigation rates, crop yield, growing periods, and holdup periods are listed in Table D.11. The plant, animal, and aquatic foods transfer factors used for the pathway dose calculations are documented in [PNNL-14584](#) and are not reproduced here.

The offsite radiological dose is related to the extent of external exposure to, or intake of, radionuclides released from Hanford Site operations that become incorporated in exposure media such as air, water, soil, sediment, and various foodstuffs. Tables D.4 through D.6 give the values for the diet, residency, and river recreation parameters for maximally exposed and average individuals.

**Meteorological Data Used in GENII Version 2.10.** GENII Version 2.10 employs an atmospheric dispersion model to calculate annual-average air concentrations and deposition rates at downwind locations based on site-specific radionuclide air emissions measurements and meteorological data ([PNNL-14583](#)). The 2011 meteorological data used in the GENII air dispersion modeling were gathered at monitoring stations in the 100 Area (station 29; 100-K), 200 Area (station 21; HMS), 300 Area (station 11; 300 Area), and 400 Area (station 9; Fast Flux Test Facility). With the exception of the 200 Area, all meteorological data were obtained at a height of 10 m. In the 200 Area, where some active stacks are 61 m (200 ft.) in height, the meteorological data used were collected at 121 m.

As described in Section 4.2, air dispersion calculations are also conducted using the CAP-88 computer code for compliance with Clean Air Act regulations. Hourly meteorological data from the monitoring stations described above were formatted for use in CAP-88 and GENII at Pacific Northwest National Laboratory. Four meteorological files, one for each of the Hanford Site operating areas, were created. These files were identified in the GENII Chronic Plume Air Module. A radial grid consisting of 16 directional sectors and 10 downwind distances was specified in the air module.

**Table D.3. Air Pathways Radionuclide Releases for GENII Calculations**

Radionuclide <sup>(a)</sup>	100 Area (Ci)	200 Areas (Ci)	300 Area (Ci)	400 Area (Ci)
Tritium <sup>(b)</sup>	NA	NA	1.07E+02	1.80E-03
Cobalt-60	ND	ND	4.30E-07	NA
Krypton-85	NA	NA	1.10E-05	NA
Strontium-90 <sup>(c)</sup>	3.33E-05	3.43E-04	1.80E-06	NA
Yttrium-90 <sup>(d)</sup>	5.00E-06	5.15E-05	2.70E-07	NA
Technetium-99	NA	NA	4.20E-06	NA
Iodine-129	NA	1.40E-03	NM	NA
Cesium-134	ND	4.50E-08	ND	NA
Cesium-137	6.00E-06	5.50E-05	1.10E-08	4.00E-07
Barium-137m <sup>(d)</sup>	6.00E-06	5.50E-05	2.10E-06	NA
Samarium-151	NA	NA	1.30E-06	NA
Europium-152	ND	ND	2.00E-07	NA
Europium-154	7.50E-08	ND	7.50E-09	NA
Europium-155	2.10E-08	ND	4.90E-07	NA
Gadolinium-153	NA	NA	2.40E-08	NA
Tantalum-183	NA	NA	6.20E-19	NA
Tungsten-188	NA	NA	1.20E-12	NA
Radon-219	NA	NA	3.90E+00	NA
Lead-211 <sup>(e)</sup>	—	—	7.00E-03	—
Bismuth-211 <sup>(e)</sup>	—	—	7.00E-03	—
Thallium-207 <sup>(e)</sup>	—	—	7.00E-03	—
Radium-226	NA	NA	1.90E-07	NA
Radon-222 <sup>(d)</sup>	—	—	2.04E-08	—
Polonium-218 <sup>(d)</sup>	—	—	2.03E-08	—
Lead-214 <sup>(d)</sup>	—	—	1.94E-08	—
Bismuth-214 <sup>(d)</sup>	—	—	1.88E-08	—
Lead-210 <sup>(f)</sup>	—	—	0	—
Thorium-228	NA	NA	2.20E-10	NA
Radium-224 <sup>(g)</sup>	—	—	0	—
Thorium-232	NA	NA	1.40E-11	NA
Uranium-232	NA	NA	5.10E-09	NA
Uranium-233	NA	NA	2.20E-08	NA
Uranium-234	NA	2.50E-08	9.60E-10	NA
Uranium-235	NA	9.10E-10	1.30E-09	NA
Thorium-231 <sup>(d)</sup>	—	3.00E-10	4.29E-10	—
Uranium-236	NA	NA	2.20E-11	NA
Uranium-238	NA	2.40E-08	1.50E-07	NA
Thorium-234 <sup>(h)</sup>	—	0	0	—
Neptunium-237	NA	6.70E-11	1.30E-07	NA
Protactinium-233 (j)	—	0	0	—
Plutonium-238	8.90E-07	1.55E-08	4.30E-09	NA
Plutonium-239/240 <sup>(k)</sup>	1.87E-05	3.92E-05	1.15E-07	9.90E-08
Plutonium-241	4.20E-05	2.90E-06	ND	NA
Plutonium-242	NA	NA	8.70E-11	NA
Americium-241	5.10E-06	3.48E-06	ND	NA
Americium-243	NA	NA	5.60E-08	NA
Neptunium-239 <sup>(d)</sup>	—	—	9.52E-09	—
Californium-252	NA	NA	1.40E-14	NA

Radionuclide <sup>(a)</sup>	100 Area (Ci)	200 Areas (Ci)	300 Area (Ci)	400 Area (Ci)
<p>(a) Radionuclides in <i>italic font</i> are short-lived progeny of the parent listed above.</p> <p>(b) GENII does not differentiate tritium gas (HT) and tritiated water vapor (HTO). H3 and HTO activity were summed and entered as HT.</p> <p>(c) Reported values include gross beta activity.</p> <p>(d) Activity based on an upper bound 15-hr air dispersion time to an exposure point.</p> <p>(e) Based on a peak activity of 0.18% of parent activity.</p> <p>(f) Has a half-life of 22 years; negligible ingrowth during a 15-hr air dispersion period.</p> <p>(g) Has a half-life of 4 days; negligible ingrowth during a 15-hr air dispersion period.</p> <p>(h) Has a half-life of 24 days; negligible ingrowth during a 15-hr air dispersion period.</p> <p>(j) Has a half-life of 27 days; negligible ingrowth during a 15-hr air dispersion period.</p> <p>(k) Reported values include gross alpha activity.</p> <p>Refer to Section 4.0, for information on radioactive air emissions from Hanford Site stacks.</p> <p>NA: not applicable. Releases of this radionuclide were not reported for this operating area.</p>				



Table D.4. Agricultural Pathway Parameters Used in Hanford Site Dose Calculations

	Leafy Vegetables	Root Vegetables	Fruits	Cereals	Eggs	Poultry	Beef	Milk	Hay (Beef Cattle, Milk Cows)	Pasture (Milk Cows)	Grains (Beef Cattle, Poultry)
Holdup time; day (MEI)	1	5	5	180	1	1	15	1	100	0	180
Holdup time; day (population)	14	14	14	180	18	34	34	4	100	0	180
Growing period; day	90	90	90	90	NA	NA	NA	NA	45	30	90
Yield; kg/m <sup>2</sup>	1.5	4	2	0.8	NA	NA	NA	NA	2	1.5	0.8
Irrigation rate; cm/year	77	88	77	(a)	NA	NA	NA	NA	103	103	(a)
Irrigation period; month	6	6	6	(a)	NA	NA	NA	NA	6	6	(a)
Water intake; L/year	NA	NA	NA	NA	0.3	0.3	50	60	NA	NA	NA
Food intake; kg/d	NA	NA	NA	NA	0.12	0.12	68 / 68 <sup>(c)</sup>	55 / 55 <sup>(d)</sup>	NA	NA	NA
Contaminated fraction of diet <sup>(b)</sup>	NA	NA	NA	NA	1.0	1.0	0.25 / 0.75 <sup>(c)</sup>	0.25 / 0.75 <sup>(d)</sup>	NA	NA	NA
Livestock soil intake; kg/d	NA	NA	NA	NA	0.0	0.0	0.0	0.375 (e)	NA	NA	NA

(a) No irrigation is assumed to occur for cereal crops or grains.

(b) Pertains to animal feed. 100 percent of animal water is assumed contaminated surface water.

(c) First value pertains to grains, and second value pertains to hay.

(d) First value pertains to hay, and second value pertains to pasture grass.

(e) Calculated as 0.5 kg soil / day (EPA 2005) while grazing × 0.75 diet fraction of pasture grass.

Holdup is the time between harvest and consumption.

MEI: maximally exposed individual

NA: not applicable

**Table D.5. Consumption Parameters Used in Hanford Site Dose Calculations**

Medium	Consumption Rate <sup>(a)</sup>			
	Maximally Exposed Individual		Average Individual (Collective Dose)	
Leafy vegetables	30 kg/year	(66 lb/year)	15 kg/year	(33 lb/year)
Root vegetables	220 kg/year	(485 lb/year)	140 kg/year	(310 lb/year)
Fruits	330 kg/year	(728 lb/year)	64 kg/year	(140 lb/year)
Cereals	80 kg/year	(180 lb/year)	72 kg/year	(160 lb/year)
Milk	270 L/year	(71 gal/year)	230 L/year	(61 gal/year)
Beef	80 kg/year	(180 lb/year)	70 kg/year	(150 lb/year)
Poultry	18 kg/year	(40 lb/year)	8.5 kg/year	(19 lb/year)
Eggs	30 kg/year	(66 lb/year)	20 kg/year	(44 lb/year)
Fish <sup>(b)</sup>	40 kg/year	(88 lb/year)	— <sup>(c)</sup>	— <sup>(c)</sup>
Drinking water <sup>(d)</sup>	730 L/year	(193 gal/year)	440 L/year	(116 gal/year)
Inadvertent soil ingestion	36.5 g/year	(1.17 oz/year)	18.3 g/year	(0.59 oz/year)

(a) A transit time of 11 hr from the release to receptor locations is assumed.

(b) A holdup time of 1 day is used for both MEI and population calculations.

(c) Average individual consumption not identified; see text of Section D.1.2.

(d) A holdup time of 1 day is used for the Riverview calculations for identification of the location of the MEI.

**Table D.6. Residency Parameters Used in Hanford Site Dose Calculations**

Pathway	Exposure (hour/year)	
	Maximally Exposed Individual	Average Individual (Collective Dose)
Soil: external (ground shine)	12 hr/d, 365 d/year	8 hr/d, 365 d/year
Air: external (submersion) <sup>(b)</sup>	24 hr/d, 365 d/year	24 hr/d, 365 d/year
Air: Inhalation <sup>(a, b)</sup>	24 hr/d, 365 d/year	24 hr/d, 365 d/year

(a) Inhalation rate, adult: 1.0 m<sup>3</sup>/hr (35 ft<sup>3</sup>/hr)

(b) Dispersion time of 15 hr is protectively assumed for ingrowth of short-lived progeny during transport (80-km population dose radius and 1.5 m/s wind speed).

**Table D.7. Columbia River Recreational Parameters Used in Hanford Site Dose Calculations**

Activity and Pathway	Exposure (hour/year) <sup>(a)</sup>	
	Maximally Exposed Individual	Average Individual (Collective Dose)
Shoreline: sediment; external	5.0 hr/d, 100 d/yr <sup>(b)</sup>	1.7 hr/d, 10 d/yr <sup>(b)</sup>
Boating: river water; external	2.0 hr/d, 50 d/yr <sup>(c)</sup>	0.1 hr/d, 50 d/yr <sup>(c)</sup>
Swimming: river water; inadvertent ingestion <sup>(d)</sup> , external	2.0 hr/d, 50 d/yr	0.2 hr/d, 50 d/yr

(a) A transit time of 11 hr from the release to receptor locations is assumed

(b) A shoreline width factor of 0.2 is used

(c) No shielding by the boat is assumed

(d) Ingestion rate: 0.02 L/hr (0.68 oz/hr).

### D.1.2 Eighty-Kilometer (50-mile) Collective Population Dose

Regulatory limits have not been established for collective doses to a population. However, evaluation of the collective population doses to all residents within 50-miles (80-kilometers) radius of Hanford Site operations is required by DOE O 458.1, Chg 2. The radiological dose to the collective population within 50 miles (80 kilometers) of the site operations areas was calculated to confirm adherence to DOE environmental protection policies, and provide information to the public. The 50-miles (80-kilometers) collective dose is the sum of doses to all individual members of the public within 50-miles (80-kilometers) of the four Hanford Site operations areas (100 Area, 200 Area, 300 Area, and 400 Area).

The same exposure pathways evaluated for the maximally exposed individual (Section D.1.1) were also used to calculate doses to the offsite population. The primary difference between the maximally exposed individual and collective dose calculations is in the values selected for certain exposure parameters. As shown in Tables D.4, D.5, and D.6, exposure parameter values for the collective dose calculations reflect an average individual rather than a maximally exposed individual.

In calculating, the collective dose related to water-mediated exposure pathways (drinking water, irrigated foods, Columbia River recreation, and fish consumption), estimates were made of the size of the offsite population expected to be affected by each pathway. The assumptions of population size and the calculation of collective dose for each of these four exposure pathways are described in the following paragraphs.

**Drinking Water** – The cities of Richland and Pasco obtain all or part of their municipal water directly from the Columbia River downstream from the Hanford Site; the city of Kennewick obtains its municipal water indirectly from the river from nearby wells. Approximately 182,000 people reside in the Tri-Cities<sup>a</sup> and are assumed to obtain all of their drinking water directly from the Columbia River or from impacted wells adjacent to the river. Annual drinking water dose for an average individual is multiplied by the Tri-Cities population to calculate the collective drinking water dose.

**Irrigated Food** – Columbia River water is withdrawn for irrigation of small vegetable gardens and farms in the Riverview area of Pasco in Franklin County. It is assumed enough food is grown in this area to feed an estimated 2,000 people. Commercial crops are also irrigated by Columbia River water in the Horn Rapids area of Benton County. Because these crops are widely distributed any individual is likely to receive only

<sup>a</sup> The cities of Pasco, Kennewick, and Richland—known as the Tri-Cities—are located in southeastern Washington State.

Population estimates from <http://quickfacts.census.gov/qfd/index.html>.

negligible potential exposure. Annual irrigated foods dose for an average individual is multiplied by the estimate population of 2,000 individuals to calculate the collective irrigated foods dose.

**Columbia River Recreation** – As described in Section 4.2 and Section D.1.1, these recreational activities include fishing, swimming, boating, and shoreline recreation. It was protectively assumed that all 182,000 individuals in the Tri-Cities participated in these recreational activities. Annual recreational dose for an average individual is multiplied by the Tri-Cities population to calculate the collective recreational dose.

**Fish Consumption** – Population doses from consuming fish obtained locally from the Columbia River were calculated from an estimated total annual catch of 15,000 kilograms (33,000 pounds) per year. It was protectively assumed that 100% of the annual catch was consumed by individuals in the Tri-Cities area. Population dose related to fish consumption was calculated as:

Population dose (person-rem) = MEI dose (mrem)  $\times$  0.001 rem/mrem  $\times$  (annual catch [kg/year] / IR\_fish [kg/year/person])

Where:

MEI dose = dose for the maximally exposed individual

Annual catch = 15,000 kg fish/year

IR\_fish = individual fish ingestion rate used in the MEI calculation (40 kg/year/person)

Collective dose related to air-mediated exposure pathways was calculated based on the geographic distribution of the population residing within a 50-mile (80-kilometer) radius of the Hanford Site operating areas, as shown in [PNNL-20631](#). These distributions are based on 2010 Bureau of the Census data ([PNNL-20631](#)). These data influence the population dose by providing estimates of the number of people exposed to radioactive air emissions and their proximity to the points of release.

The air pathways collective dose calculations are based on modeled radionuclide air concentrations and deposition rates downwind of the Hanford Site operating areas coupled with the geographic population distribution in these areas. Both the meteorological data and the population distribution data are organized according to 16 directional sectors based on the four cardinal, four ordinal, and eight cross-wind directions (N, NNE, NE, ENE, etc.). These sectors were transformed into grids using concentric circles with radii of 1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles. These radii correspond to the downwind distances specified in the GENII Chronic Plume Air Module. Four population files were created based on the number of individuals located in each of the 160 grid segments, as tabulated in [PNNL-20631](#). These files were identified in the GENII Air Dose Report Module.

## D.2 Supporting Information for Calculation of Biota Doses

The RESRAD-BIOTA computer code was used to screen the 2011 radionuclide concentrations in water and sediment to see if they exceeded the established biota concentration guides. Biota concentration guides are concentrations that could result in a dose rate of 1 rad per day for aquatic biota or 0.1 rad per day for terrestrial organisms. Table D.8 presents the biota concentration guides for the radionuclides evaluated. Both internal and external doses to aquatic, riparian, and terrestrial animals and plants are included in the screening process. For analyses with multiple media and multiple radionuclides, a sum of fractions is calculated to account for the contribution to dose from each radionuclide relative to its corresponding biota concentration guide. If the sum of fractions exceeds 1.0, then the dose guideline has been exceeded. If the initial estimated screening value (Tier 1) exceeds the dose limit (sum of fractions more than 1.0), additional screening calculations are

performed (Tier 2 or Tier 3) to evaluate more accurately exposure of the biota to the radionuclides. The process may culminate in a site-specific assessment requiring additional sampling and study of exposure.

In the initial screening assessment, researchers compare maximum measured concentrations to the biota concentration guides. The maximum detected concentrations are presented in Table D.9. If the sum of fractions does not exceed one, no further analysis is required. However, if the sum of fractions does exceed 1, a second analysis is performed using average concentrations. For the aquatic biota dose assessment paired sediment and water data are required and in the event only one of these media was sampled then the other is calculated using the water to sediment partition coefficient. These coefficients are tabulated in Table D.8. For West Lake Tier 2 and Tier 3 calculations were implemented using the mean media concentrations presented in Table D.10. Means were calculated based on the reported concentrations in biota, water, and sediment. For a given quarter only a single sample was pulled of sediment and water. Some exceptions were cases where filtered and total samples were collected and analyzed. The biota also sometime represented multiple samples. For 2011, the average of the water concentrations for uranium was also calculated these mean values were used in the Tier 2 and Tier 3 calculations. The screening process is further described in *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* ([DOE-STD-1153-2002](#)).

The Tier 1 and Tier 2 West Lake biota dose assessments were driven by the potential for dose from uranium isotopes in water and the assumed potential for these isotopes to accumulate in biota. Therefore, the Tier 3 West Lake biota dose calculations utilized site-specific information on bioaccumulation. As defined in [DOE-STD-1153-2002](#), bioaccumulation is the ratio of the contaminant concentration in the organism relative to the contaminant concentration in an environmental medium resulting from the uptake of the contaminant from one or more routes of exposure. The more relevant biota data collected from West Lake are the brine flies sampled in 2000 and 2007 (PNNL-13487, [DOE/RL-2007-50](#)). Birds (avocets) were also sampled in 2000 and had lower concentrations than the brine flies (PNNL-13487). Birds are not year-round residents and thus have lower exposure and less potential for bioaccumulation from West Lake ([DOE/RL-2007-50](#), Appendix K). The maximum concentration of any of the uranium isotopes in brine flies was 0.77 pCi/g in 2007. The maximum uranium-238 water concentration was 1400 pCi/L in 2007. The bioaccumulation factor is calculated by dividing the biota concentration (in pCi/g) by the water concentration (in pCi/ml). Therefore, the maximum bioaccumulation factor for uranium would be less than one. As presented in Table D.10 the bioaccumulation factors for uranium isotopes based on the mean concentrations in flies and water are between 0.2 and 0.5. A bioaccumulation factor of one was used for the West Lake Tier 3 biota dose calculation as a somewhat protective measure of site-specific uranium uptake into the food chain.

**Table D.8. Biota Concentration Guides and Water to Sediment Partition Coefficients**

Radionuclide	Water (pCi/L) <sup>(a)</sup>	Limiting Organism	Sediment (pCi/g) <sup>(a)</sup>	Limiting Organism	Default K <sub>d</sub> (mL/g)
Am-241	4.38E+02	Aquatic animal	5.15E+03	Riparian animal	5000
Co-60	3.76E+03	Aquatic animal	1.46E+03	Riparian animal	1000
Cs-137	4.26E+01	Riparian animal	3.12E+03	Riparian animal	500
Eu-152	2.55E+04	Aquatic animal	3.04E+03	Riparian animal	500
Eu-155	2.64E+05	Aquatic animal	3.16E+04	Riparian animal	500
H-3	2.65E+08	Riparian animal	3.74E+05	Riparian animal	0.001
Pu-238	1.76E+02	Aquatic animal	5.73E+03	Riparian animal	2000
Pu-239/240	1.87E+02	Aquatic animal	5.86E+03	Riparian animal	2000
Sr-90	2.78E+02	Riparian animal	5.82E+02	Riparian animal	30
Tc-99	6.67E+05	Riparian animal	4.22E+04	Riparian animal	5
U-234	2.02E+02	Aquatic animal	5.27E+03	Riparian animal	50
U-235	2.17E+02	Aquatic animal	3.73E+03	Riparian animal	50
U-238	2.23E+02	Aquatic animal	2.49E+03	Riparian animal	50

(a) Biota concentration guides, (pCi/L or pCi/g)

K<sub>d</sub> = Water to Sediment Partition Coefficients, (mL/g)**Table D.9. Maximum concentrations of Sediment and Water Evaluated in the Biota Dose Assessment**

Radionuclide	Priest Rapids						
	Dam Sediment <sup>(a)</sup>	100-B Area Sediment <sup>(a)</sup>	100-B Area Seeps <sup>(b)</sup>	100-K Area Sediment <sup>(a)</sup>	100-K Area Seeps <sup>(b)</sup>	100-N Area Seeps <sup>(b)</sup>	100-D Area Seeps <sup>(b)</sup>
Am-241	—	—	—	—	—	—	—
Co-60	—	—	—	—	—	—	—
Cs-137	0.291	0.0447	—	0.0268	—	—	2.54
Eu-152	—	—	—	—	—	—	—
Eu-155	—	—	—	0.0754	—	—	—
H-3	—	—	1340	—	1090	492	1840
Pu-238	0.00105	—	—	—	—	—	—
Pu-239/240	0.0113	—	—	—	—	—	—
Sr-90	—	—	—	—	—	—	—
Tc-99	—	—	2.37	—	—	—	—
U-234	1.36	0.728	—	0.716	—	—	—
U-235	0.0499	0.0506	—	0.049	—	—	—
U-238	1.22	0.731	—	0.69	—	—	—
Radionuclide	White Bluffs Slough						
	100-H Area Sediment <sup>(a)</sup>	100-H Area Seeps <sup>(b)</sup>	White Bluffs Slough <sup>(a)</sup>	300 Area Springs Seeps <sup>(b)</sup>	McNary Dam Sediment <sup>(a)</sup>	West Lake Sediment <sup>(a)</sup>	West Lake Water <sup>(b)</sup>
Am-241	—	—	—	—	—	—	—
Co-60	—	—	—	—	—	—	—
Cs-137	0.0675	—	0.47	—	0.235	0.96	—
Eu-152	—	—	—	—	—	—	—
Eu-155	0.0545	—	—	—	—	—	—
H-3	—	299	—	3160	—	—	—
Pu-238	—	—	—	—	0.0155	—	—
Pu-239/240	—	—	0.00285	—	0.0112	—	—
Sr-90	—	—	—	—	—	0.274	—
Tc-99	—	—	—	—	—	—	—
U-234	0.88	2.47	1.01	7.96	1.73	2.13	1200
U-235	0.0395	0.108	0.053	0.565	0.0897	0.126	59.7
U-238	0.75	2.16	1.02	7.56	1.31	2.04	1180

(a) pCi/g

(b) pCi/L

— not detected or not measured

**Table D.10. Mean Concentrations of Biota, Sediment, and Water Measured in West Lake (2000 through 2011)**

Media Groups	Year - Quarter	Units	U-234 Mean	U-235 Mean	U-238 Mean
Avocet	2000-Q2	pCi/g	0.013	0.001	0.013
Brine flies	2000-Q2	pCi/g	0.43	0.021	0.40
Brine flies	2007-Q2	pCi/g	0.52	0.028	0.42
Brine fly BAF	2000-ALL	g/ml	0.27	0.30	0.26
Brine fly BAF	2007-ALL	g/ml	0.42	0.48	0.38
Lake	2000-Q1	pCi/L	810	30	754
Lake	2000-Q2	pCi/L	1036	39	964
Lake	2000-Q3	pCi/L	1990	86	1880
Lake	2000-Q4	pCi/L	2650	132	2500
Lake	2001-Q1	pCi/L	345	14	326
Lake	2001-Q2	pCi/L	461	18	425
Lake	2001-Q3	pCi/L	2460	89	2240
Lake	2006-Q2	pCi/L	2175	47	1423
Lake	2007-Q2	pCi/L	1235	59	1118
Lake	2011-Q2	pCi/L	370	17	353
Lake	2011-Q3	pCi/L	1200	60	1180
Lake	2011-Q4	pCi/L	8.8	0.54	7.9
Lake	2011-ALL	pCi/L	526	26	514
Sediment	2000-Q2	pCi/g	1.2	0.063	1.2
Sediment	2001-Q4	pCi/g	2.5	0.095	2.4
Sediment	2002-Q1	pCi/g	0.289	0.01	0.29
Sediment	2002-Q2	pCi/g	0.625	0.02	0.61
Sediment	2002-Q3	pCi/g	4.8	0.18	4.3
Sediment	2002-Q4	pCi/g	2.3	0.08	2.1
Sediment	2003-Q1	pCi/g	0.55	0.02	0.50
Sediment	2003-Q2	pCi/g	1.1	0.04	1.0
Sediment	2003-Q3	pCi/g	9.1	0.34	8.5
Sediment	2003-Q4	pCi/g	3.2	0.11	3.0
Sediment	2004-Q1	pCi/g	0.38	0.01	0.34
Sediment	2004-Q2	pCi/g	0.70	0.02	0.66
Sediment	2004-Q3	pCi/g	3.9	0.12	3.7
Sediment	2004-Q4	pCi/g	4.8	0.17	4.4
Sediment	2005-Q1	pCi/g	0.91	0.035	0.87
Sediment	2005-Q2	pCi/g	0.65	0.019	0.59
Sediment	2005-Q3	pCi/g	7.7	0.32	7.2
Sediment	2005-Q4	pCi/g	2.8	0.093	2.6
Sediment	2006-Q1	pCi/g	0.28	0.008	0.28
Sediment	2006-Q2	pCi/g	1.3	0.044	1.1
Sediment	2006-Q3	pCi/g	4.9	0.18	4.5
Sediment	2006-Q4	pCi/g	1.2	0.085	1.9
Sediment	2007-Q1	pCi/g	1.1	0.038	0.94
Sediment	2007-Q4	pCi/g	1.8	0.047	1.7
Sediment	2008-Q1	pCi/g	0.68	0.057	0.68
Sediment	2008-Q3	pCi/g	1.7	0.15	2.6
Sediment	2009-Q1	pCi/g	1.9	0.10	1.8
Sediment	2009-Q4	pCi/g	6.4	0.36	6.1
Sediment	2010-Q1	pCi/g	1.4	0.072	1.3
Sediment	2011-Q2	pCi/g	2.1	0.13	2.0
Seep	2000-Q2	pCi/L	29	0.95	28
Seep	2007-Q2	pCi/L	92	5.3	81



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Kahlotus, WA 99335  
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850 A. Street  
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Yakama Agency Bureau of Indian Affairs  
P.O. Box 632  
Toppenish, WA 98948

Yakama Nation  
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2808 Main Street  
Union Gap, WA 98903

Nez Perce Tribe  
Environmental Restoration/Waste Management  
ATTN: Gabe Bohnee/D. Landeen/L. Liligren/S. Sobczyk/John Stanfill  
P.O. Box 365  
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The Confederated Tribes and Bands of the Yakama Nation  
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The Confederated Tribes and Bands of the Yakama Nation  
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The Confederated Tribes of the Umatilla Indian Reservation  
Environmental Planning/Rights Protection  
ATTN: J. Cox/ B. Harper/S. Harris/J. H. Richards  
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The Confederated Tribes of the Warm Springs Reservation  
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