Chapter 3
Affected Environment

3.1 APPROACH TO DEFINING THE AFFECTED ENVIRONMENT

In accordance with the Council on Environmental Quality National Environmental Policy Act (NEPA) regulations (CEQ 1986) on preparing an environmental impact statement (EIS), the affected environment is "interpreted comprehensively to include the natural and physical environment and the relationship of people with that environment." The affected environment descriptions presented in this chapter provide the context for understanding the environmental consequences described in Chapter 4. As such, they serve as a baseline from which any environmental changes that may be brought about by implementing the proposed action and alternatives can be identified and evaluated. For this *Surplus Plutonium Disposition Environmental Impact Statement* (SPD EIS), the baseline conditions are the existing conditions.

The candidate sites for the proposed surplus plutonium disposition facilities are the Hanford Site (Hanford), Idaho National Engineering and Environmental Laboratory (INEEL), the Pantex Plant (Pantex), and the Savannah River Site (SRS). As described in Chapter 2, areas within the boundaries of the sites that are potential locations for the proposed facilities include the 200 East and 400 Areas at Hanford, the Idaho Nuclear Technology and Engineering Center (INTEC)[1] at INEEL, Zone 4 West at Pantex, and F- and S-Areas at SRS. The resources that are described for the candidate sites are air quality and noise, waste management, socioeconomics, human health risk, environmental justice, geology and soils, water resources, ecological resources, cultural and paleontological resources, land use and visual resources, and infrastructure.

Selected Characteristics of the Candidate Sites for the Proposed Surplus Plutonium Disposition Facilities

		Population			Dose per Year[a]	
Site	Area (km^2)	Health Risk ROI[a]	Socio-economic ROI	Site Work Force	MEI (mrem)	Population (person-rem)
Hanford	1,450	380,000	179,949	12,882	0.0074	0.20
INEEL	2,300	121,500	213,547	8,291	0.031	0.24
Pantex	60	275,000	212,729	2,944	0.000088	0.0021
SRS	800	620,100	453,778	15,032	0.20	8.6

[a] For 1996.

Key: MEI, maximally exposed individual; ROI, region of influence.

Candidate sites for mixed oxide (MOX) fuel lead assembly fabrication and postirradiation examination are described in Section 3.6. These sites are Hanford, INEEL (at Argonne National Laboratory–West [ANL–W]), Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), Oak Ridge Reservation (ORR) (at Oak Ridge National Laboratory [ORNL]), and SRS. These additional sites are evaluated for related plutonium disposition activities only; therefore, they are not described in detail. Sites that would supply uranium dioxide are not described in this section because these activities are routinely performed at these locations, would be conducted in existing buildings with existing personnel, and would not be expected to result in additional impacts at these sites. See Figure 2–1 for the location of these sites.

Proposed reactor sites where the irradiation of MOX fuel would be performed are described in Section 3.7. The reactors that would be used are Catawba Nuclear Station Units 1 and 2, McGuire Nuclear Station Units 1 and 2, and North Anna Power Station Units 1 and 2. As described in Section 2.4.3, these reactors would be used for the irradiation of MOX fuel only.

[1] Formerly known as the Idaho Chemical Processing Plant (ICPP).

The U.S. Department of Energy (DOE) evaluated the environmental impacts of the surplus plutonium disposition alternatives within defined regions of influence (ROI) at each of the four candidate sites and along transportation routes. The ROIs are specific to the type of effect evaluated and encompass geographic areas within which any significant impact would be expected to occur. For example, human health risks to the general public from exposure to airborne contaminant emissions were assessed for an area within an 80 km (50 mi) radius of the proposed facilities. The human health risks of shipping materials among sites were evaluated for populations living along the roadways linking the DOE sites. Economic effects such as job and income growth were evaluated within a socioeconomic ROI that includes the county in which the site is located and nearby counties in which a substantial portion of the site's workforce resides. Brief descriptions of the ROIs are given in Table 3–1. More detailed descriptions of the ROI and the methods used to evaluate impacts are presented in Appendix F.

Table 3–1. General Regions of Influence for the Affected Environment

Environmental Feature	Region of Influence
Air quality and noise	The site and nearby offsite areas within local air quality control regions and the transportation corridors between the sites
Waste management	Waste management facilities on the site
Socioeconomics	The counties where at least 90 percent of site employees reside
Human health risk	The site and nearby offsite areas (within 80 km of the site and the transportation corridors between the sites) where worker and general population radiation, radionuclide, and hazardous chemical exposures may occur
Environmental justice	The minority and low-income populations within 80 km of the site and along the transportation corridors between the sites
Geology and soils	Geologic and soil resources within the site and nearby offsite areas
Water resources	Onsite and adjacent surface water bodies and groundwater
Ecological resources	The site and adjacent areas where ecological communities exist including nonsensitive and sensitive habitats and species
Cultural and paleontological resources	The area within the site and adjacent to the site boundary
Land use and visual resources	The site and the areas immediately adjacent to the site
Infrastructure	Power, fuel supply, water supply, and road systems on the site

At each of the four candidate sites, baseline conditions for each environmental resource area were determined from information provided in previous environmental studies, relevant laws and regulations, and other government reports and databases. More detailed information on the affected environment at the candidate sites can be found in annual site environmental reports and site NEPA documents.

For More Detailed Information on Environmental Conditions at the Candidate Sites for the Proposed Surplus Plutonium Disposition Facilities[a]

Draft Hanford Remedial Action EIS and Comprehensive Land Use Plan, 1996

DOE Programmatic Spent Nuclear Fuel Management and INEL Environmental Restoration and Waste Management Final EIS, 1995

Final EIS for the Continued Operation of the Pantex Plant and Associated Storage of Nuclear Weapon Components, 1996

SRS Waste Management Final EIS, 1995

[a] Also consult annual site environmental reports.

3.2 HANFORD

Hanford, established in 1943 as one of the three original Manhattan Project sites, is in Washington State just north of Richland (Figure 2–2). Hanford was a U.S. Government nuclear materials production site that included nuclear reactor operation, storage and reprocessing of spent nuclear fuel, and management of radioactive and dangerous wastes. Present Hanford programs are diversified and include management of radioactive wastes, research and development (R&D) for advanced reactors, renewable energy technologies, waste disposal technologies and contamination cleanup, and plutonium stabilization and storage (DOE 1996a:3-20).

Hanford is owned and used primarily by DOE, but portions of it are owned, leased, or administered by other government agencies. Public access is limited to travel on the Route 4 and Route 10 access roads as far as the Wye Barricade, State Routes 24 and 240, and the Columbia River. By restricting access to the site, the public is buffered from the areas formerly used for production of nuclear materials and currently used for waste storage and disposal. Only about 6 percent of the land area has been disturbed and is actively used, leaving mostly vacant land with widely scattered facilities. The entire Hanford Site has been designated a National Environmental Research Park (DOE 1996a:3-20).

Hanford includes extensive production, service, and R&D areas. Onsite programmatic and general purpose facilities total approximately 799,000 m^2 (8.6 million ft^2) of space. Fifty-one percent (408,000 m^2 [4.4 million ft^2]) is general purpose space, including offices, laboratories, shops, warehouses, and other support facilities. The remaining 392,000 m^2 (4.2 million ft^2) of space are programmatic facilities comprising processing, evaporation, filtration, waste recovery, waste treatment, waste storage facilities, and R&D laboratories. More than half of the general purpose and programmatic facilities are more than 30 years old. Facilities designed to perform previous missions are being evaluated for reuse in the cleanup mission. The existing facilities are grouped into the following numbered operational areas (DOE 1996a:3-20, 3-21).

- The 100 Areas, in the northern part of the site on the southern shore of the Columbia River, are the site of eight retired plutonium production reactors and the dual-purpose N Reactor, all of which have been permanently shut down since 1991. The 100 Areas cover about 1,100 ha (2,720 acres).

- The 200 West and 200 East Areas are in the center of the site and are about 8 and 11 km (5 and 6.8 mi), respectively, south of the Columbia River. Historically, these areas have been used for fuel reprocessing; plutonium processing, fabrication, and storage; and waste management and disposal activities. The 200 Areas cover about 1,600 ha (3,950 acres).

- The 300 Area is in the southern part of the site, just north of the city of Richland. A few of the facilities continue to support nuclear and nonnuclear R&D to include the Pacific Northwest National Laboratory (PNNL). Many of the facilities in the 300 Area are in the process of being deactivated. This area covers 150 ha (370 acres).

- The 400 Area, about 8 km (5 mi) northwest of the 300 Area, is the location of the recently shut down Fast Flux Test Facility (FFTF) and Fuels and Materials Examination Facility (FMEF). FFTF is an advanced liquid-metal-cooled research reactor that was used in the testing of breeder reactor systems. The six-level process building (427 Building) is the main structure of FMEF and encloses about 17,000 m^2 (183,000 ft^2) of operating area. FMEF also consists of several connected buildings. This building has never been operated and is free of contamination. The exterior walls are reinforced concrete, and the cell walls are constructed of high-density concrete. The facility was designed and constructed for spent fuel examination and was subsequently partially converted for MOX fuel fabrication.

- The 600 Area comprises the remainder of Hanford, which includes most of the undisturbed land and support facilities and infrastructure (e.g., roads, railroads, telecommunications, water treatment and distribution, electrical transmission lines and substations, fire and ambulance, access control facilities, borrow pits, and a landfill).

- The 700 Area is the administrative center in downtown Richland and consists of government-owned buildings (e.g., the Federal Building).

- The 3000 Area is a support area in north Richland that is being vacated but still contains some administrative and support facilities.

In addition, there are DOE-leased facilities and DOE contractor-owned facilities that support Hanford operations. These facilities are on private land south of the 300 Area and outside of the 3000 Area (DOE 1996a:3-21).

DOE Activities. The Hanford mission is to clean up the site, provide scientific and technological excellence to meet global needs, and partner the economic diversification of the region. Current DOE activities that support Hanford's mission are shown in Table 3–2. In the area of waste management, Hanford has embarked on a long-range cleanup program in compliance with the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) and applicable Federal, State, and local laws. DOE has set a goal of cleaning up Hanford's waste sites and bringing its facilities into compliance with Federal, State, and local environmental laws by the year 2028. In addition, as part of the cleanup mission, DOE has the responsibility to safely store, handle, and stabilize plutonium materials and spent fuel (DOE 1996a:3-21, 3-22).

Table 3–2. Current Missions at Hanford

Mission	Description	Sponsor
Waste management	Store defense wastes and handle, store, and dispose of radioactive, hazardous, mixed, or sanitary wastes from current operations	Assistant Secretary for Environmental Management
Environmental restoration	Restore approximately 1,100 inactive radioactive, hazardous, and mixed waste sites and about 100 surplus facilities	Assistant Secretary for Environmental Management
Research and development	Conduct research in the fields of energy, health, safety, environmental sciences, molecular sciences, environmental restoration and waste management R&D, and national security activities	Various DOE Program Managers
Technology development	Develop new technologies for environmental restoration and waste management, including site characterization and assessment methods, and waste minimization	Various DOE Program Managers

Source: DOE 1996a:3-22.

Non-DOE Activities. In addition to the DOE mission-related activities, Hanford has some unique and diverse assets and non-DOE missions that include the following (DOE 1996a:3-22):

- The Fitzner-Eberhardt Arid Lands Ecology Reserve, 31,100 ha (76,800 acres), established in 1967, managed by the U.S. Fish and Wildlife Service (USFWS) for DOE as a habitat and wildlife reserve and nature research center (Sandberg 1998a).

- The area north of the Columbia River, managed in part by the Washington State Department of Wildlife as the Wahluke Slope Wildlife Recreation Area and in part by the USFWS as the Saddle Mountain National Wildlife Refuge.

- The Washington Nuclear Plant–2 (WNP–2), 1,100-MWe reactor operated by Energy Northwest (formerly Washington Public Power Supply System [WPPSS]) and also the partially completed WNP–1 reactor.

- The Laser Interferometer Gravitational-Wave Observatory, operated by the National Science Foundation as one of two widely separated installations (within the United States) that are operated in unison as a single gravitational-wave observatory.

- The Hanford Meteorological Station and towers.

- An observatory and radio telescope facilities on Rattlesnake Mountain.

- The U.S. Ecology commercial low-level radioactive waste disposal site on State-leased lands south of the 200 Areas near the center of Hanford.

3.2.1 Air Quality and Noise

3.2.1.1 Air Quality

Air pollution refers to any substance in the air that could harm human or animal populations, vegetation, or structures, or that unreasonably interferes with the comfortable enjoyment of life and property. Air pollutants are transported, dispersed, or concentrated by meteorological and topographical conditions. Air quality is affected by air pollutant emission characteristics, meteorology, and topography.

3.2.1.1.1 General Site Description

The climate at Hanford and the surrounding region is characterized as that of a semiarid steppe. The humidity is low, and winters are mild. The average annual temperature is 11.8 EC (53.3 EF); average monthly temperatures range from a minimum of -1.5 EC (29.3 EF) in January to a maximum of 24.7 EC (76.5 EF) in July. The average annual precipitation is 16 cm (6.3 in). Prevailing winds at the Hanford Meteorological Station are from the west-northwest. The average annual windspeed is 3.4 m/s (7.6 mph) (DOE 1996a:3-29). Additional information related to meteorology and climatology at Hanford is presented in Appendix F of the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement (Storage and Disposition PEIS)* (DOE 1996a:F-2–F-5) and in the *Hanford Site National Environmental Policy Act (NEPA) Characterization* (Neitzel 1996).

Most of Hanford is within the South-Central Washington Intrastate Air Quality Control Region (AQCR) #230, but a small portion of the site is in the Eastern Washington-Northern Idaho Interstate AQCR #62. None of the areas within Hanford and its surrounding counties are designated as nonattainment areas with respect to National Ambient Air Quality Standards (NAAQS) for criteria air pollutants (EPA 1997a). Applicable NAAQS and Washington State ambient air quality standards are presented in Table 3–3.

There are no prevention of significant deterioration (PSD) Class I areas within 100 km (62 mi) of Hanford. Hanford operates under a PSD permit issued in 1980 that limits emissions of nitrogen dioxide from the Plutonium-Uranium Extraction (PUREX) and Uranium Trioxide Plants in the 200 Area (DOE 1996a:3-29). These facilities have not been operated since 1994 and have been deactivated and transferred to the

Table 3–3. Comparison of Ambient Air Concentrations From Hanford Sources With Most Stringent Applicable Standards or Guidelines, 1994

Pollutant	Averaging Period	Most Stringent Standard or Guideline (μg/m³)[a]	Concentration (μg/m³)
Criteria pollutants			
Carbon monoxide	8 hours	10,000[b]	0.7
	1 hour	40,000[b]	2.6
Nitrogen dioxide	Annual	100[b]	0.2
Ozone	8 hours	157[c]	(d)
PM_{10}	Annual	50[b]	0.01
	24 hours	150[b]	0.1
$PM_{2.5}$	3-year annual	15[c]	(e)
	24 hours (98th percentile over 3 years)	65[c]	(e)
Sulfur dioxide	Annual	50[f]	0.8
	24 hours	260[f]	6.6
	3 hours	1,300[b]	22.9
	1 hour	1,000[f]	47.9
	1 hour	660[f,g]	47.9
Other regulated pollutants			
Gaseous fluoride	30 days	0.84[f]	(i)
	7 days	1.7[f]	(i)
	24 hours	2.9[f]	(i)
	12 hours	3.7[f]	(i)
	8 months (Mar-Oct)	0.50[f]	(i)
Total suspended particulates	Annual	60[f]	0.01
	24 hours	150[f]	0.1
Hazardous and other toxic compounds			
Benzene	24 hours	0.12[h]	(i)
[Text deleted.]			

[a] The more stringent of the Federal and State standards is presented if both exist for the averaging period. The National Ambient Air Quality Standards (NAAQS) (EPA 1997a), other than those for ozone, particulate matter, and lead, and those based on annual averages, are not to be exceeded more than once per year. The 1-hr ozone standard is attained when the expected number of days per year with maximum hourly average concentrations above the standard is ≤1. The 1-hr ozone standard applies only to nonattainment areas. The 8-hr ozone standard is attained when the 3-year average of the annual fourth-highest daily maximum 8-hr average concentration is less than or equal to 157 μg/m³. The 24-hr particulate matter standard is attained when the expected number of days with a 24-hr average concentration above the standard is ≤1. The annual arithmetic mean particulate matter standard is attained when the expected annual arithmetic mean concentration is less than or equal to the standard.

[b] Federal and State standard.

[c] Federal standard.

[d] Not directly emitted or monitored by the site.

[e] No data is available with which to assess $PM_{2.5}$ concentrations.

[f] State standard.

[g] Not to be exceeded more than twice in any 7 consecutive days.

[h] State's risk-based acceptable source impact levels.

[i] No sources identified at the site.

Note: NAAQS also include standards for lead. No sources of lead emissions have been identified at the site. Emissions of other air pollutants not listed here have been identified at Hanford, but are not associated with any alternatives evaluated. These other air pollutants are quantified in the *Storage and Disposition PEIS* (DOE 1996a). EPA recently revised

ambient air quality standards for particulate matter and ozone. The new standards, finalized on July 18, 1997, changed the ozone primary and secondary standards from a 1-hr concentration of 235 Fg/m^3 (0.12 ppm) to an 8-hr concentration of 157 Fg/m^3 (0.08 ppm). During a transition period while States are developing State implementation plan revisions for attaining and maintaining these standards, the 1-hr ozone standard will continue to apply in nonattainment areas (EPA 1997b:38855). For particulate matter, the current PM_{10} annual standard is retained, and two $PM_{2.5}$ (particulate matter with an aerodynamic diameter less than or equal to 2.5 Fm) standards are added. These standards are set at a 15-Fg/m^3 3-year annual arithmetic mean based on community-oriented monitors and a 65-Fg/m^3 3-year average of the 98th percentile of 24-hr concentrations at population-oriented monitors. The revised 24-hr PM_{10} standard is based on the 99th percentile of 24-hr concentrations. The existing PM_{10} standards will continue to apply in the interim period (EPA 1997c:38652).
Source: DOE 1996a:3-30; EPA 1997a; WDEC 1994.

DOE Office of Environmental Restoration for continued surveillance and maintenance awaiting eventual decommissioning.

Ambient air quality near the Hanford boundary is currently monitored for particulate matter. Particulate concentrations can reach rather high levels in eastern Washington because of extreme natural events (dust storms, volcanic eruptions, and large brush fires [DOE 1996b:4-46–4-50]). The 24-hr standard for particulate matter with an aerodynamic diameter less than or equal to 10 Fm (PM_{10}) was exceeded in 1993 at Columbia Center in Kennewick, about 10 km (6.2 mi) southeast of Hanford, likely as a result of windblown dust. Ambient air quality at Hanford is discussed in more detail in the *Hanford Site 1995 Environmental Report* (Dirkes and Hanf 1996:56, 61, 62, 95–108). Routine monitoring of most nonradiological pollutants is not conducted at the site. Monitoring of nitrogen oxides and total suspended particulates at Hanford has been discontinued as a result of phasing out programs for which the monitoring was required. Carbon monoxide, sulfur dioxide, and nitrogen dioxide have been monitored periodically in communities and commercial areas southeast of Hanford. In 1995, air samples of semivolatile organic compounds were collected on the site and at an offsite location, and the results are discussed in the annual environmental report (Dirkes and Hanf 1996:95–108). All concentrations of these compounds were below the applicable risk-based concentrations.

The primary sources of air pollutants at Hanford include process emissions, vehicular emissions, and construction activities. Table 3–3 presents the existing ambient air pollutant concentrations at the site boundary attributable to sources at Hanford. These concentrations are based on emissions for the year 1994. The emissions were modeled using meteorological data from 1989–1990 (DOE 1996a:3-30). Only those pollutants that would be emitted by any of the surplus plutonium disposition alternatives are presented. With the exception of particulate matter, as discussed previously, the concentrations of these pollutants—concentrations from Hanford combined with those from background (non-Hanford) sources—are in compliance with the ambient air quality standards. All coal-fired steam generation facilities have been shut down at Hanford. The conversion to oil, natural gas, and electric energy sources was completed in 1998. This will result in a significant reduction in air pollutant emissions from the site. Detailed information on emissions of other pollutants at Hanford is discussed in the *Hanford Site NEPA Characterization* (Neitzel 1996:4.28–4.32, 6.12).

3.2.1.1.2 Proposed Facility Locations

Prevailing winds in the 200 Areas (Hanford Meteorological Station) are from the west-northwest (Neitzel 1996:4.3, 4.6; Hoitink and Burk 1996:2.10). The 200 East Area has emissions of various air pollutants from oil-fired steam generation and releases of various toxic pollutants from tank farms, waste processing, and laboratories. Emissions from these sources are quantified in the *Tank Waste Remediation System EIS* (DOE 1996c:G-35–G-111).

Prevailing winds in the 400 Area are from the south-southwest, with a secondary maximum from the northwest (Neitzel 1996:4.6; Hoitink and Burk 1996:2.10). The 400 Area has no nonradioactive air pollutant emission sources of concern (Neitzel 1996:4.30).

3.2.1.2 Noise

Noise is unwanted sound that interferes or interacts negatively with the human or natural environment. Noise may disrupt normal activities or diminish the quality of the environment.

3.2.1.2.1 General Site Description

Major noise sources within Hanford include various facilities, equipment, and machines (e.g., cooling systems, transformers, engines, pumps, boilers, steam vents, paging systems, construction and materials-handling equipment, and vehicles). Data from two noise surveys indicate that background noise levels (measured as the 24-hr equivalent sound level) at Hanford range from 30 to 60.5 decibels A-weighted (dBA) (DOE 1996a:3-29). The 24-hr background sound level in undeveloped areas at Hanford ranges from 24 to 36 dBA, except when high winds elevate sound levels (Neitzel 1996:4.127). The primary source of noise at the site and nearby residences is traffic. Most Hanford industrial facilities are far enough from the site boundary that noise levels from these sources at the boundary are not measurable or are barely distinguishable from background noise levels (DOE 1996a:3-29). Hanford is currently in compliance with the State noise regulations (DOE 1996a:3-29–3-31). Noise sources, existing noise levels at Hanford, and noise standards are described in the *Storage and Disposition PEIS* (DOE 1996a:3-29–3-31, F-31, F-32) and in the *Hanford Site NEPA Characterization* (Neitzel 1996:4.125–4.130).

The potential impact of traffic noise resulting from Hanford activities was evaluated for a draft EIS addressing the siting of the proposed New Production Reactor. Estimates were made of baseline traffic noise along two major access routes: State Route 24, leading from the Hanford Site west to Yakima, and State Route 240, south of the site and west of Richland, where it handles maximum traffic volume. Modeled traffic noise levels (equivalent sound level [1-hr]) at 15 m (50 ft) from State Route 24 for both peak and offpeak periods were 62 dBA. Traffic noise levels from State Route 240 for both peak and offpeak periods were 70 dBA (Neitzel 1996:4.127, 4.130). These traffic noise levels were projections based on employment levels about 30 percent higher than actual levels at Hanford in 1997. About 9 percent of Hanford's employees commute by vanpool or bus (Mecca 1997a). Existing traffic noise levels may be different as a result of changes in site employment and ride-sharing activities.

The U.S. Environmental Protection Agency (EPA) guidelines for environmental noise protection recommend an average day-night average sound level of 55 dBA as sufficient to protect the public from the effects of broadband environmental noise in typically quiet outdoor and residential areas (EPA 1974:29). Land-use compatibility guidelines adopted by the Federal Aviation Administration and the Federal Interagency Committee on Urban Noise indicate that yearly day-night average sound levels less than 65 dBA are compatible with residential land uses and levels up to 75 dBA are compatible with residential uses if suitable noise reduction features are incorporated into structures (DOT 1995). It is expected that for most residences near Hanford, the day-night average sound level is less than 65 dBA and is compatible with the residential land use, although for some residences along major roadways noise levels may be higher.

3.2.1.2.2 Proposed Facility Locations

No distinguishing noise characteristics have been identified at either the 200 East Area or the 400 Area. Both are far enough from the site boundary—the 200 East Area is 12.6 km (7.8 mi) and the 400 Area is 6.1 km (3.8 mi) away—that noise levels from the facilities at the boundary are not measurable or are barely distinguishable from background levels.

3.2.2 Waste Management

Waste management includes minimization, characterization, treatment, storage, transportation, and disposal of waste generated from ongoing DOE activities. The waste is managed using appropriate treatment, storage, and disposal technologies and in compliance with all applicable Federal and State statutes and DOE orders.

3.2.2.1 Waste Inventories and Activities

Hanford manages the following types of waste: high-level waste (HLW), transuranic (TRU), mixed TRU, low-level waste (LLW), mixed LLW, hazardous, and nonhazardous. HLW would not be generated by surplus plutonium disposition activities at Hanford, and thus is not discussed further. Waste generation rates and the inventory of stored waste from activities at Hanford are provided in Table 3–4. Table 3–5 summarizes the Hanford waste management capabilities. More detailed descriptions of the waste management system capabilities at Hanford are included in the *Storage and Disposition PEIS* (DOE 1996a:3-61, E-12).

Table 3–4. Waste Generation Rates and Inventories at Hanford

Waste Type	Generation Rate (m^3/yr)	Inventory (m^3)
TRU[a]		
Contact handled	450	11,450
Remotely handled	72	273
LLW	3,902	0
Mixed LLW		
RCRA	840	8,170
TSCA	7	103
Hazardous	560	NA[b]
Nonhazardous		
Liquid	200,000	NA[b]
Solid	43,000	NA[b]

[a] Includes mixed TRU waste.
[b] Generally, hazardous and nonhazardous wastes are not held in long-term storage.
Key: LLW, low-level waste; NA, not applicable; RCRA, Resource Conservation and Recovery Act; TRU, transuranic; TSCA, Toxic Substances Control Act.
Source: DOE 1996d:15, 16, except hazardous and nonhazardous solid wastes (DOE 1996a:3-62, E-19), and nonhazardous liquid wastes (Teal 1997).

EPA placed Hanford on the National Priorities List on November 3, 1989. In accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), DOE entered into a Tri-Party Agreement with EPA and the State of Washington to govern the environmental compliance and cleanup of Hanford. That agreement meets the legal requirements specified under the Federal Facility Compliance Agreement (FFCA). An aggressive environmental restoration program is under way using priorities established in the Tri-Party Agreement (DOE 1996a:3-61). More information on regulatory requirements for waste disposal is provided in Chapter 5.

3.2.2.2 Transuranic and Mixed Transuranic Waste

All currently generated contact-handled TRU waste is being placed in above-grade storage buildings at the Hanford Central Waste Complex and the TRU Waste Storage and Assay Facility (DOE 1996a:3-64). TRU waste will be maintained in storage until shipped to the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico, for disposal, beginning in 2000 (Aragon 1999). The new Waste Receiving and Processing Facility has the capability to process retrieved suspect TRU waste and certify newly generated and stored TRU waste for shipment to WIPP (Dirkes and Hanf 1996:10). Treatment of TRU waste will be provided in the future at the Stabilization Facility and Thermal Treatment Facility. TRU waste will be treated to meet WIPP waste acceptance criteria, packaged in accordance with DOE and U.S. Department of Transportation (DOT) requirements, and transported to WIPP for disposal (DOE 1996a:3-144). Mixed TRU

Table 3–5. Waste Management Capabilities at Hanford

Facility Name/Description	Capacity	Status	TRU	Mixed TRU	LLW	Mixed LLW	Haz	Non-Haz
Treatment Facility (m^3/yr except as otherwise specified)								
242-A Evaporator, m^3/day	265	Online	X	X	X	X		
Waste Receiving and Processing Facility	1,820	Online	X	X	X	X		
Stabilization Facility Contract	1,860	Planned for 1999	X	X		X		
Thermal Treatment Facility Contract	5,135	Planned for 2001	X	X		X		
Grout Treatment Facility	15,000	Online				X		
Shielded Analytical Lab Waste Treatment Unit, kg/hr	4	Online				X		
Maintenance & Storage Facility, batch/yr	26	Online				X		
200 Area Effluent Treatment Facility, m^3/min	0.57	Online			X	X		
200 East Area Sanitary Wastewater Treatment Facility	120,000	Online						X
Storage Facility (m^3)								
Central Waste Complex	16,800	Online	X	X	X	X		
TRU Waste Storage and Assay Facility	416	Standby	X	X	X	X		
305-B Storage Facility	20	Online			X	X	X	
B-Plant Canyon Waste Pile	5	Online			X			
B-Plant Container Storage	51	Online				X		
PUREX Tunnel 1	4,141	Online			X	X		
PUREX Tunnel 2	19,528	Online			X	X		
PUREX Canyon Waste Pile	432	Online				X		
200 Area Liquid Effluent Retention Facility	59,000	Online			X	X		
4843 Alkali Metal Storage Facility	95	Standby				X	X	
Disposal Facility (m^3 except as otherwise specified)								
Grout Vaults	230,000	Online			X			
LLW Burial Ground	1,740,000	Online			X			
Radioactive Mixed Waste Disposal Facility	14,200	Standby			X	X		
200 Area Treated Effluent Disposal Facility, m^3/min	8.7	Online						X
Energy Northwest Sewage Treatment Facility, m^3/yr	235,000	Online						X

Key: Haz, hazardous; LLW, low-level waste; PUREX, Plutonium-Uranium Extraction (Plant); TRU, transuranic.
Source: Dirkes and Hanf 1996:46; Kovacs 1997; Rhoderick 1998; Sandberg 1998a; Teal 1997.

wastes are included in the TRU waste category because these wastes are expected to go to WIPP for ultimate disposal (DOE 1996a:3-64).

3.2.2.3 Low-Level Waste

Solid LLW is compacted and sent to the LLW Burial Ground in the 200 West Area for disposal in trenches. Additional LLW is received from offsite generators and disposed of at the LLW Burial Ground. LLW resulting from the tank waste remediation system waste pretreatment program will be vitrified; as a contingency, the Grout Facility will be maintained in standby condition. The vitrified LLW will be disposed of on the site in the 200 Area under the tank waste remediation system program (DOE 1996a:3-64).

U.S. Ecology operates a licensed commercial LLW Burial Ground on a site southwest of the 200 East Area that is leased to the State of Washington. The facility is not a DOE facility and is not considered part of DOE's Hanford operations (DOE 1996a:E-17).

3.2.2.4 Mixed Low-Level Waste

One of the existing treatment facilities for mixed LLW is the 242-A Evaporator in the 200 East Area, which reduces the volume of these wastes and removes cesium via ion exchange (DOE 1996a:3-64). The process condensate from the evaporator is temporarily stored in the Liquid Effluent Retention Facility until it is treated in the Liquid Effluent Treatment Facility. The Liquid Effluent Retention Facility consists of three Resource Conservation and Recovery Act (RCRA)–compliant surface impoundments for storing process condensate from the 242-A Evaporator. This facility provides equalization of the flow and pH to the Liquid Effluent Treatment Facility. The Liquid Effluent Treatment Facility provides ultraviolet light/peroxide destruction of organic compounds, reverse osmosis to remove dissolved solids, and ion exchange to remove the last traces of contaminants. Discharge of the treated effluent is via a dedicated pipeline to an underground drain field. The effluent treatment process produces a mixed LLW sludge that is concentrated, dried, packaged in 208-l (55-gal) drums, and transferred to the Central Waste Complex. This secondary waste is stored prior to treatment (if necessary) and disposal in the Mixed Waste Trench (Dirkes and Hanf 1996:10, 45, 46). In a recent modification to the Tri-Party Agreement, DOE has agreed to begin designing a vitrification facility to treat liquid mixed LLW (DOE 1996a:E-17; E-18).

The Waste Receiving and Processing Facility, near the Central Waste Complex in the 200 West Area, eventually will provide size reduction, decontamination, condensation, melting, amalgamation, incineration, ash stabilization, and shipping for Hanford mixed waste. The Waste Receiving and Processing Facility is being constructed in two phases: module 1 and module 2 (2A and 2B) and is designed to process 6,800 drums of waste annually (Dirkes and Hanf 1996:40). Module 1 will be designed to prepare retrieved and stored TRU waste and will be operational in 1999. Module 2A is designed to process LLW, TRU waste, mixed LLW, and mixed TRU waste, and is operational. Module 2B, if authorized, will be designed to process LLW, TRU waste, mixed LLW, and mixed TRU waste with a dose rate greater than 200 mrem/hr. Module 2B has an undetermined startup date (DOE 1996a:E-18).

The Radioactive Mixed Waste Disposal Facilities are in the Hanford LLW Burial Ground and are designated as 218-W-5, Trench 31, and Trench 34. The facilities consist of rectangular trenches with approximate dimensions of 76 by 30 m (250 by 100 ft). These facilities are RCRA compliant, with double liners and leachate collection and removal systems (Dirkes and Hanf 1996:40).

3.2.2.5 Hazardous Waste

There are no treatment facilities for hazardous waste at Hanford; therefore, the wastes are accumulated in satellite storage areas (for less than 90 days) or at interim RCRA-permitted facilities such as the 305-B Waste Storage Facility. The common practice for newly generated hazardous waste is to ship it off the site by truck using

DOT-approved transporters for treatment, recycling, recovery, and disposal at RCRA-permitted facilities (DOE 1996a:3-65, E-18; Sandberg 1998a).

3.2.2.6 Nonhazardous Waste

Sanitary wastewater is discharged to onsite treatment facilities such as septic tanks, subsurface soil adsorption systems, and wastewater treatment plants. These facilities treat an average of 600,000 l/day (159,000 gal/day) of sewage (DOE 1996a:E-19).

The 200 Area Treated Effluent Disposal Facility industrial sewer collects the treated wastewater streams from various plants in the 200 Areas and disposes of the clean effluent at two 2-ha (5-acre) ponds permitted by the State of Washington (DOE 1996a:E-19). The design capacity of the facility is approximately 8,700 l/min (2,300 gal/min), although the discharge permit presently limits the average monthly flow to about 2,400 l/min (640 gal/min) (Dirkes and Hanf 1996:46).

Nonhazardous solid wastes include construction debris, office trash, cafeteria wastes, furniture and appliances, nonradioactive friable asbestos, powerhouse ash, and nonradioactive/nonhazardous demolition debris. Until 1997, nonhazardous solid wastes were disposed of in the 600 Area central landfill. Under an agreement between DOE and the city of Richland, most of the site's nonregulated and nonradioactive solid wastes are now sent to the Richland Sanitary Landfill for disposal (DOE 1996a:3-65, E-19). The Richland Sanitary Landfill is at the southern edge of the Hanford Site boundary. Nonradioactive friable asbestos and medical waste are shipped off the site for disposal (Dirkes and Hanf 1996:83; Sandberg 1998a).

3.2.2.7 Waste Minimization

The Hanford Site Pollution Prevention Program is a comprehensive and continual effort to systematically reduce the quantity and toxicity of hazardous, radioactive, mixed, and sanitary wastes; conserve resources and energy; reduce hazardous substance use; and prevent or minimize pollutant releases to all environmental media from all operations and site cleanup activities. In accordance with sound environmental management, preventing pollution through source reduction is the first priority in the Hanford Site Pollution Prevention Program, and the second priority is environmentally safe recycling. For instance, Hanford pollution prevention efforts in 1995 helped to prevent the generation of approximately 2,900 m^3 (3,790 yd^3) of radioactive mixed waste, 207 t (228 tons) of RCRA waste, 30,000 m^3 (39,200 yd^3) of process wastewater, and 4,400 t (4,850 tons) of sanitary waste. Also during 1995, Hanford recycled approximately 632 t (697 tons) of office paper, 20 t (22 tons) of cardboard, 3,600 t (3,970 tons) of ferrous metal, 215 t (237 tons) of nonferrous metal, 57 t (63 tons) of lead, 16 t (18 tons) of solid chemicals, and 78,000 l (20,600 gal) of liquid chemicals. In addition, Hanford's new centralized recycling center collects aerosol cans, fluorescent light ballasts, fluorescent light tubes, and lead acid batteries (Dirkes and Hanf 1996:44, 45).

3.2.2.8 Preferred Alternatives From the WM PEIS

Preferred alternatives from the *Waste Management Programmatic Environmental Impact Statement* (WM PEIS) (DOE 1997a:summary, 95) are shown in Table 3–6 for the four waste types analyzed in this SPD EIS. A decision on the future management of these wastes could result in the construction of new waste management facilities at Hanford and the closure of other facilities. Decisions on the various waste types are expected to be announced in a series of records of decision (RODs) to be issued on this WM PEIS. In fact, the TRU waste ROD was issued on January 20, 1998 (DOE 1998a) with the hazardous waste ROD issued on August 5, 1998 (DOE 1998b). The TRU waste ROD states that DOE will develop and operate mobile and fixed facilities to characterize and prepare TRU waste for disposal at WIPP. Each DOE site that has, or will

Table 3–6. Preferred Alternatives From the WM PEIS

Waste Type	Preferred Action
TRU and mixed TRU	DOE prefers onsite treatment and storage of Hanford's TRU waste pending disposal at WIPP.[a]
LLW	DOE prefers to treat Hanford's LLW on the site. Hanford could be selected as one of the regional disposal sites for LLW.
Mixed LLW	DOE prefers regionalized treatment at Hanford. This includes the onsite treatment of Hanford's wastes and could include treatment of some mixed LLW generated at other sites. Hanford could be selected as one of the regional disposal sites for mixed LLW.
Hazardous	DOE prefers to continue to use commercial facilities for hazardous waste treatment.[a]

[a] ROD for TRU waste (DOE 1998a) and ROD for hazardous waste (DOE 1998b) selected the preferred alternatives for these waste types at Hanford.

Key: LLW, low-level waste; ROD, record of decision; TRU, transuranic; WIPP, Waste Isolation Pilot Plant.

Source: DOE 1997a:summary, 95.

generate, TRU waste will, as needed, prepare and store its TRU waste on the site. The hazardous waste ROD states that most DOE sites will continue to use offsite facilities for the treatment and disposal of major portions of the nonwastewater hazardous waste, with ORR and SRS continuing to treat some of their own hazardous waste on the site in existing facilities where this is economically favorable. More detailed information and DOE's alternatives for the future configuration of waste management facilities at Hanford is presented in the WM PEIS and the hazardous waste and TRU waste RODs.

3.2.3 Socioeconomics

Statistics for employment and regional economy are presented for the regional economic area (REA) as defined in Appendix F.9, which encompasses nine counties surrounding Hanford in Washington. Statistics for population, housing, community services, and local transportation are presented for the ROI, a two-county area in which 91 percent of all Hanford employees reside as shown in Table 3–7. In 1997, Hanford employed about 12,882 persons (about 3.7 percent of the REA civilian labor force) (Mecca 1997b).

Table 3–7. Distribution of Employees by Place of Residence in the Hanford Region of Influence, 1997

County	Number of Employees	Total Site Employment (Percent)
Benton	10,563	82
Franklin	1,159	9
ROI total	11,722	91

Source: Mecca 1997b.

3.2.3.1 Regional Economic Characteristics

Selected employment and regional economy statistics for the Hanford REA and Washington are summarized in Figure 3–1. Between 1990 and 1996, the civilian labor force in the REA increased 35.3 percent to 344,611. In 1996, the unemployment rate in the REA was 11.1 percent, significantly higher than the rate of 6.5 percent in Washington State (DOL 1999).

In 1995, service activities represented the largest sector of employment in the REA (22.3 percent). This was followed by agriculture (19.6 percent) and government (17.4 percent). Overall, the State total for these employment sectors was 25.0 percent, 3.7 percent, and 18.0 percent, respectively (DOL 1997).

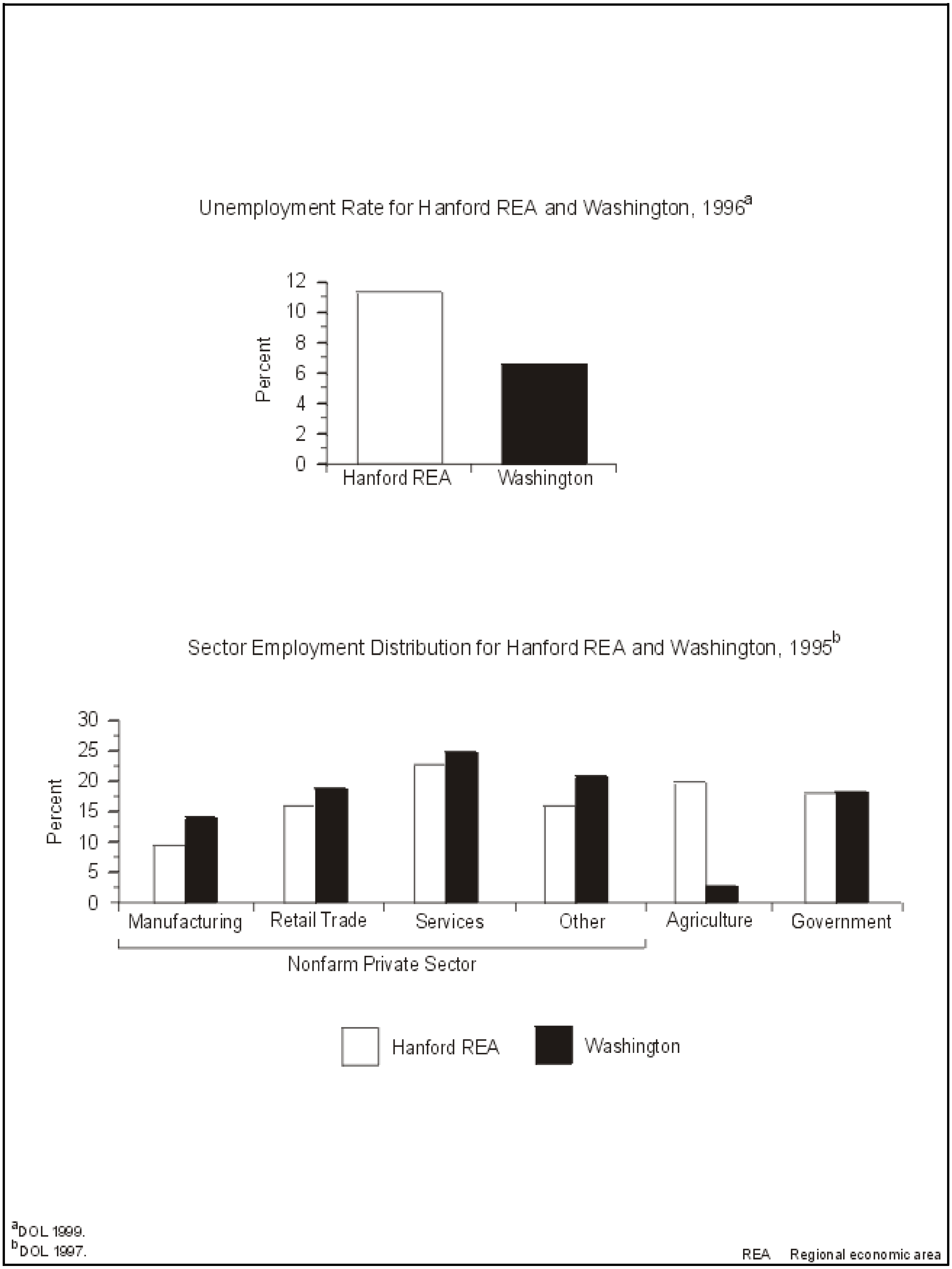


Figure 3–1. Employment and Local Economy for the Hanford Regional Economic Area and the State of Washington

3.2.3.2 Population and Housing

In 1996, the ROI population totaled 179,949. Between 1990 and 1996, the ROI population increased 18.9 percent compared with the 12.9 percent increase experienced in Washington (DOC 1997). Between 1980 and 1990, the number of housing units in the ROI increased by about 4.6 percent, compared with a 20.3 percent increase in Washington. The total number of housing units within the ROI for 1990 was 58,541 (DOC 1994). The 1990 homeowner vacancy rates for the ROI was 1.4 percent compared with the State's rate of 1.3 percent. The ROI renter vacancy rate was 5.5 percent compared with 5.8 percent for the State (DOC 1990a). Population and housing trends in the ROI and Washington are summarized in Figure 3–2.

3.2.3.3 Community Services

3.2.3.3.1 Education

Ten school districts provide public education in the Hanford ROI. As shown in Figure 3–3, school districts in 1997 were operating at capacities ranging from 65 to 100 percent. In 1997, the student-to-teacher ratio in the ROI averaged 16:1 (Nemeth 1997a). In 1990, the average student-to-teacher ratio for Washington was 11.4:1 (DOC 1990b; 1994).

3.2.3.3.2 Public Safety

In 1997, a total of 281 sworn police officers were serving the ROI. The ROI average officer-to-population ratio was 1.6 officers per 1,000 persons (Nemeth 1997b). This compares with the 1990 State average of 1.7 police officers per 1,000 persons (DOC 1990b). In 1997, 616 paid and volunteer firefighters provided fire protection services in the Hanford ROI. The average firefighter-to-population ratio in 1997 in the ROI was 3.4 firefighters per 1,000 persons (Nemeth 1997b). This compares with the 1990 State average of 1 firefighter per 1,000 persons (DOC 1990b). Figure 3–4 displays the ratio of sworn police officers and firefighters to population for the two counties in the Hanford ROI.

3.2.3.3.3 Health Care

In 1996, a total of 257 physicians served the ROI. The average physician-to-population ratio in the ROI was 1.4 physicians per 1,000 persons compared with the 1996 State average of 3.7 per 1,000 persons (Randolph 1997). In 1997, there were four hospitals serving the ROI. The hospital bed-to-population ratio averaged 2.1 beds per 1,000 persons (Nemeth 1997c). This compares with a State 1991 average of 2.4 beds per 1,000 persons (DOC 1996:128). Figure 3–4 displays the ratio of physicians-to-population and hospital bed-to-population for the two counties in the Hanford ROI.

3.2.3.4 Local Transportation

Vehicular access to Hanford is provided by State Routes 240, 243, 24, and Stevens Drive. State Route 240 connects to the Richland bypass highway, which interconnects with I–182. State Route 243 exits the site's northwestern boundary and serves as a primary link between the site and I–90. State Route 24 enters the site from the west and continues eastward across the northernmost portion of the site and intersects State Route 26 about 16 km (10 mi) east of the site boundary. Stevens Drive out of north Richland is the favored route to Hanford (see Figure 2–2).

One current road improvement project that could affect vehicular access to Hanford is repaving and signal work at the intersection of State Route 240 and Stevens Drive. Two projects, currently in the planning stage, could affect vehicular access to Hanford in the future: a realignment of State Route 240 from Stevens Drive

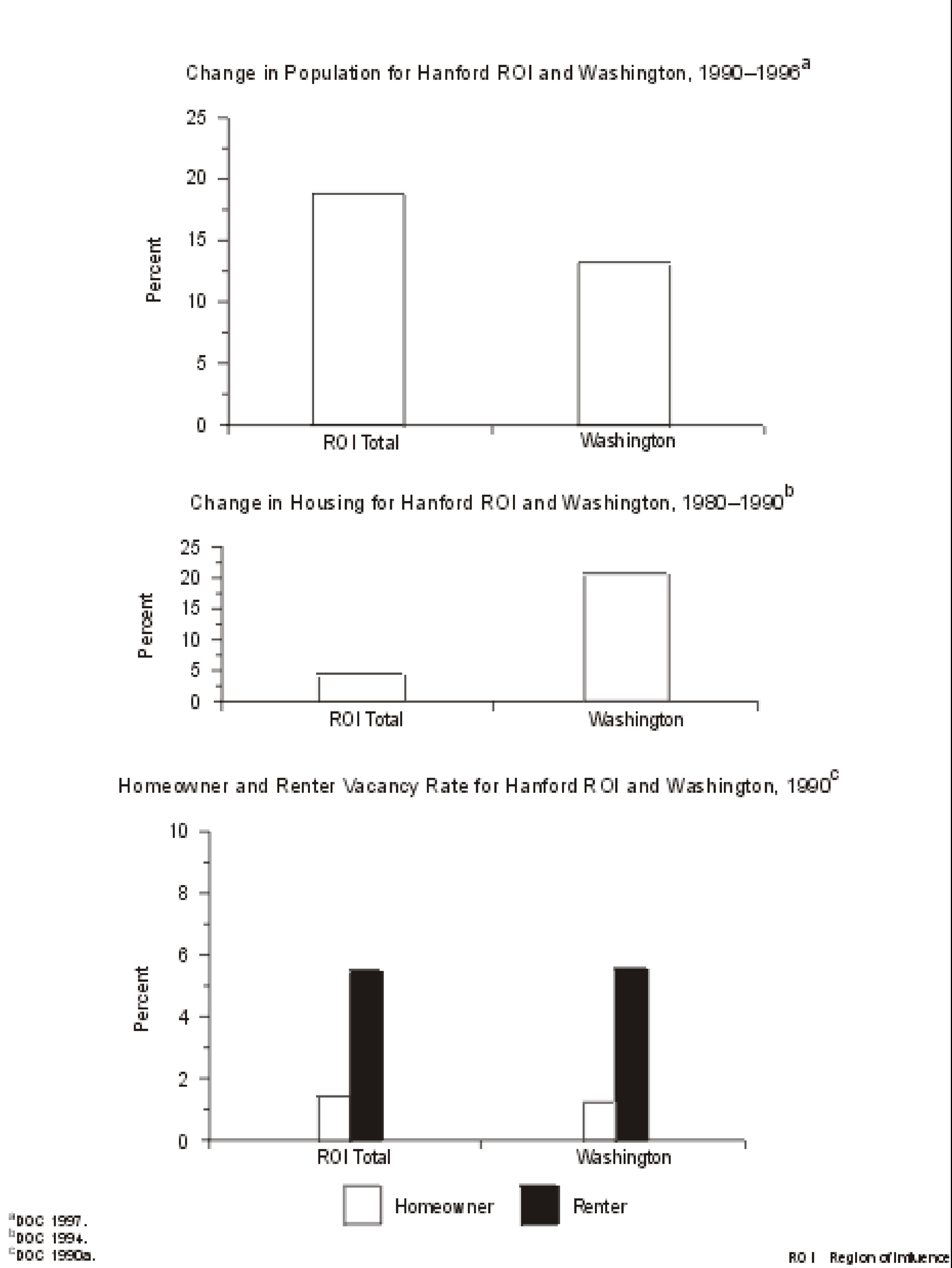
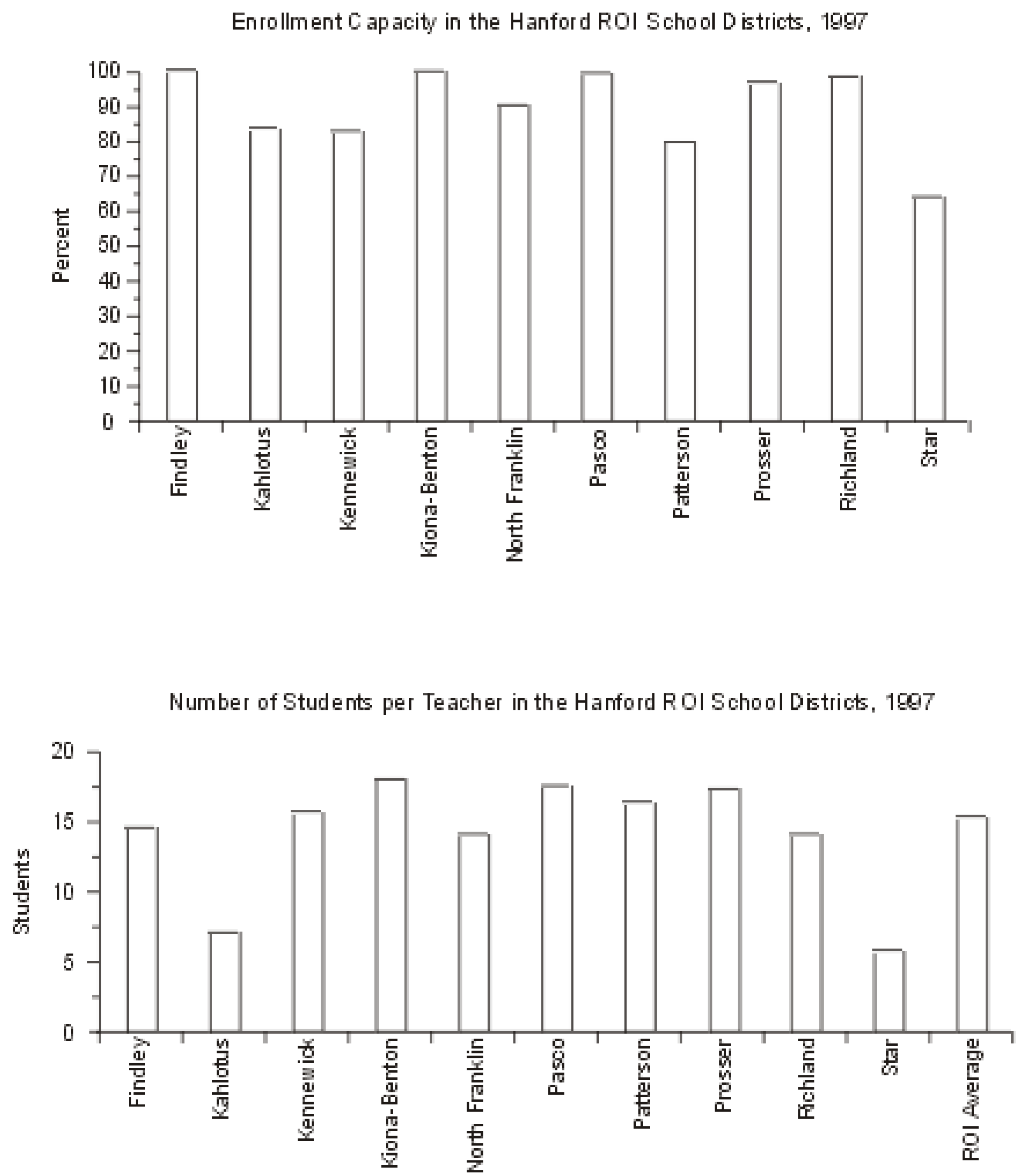


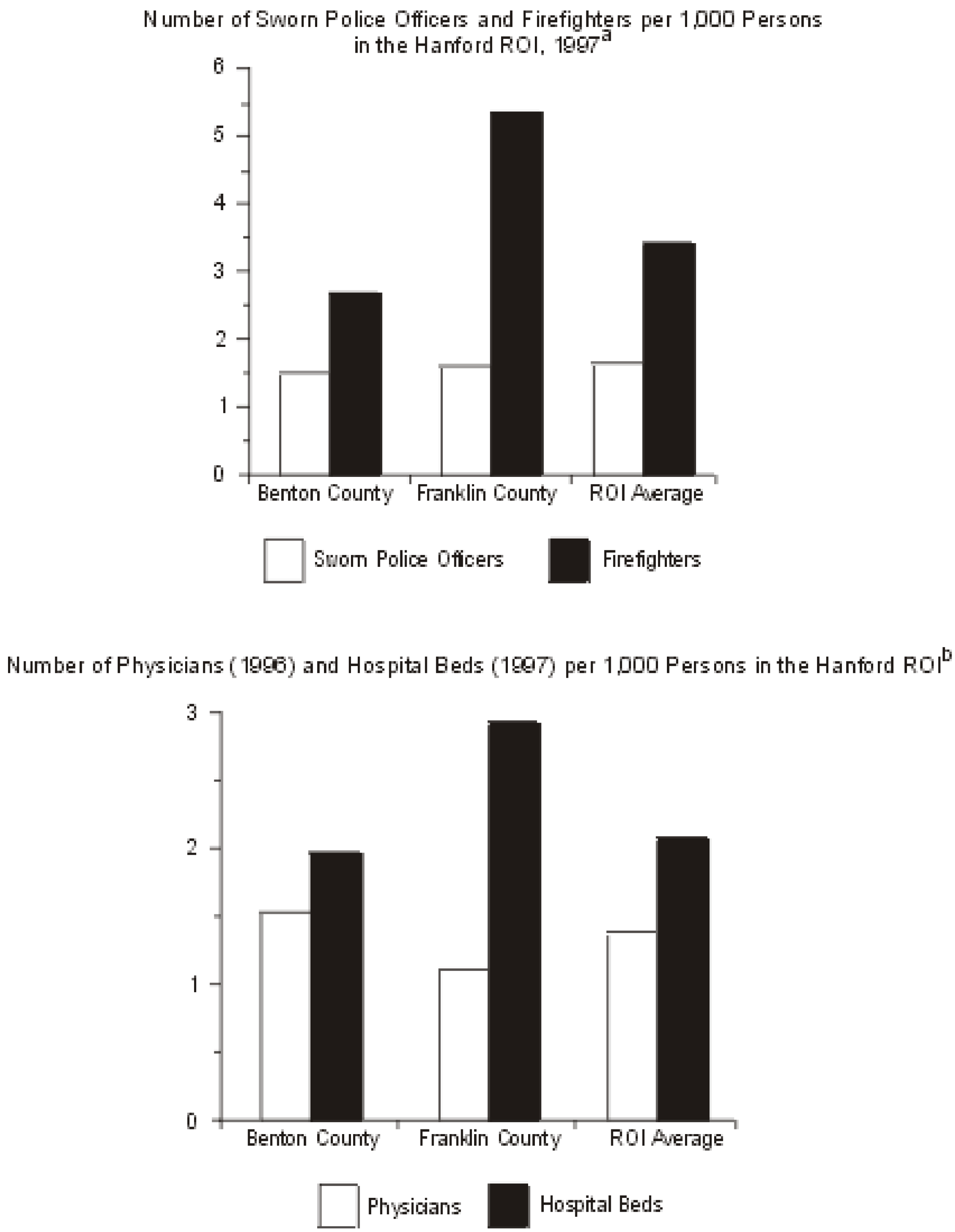
Figure 3–2. Population and Housing for the Hanford Region of Influence and the State of Washington



Source: Nemeth 1997a.

ROI Region of Influence

Figure 3–3. School District Characteristics for the Hanford Region of Influence



[a] Nemeth 1997b.
[b] Nemeth 1997c; Randolph 1997.

ROI Region of Influence

Figure 3–4. Public Safety and Health Care Characteristics for the Hanford Region of Influence

to State Route 224 and the paving of asphalt overlay of State Route 224 from West Richland to State Route 240 in the year 2000 (MacNeil 1997). However, an improvement project on Grosscup Road would provide relief of congestion due to State Route 224 paving activities.

The local intercity transit system, Ben Franklin Transit, supplies bus service between the Tri-Cities and Hanford. Both private interests and Ben Franklin Transit provide vanpooling opportunities in the ROI.

Onsite rail transport is provided by a short-line railroad that connects with the Union Pacific line just south of the Yakima River. The Union Pacific line interchanges with the Washington Central and Burlington Northern and Santa Fe at the city of Kennewick. There is no passenger rail service at Hanford (see Section 3.2.11.1.1 for more information).

In the ROI, the Columbia River is used as an inland waterway for barge transportation from the Pacific Ocean. The Port of Benton provides a barge slip where shipments arriving at Hanford may be off-loaded.

Tri-Cities Airport, near the city of Pasco, provides jet air passenger and cargo service by both national and local carriers. Numerous smaller private airports are located throughout the ROI (DOE 1996a).

3.2.4 Existing Human Health Risk

Public and occupational health and safety issues include the determination of potentially adverse effects on human health that result from acute and chronic exposures to ionizing radiation and hazardous chemicals.

3.2.4.1 Radiation Exposure and Risk

3.2.4.1.1 General Site Description

Major sources and levels of background radiation exposure to individuals in the vicinity of Hanford are shown in Table 3–8. Annual background radiation doses to individuals are expected to remain constant over time. The total dose to the population, in terms of person-rem, changes as the population size changes. Background radiation doses are unrelated to Hanford operations.

Table 3–8. Sources of Radiation Exposure to Individuals in the Hanford Vicinity Unrelated to Hanford Operations

Source	Effective Dose Equivalent (mrem/yr)
Natural background radiation[a]	
Cosmic radiation	30
External terrestrial radiation	30
Internal terrestrial radiation	40
Radon in homes (inhaled)	200[b]
Other background radiation[c]	
Diagnostic x rays and nuclear medicine	53
Weapons test fallout	<1
Air travel	1
Consumer and industrial products	10
Total	365

[a] Dirkes and Hanf 1997:264.
[b] An average for the United States.

[c] NCRP 1987:11, 40, 53.

Releases of radionuclides to the environment from Hanford operations provide another source of radiation exposure to individuals in the vicinity of Hanford. Types and quantities of radionuclides released from Hanford operations in 1996 are listed in the *Hanford Site Environmental Report for Calendar Year 1996* (Dirkes and Hanf 1997:65–71). Doses to the public resulting from these releases are presented in Table 3–9. These doses fall within radiological limits per DOE Order 5400.5 (DOE 1993a:II-1–II-5) and are much lower than those of background radiation.

Table 3–9. Radiation Doses to the Public From Normal Hanford Operations in 1996 (Total Effective Dose Equivalent)

	Atmospheric Releases[a]		Liquid Releases		Total	
Members of the Public	**Standard[b]**	**Actual**	**Standard[b]**	**Actual**	**Standard[b]**	**Actual**
Maximally exposed individual (mrem)	10	4.6×10^{-3}	4	2.8×10^{-3}[c]	100	7.4×10^{-3}
Population within 80 km (person-rem)[d]	None	0.13	None	0.072	100	0.20
Average individual within 80 km (mrem)[e]	None	3.4×10^{-4}	None	1.9×10^{-4}	None	5.3×10^{-4}

[a] Includes direct radiation dose from surface deposits of radioactive material.

[b] The standards for individuals are given in DOE Order 5400.5 (DOE 1993a:II-1–II-5). As discussed in that order, the 10-mrem/yr limit from airborne emissions is required by the Clean Air Act, and the 4-mrem/yr limit is required by the Safe Drinking Water Act; for this SPD EIS, the 4-mrem/yr value is conservatively assumed to be the limit for the sum of doses from all liquid pathways. The total dose of 100 mrem/yr is the limit from all pathways combined. The 100-person-rem value for the population is given in proposed 10 CFR 834, as published in 58 FR 16268 (DOE 1993b:para. 834.7). If the potential total dose exceeds the 100 person-rem value, it is required that the contractor operating the facility notify DOE.

[c] Includes the drinking water dose.

[d] About 380,000 in 1996.

[e] Obtained by dividing the population dose by the number of people living within 80 km (50 mi) of the site.

Source: Dirkes and Hanf 1997:chap. 5.

Using a risk estimator of 500 cancer deaths per 1 million person-rem (5×10^{-4} fatal cancer per person-rem) to the public (see Appendix F.10), the fatal cancer risk to the maximally exposed member of the public due to radiological releases from Hanford operations in 1996 is estimated to be 3.7×10^{-9}. That is, the estimated probability of this person dying of cancer at some point in the future from radiation exposure associated with 1 year of Hanford operations is less than 4 in 1 billion. (It takes several to many years from the time of radiation exposure for a cancer to manifest itself.)

According to the same risk estimator, 1×10^{-4} excess fatal cancers are projected in the population living within 80 km (50 mi) of Hanford from normal operations in 1996. To place this number in perspective, it may be compared with the number of fatal cancers expected in the same population from all causes. The 1996 mortality rate associated with cancer for the entire U.S. population was 0.2 percent per year (Famighetti 1998:964). Based on this mortality rate, the number of fatal cancers expected during 1996 from all causes in the population living within 80 km (50 mi) of Hanford was 760. This expected number of fatal cancers is much higher than the 1×10^{-4} fatal cancer estimated from Hanford operations in 1996.

Hanford workers receive the same dose as the general public from background radiation, but they also receive an additional dose from working in facilities with nuclear materials. Table 3–10 presents the average dose to the individual worker and the cumulative dose to all workers at Hanford from operations in 1996. These doses fall within the radiological regulatory limits of 10 CFR 835 (DOE 1995a:para. 835.202). According to a risk

Table 3–10. Radiation Doses to Workers From Normal Hanford Operations in 1996 (Total Effective Dose Equivalent)

Occupational Personnel	Onsite Releases and Direct Radiation: Standard[a]	Onsite Releases and Direct Radiation: Actual
Average radiation worker (mrem)	None[b]	19
Total workers (person-rem)[c]	None	266

[a] The radiological limit for an individual worker is 5,000 mrem/yr (DOE 1995a:para. 835.202). However, DOE's goal is to maintain radiological exposure as low as is reasonably achievable. It has therefore established an administrative control level of 2,000 mrem/yr (DOE 1994a:2-3); the site must make reasonable attempts to maintain individual worker doses below this level.

[b] No standard is specified for an "average radiation worker"; however, the maximum dose that this worker may receive is limited to that given in footnote "a."

[c] About 14,000 (badged) in 1996.

Source: Lyon 1997.

estimator of 400 fatal cancers per 1 million person-rem among workers[2] (Appendix F.10), the number of projected fatal cancers among Hanford workers from normal operations in 1996 is 0.11.

A more detailed presentation of the radiation environment, including background exposures and radiological releases and doses, is presented in the *Hanford Site Environmental Report for Calendar Year 1996* (Dirkes and Hanf 1997). The concentrations of radioactivity in various environmental media (including air, water, and soil) in the site region (on and off the site) are also presented in that report.

3.2.4.1.2 Proposed Facility Locations

External radiation doses have been measured in the 200 and 400 Areas. In 1996, the annual doses in the 200 and 400 Areas were roughly the same, about 85 mrem. This is 10 mrem higher than the value measured at the offsite control locations. The concentration of plutonium 239/240 in air in the 200 Area in 1996 was about 1×10^{-5} pCi/m^3. Although this was about 100 times higher than the value at the control location, it was still very small. No measurements of plutonium concentrations in air were reported for the 400 Area (Dirkes and Hanf 1997:75, 76, 124, 185, 186).

3.2.4.2 Chemical Environment

The background chemical environment important to human health consists of the atmosphere, which may contain hazardous chemicals that can be inhaled; drinking water, which may contain hazardous chemicals that can be ingested; and other environmental media through which people may come in contact with hazardous chemicals (e.g., surface water during swimming, soil through direct contact, or food). Hazardous chemicals can cause cancer and noncancer health effects. The baseline data for assessing potential health impacts from the chemical environment are addressed in Section 3.2.1.

[2] The risk estimator for workers is lower than the estimator for the public because of the absence from the workforce of the more radiosensitive infant and child age groups.

Effective administrative and design controls that decrease hazardous chemical releases to the environment and help achieve compliance with permit requirements (e.g., air emissions and National Pollutant Discharge Elimination System [NPDES] permit requirements) contribute to minimizing health impacts on the public. The effectiveness of these controls is verified through the use of monitoring information and inspection of mitigation measures. Health impacts on the public may occur via inhalation of air containing hazardous chemicals released to the atmosphere during normal Hanford operations. Risks to public health from other possible pathways, such as ingestion of contaminated drinking water or direct exposure, are lower than those via the inhalation pathway.

Baseline air emission concentrations and applicable standards for hazardous chemicals are addressed in Section 3.2.1. The baseline concentrations are estimates of the highest existing offsite concentrations and represent the highest concentrations to which members of the public could be exposed. These concentrations are in compliance with applicable guidelines and regulations. Information on estimating the health impacts of hazardous chemicals is presented in Appendix F.10.

Exposure pathways to Hanford workers during normal operations may include the inhalation of contaminants in the workplace atmosphere and direct contact with hazardous materials. The potential for health impacts varies among facilities and workers, and available information is insufficient for a meaningful estimate of impacts. However, workers are protected from workplace hazards through appropriate training, protective equipment, monitoring, substitution, and engineering and management controls. They are also protected by adherence to Occupational Safety and Health Administration (OSHA) and EPA standards that limit workplace atmospheric and drinking water concentrations of potentially hazardous chemicals. Appropriate monitoring that reflects the frequency and amounts of chemicals used in the operational processes ensures that these standards are not exceeded. Additionally, DOE requires that conditions in the workplace be as free as possible from recognized hazards that cause, or are likely to cause, illness or physical harm. Therefore, workplace conditions at Hanford are substantially better than required by standards.

3.2.4.3 Health Effects Studies

Three epidemiological studies and a feasibility study have been conducted on communities around Hanford to determine whether there are excess cancers in the general population. One study found no excess cancers but identified an elevated rate of neural tube defects in progeny. This elevated rate was not attributed to parental employment at Hanford. A second study suggested that neural tube defects were associated with cumulative radiation exposure, and showed other defects statistically associated with parental employment at Hanford, but not with parental radiation exposure. The third study did not show any cancer risk associated with living near the facility.

Many epidemiological studies have been carried out on the Hanford workers over the years. The studies have consistently shown a statistically significant elevated risk of death from multiple myeloma associated with radiation exposure among Hanford male workers. The elevated risk was observed only among workers exposed to 10 rads (-10 rem) or more. Other studies have also identified an elevated risk of death from pancreatic cancers, but a recent reanalysis did not conclude there was an elevated risk. Studies of female Hanford workers have shown an elevated risk of deaths from musculoskeletal system and connective tissue conditions. For a more detailed description of the studies reviewed and their findings, and for a discussion of the epidemiologic surveillance program implemented by DOE to monitor the health of current workers, refer to Appendix M.4.2 of the *Storage and Disposition PEIS* (DOE 1996a:M-224–M-230).

3.2.4.4 Accident History

Prior to 1997, there were 128 nuclear-process-related incidents with some degree of safety significance at Hanford over its period of operation. These do not include less-significant instances of radioactivity release or contamination during normal operations, which have been the subject of other reviews. The 128 incidents fall into three significant categories, based on the seriousness of the actual or potential consequences.

Fifteen of the incidents were Category 1, indicating that serious injury, radiation release or exposure above limits, substantial actual plant damage, or a significant challenge to safety resulted. Forty-six events were Category 2, less severe than Category 1, but involving significant cost or a less significant threat to safety. The remaining 67 incidents were Category 3, causing minor radiation exposure or monetary cost, or involving a violation of operating standards without a serious threat to safety (DOE 1996a:3-60).

On May 14, 1997, a chemical explosion occurred at the Hanford Plutonium Reclamation Plant in a room where nonradioactive bulk chemicals were mixed for the now-discontinued plutonium recovery process. The reclamation plant was designed to concentrate liquid feeds, dissolve and process solid material, and perform solvent-extraction recovery of plutonium from aqueous streams. Eight workers outside the plant at the time of the explosion complained of various symptoms, including headaches, light-headedness, and a strange metallic taste. All eight workers were transported to a nearby medical center, where they were examined and released. A small fire protection water line ruptured during the explosion, resulting in the release of water from the building. No one was injured and no radioactive materials were released to the environment. The explosion caused significant localized damage to the facility.

3.2.4.5 Emergency Preparedness

Each DOE site has established an emergency management program that would be activated in the event of an accident. This program has been developed and maintained to ensure adequate response to most accident conditions and to provide response efforts for accidents not specifically considered. The emergency management program includes emergency planning, preparedness, and response.

Accordingly, the DOE Richland Operations Office has developed and maintains a comprehensive set of emergency preparedness plans and procedures for Hanford to support onsite and offsite emergency management actions in the event of an accident. The DOE Richland Operations Office also provides technical assistance to other Federal agencies and to State and local governments. Hanford contractors are responsible for ensuring that emergency plans and procedures are prepared and maintained for all facilities, operations, and activities under their jurisdiction, and for directing implementation of those plans and procedures during emergency conditions. The DOE Richland Operations Office, contractor, and State and local government plans are fully coordinated and integrated. Emergency control centers have been established by the DOE Richland Operations Office and its contractors for the principal work areas to provide oversight and support to emergency response actions within those areas.

Following the May 1997 explosion at Hanford (discussed previously), a review of the emergency management response indicated that multiple programs and systems failed in the hours following the accident. In a letter to Secretarial Offices, Secretary of Energy Federico Peña identified actions to be taken at all DOE sites to implement lessons learned from the emergency response (Peña 1997). The actions involve the following elements:

1. Improve training for facility and site emergency personnel
2. Ensure that equipment and qualified personnel are ready for the wide variety of potential radiological and chemical hazards
3. Improve coordination with local medical communities
4. Have in place comprehensive procedures to attend to personnel who are potentially affected by an accident

3.2.5 Environmental Justice

Environmental justice concerns the environmental impacts that proposed actions may have on minority and low-income populations, and whether such impacts are disproportionate to those on the population as a whole in the potentially affected area. In the case of Hanford, the potentially affected area includes parts of Washington and Oregon.

The potentially affected area around the 200 East Area is defined by a circle with an 80-km (50-mi) radius centered at the planned HLW vitrification facility (lat. 46E33'03.64" N, long. 119E30'13.95" W). The total population residing within that area in 1990 was 346,031. The proportion of the population that was considered minority was 26.2 percent. The potentially affected area surrounding the 400 Area is defined by a circle with an 80-km (50-mi) radius centered at FMEF (lat. 46E26'07" N, long. 119E21'55" W). The total population residing within that area in 1990 was 277,515, and the proportion of the population deemed minority was 25.4 percent. The same census data show that the percentage of minorities for the contiguous United States was 24.1, and the percentages for the States of Washington and Oregon were 13.3 and 9.2, respectively (DOC 1992).

Figure 3–5 illustrates the racial and ethnic composition of the minority population in the potentially affected area around the 200 East Area. At the time of the 1990 census, Hispanics were the largest minority group within the potentially affected area, constituting 21.5 percent of the total population. Native Americans contributed about 2 percent, and Asians, about 1.4 percent. Blacks made up about 1.2 percent of the population (DOC 1992).

As for the racial and ethnic composition of the minority population in the potentially affected area around the 400 Area, Hispanics were the largest minority group, constituting 21.5 percent of the total population during the 1990 census. Asians contributed about 1.4 percent, and Native Americans, about 2.0 percent. Blacks were about 1.2 percent of the population (DOC 1992).

A breakdown of incomes in the potentially affected area is also available from the 1990 census data (DOC 1992). At that time, the poverty threshold was $9,981 for a family of three with one related child under 18 years of age. A total of 64,780 persons (19.0 percent of the total population) residing within the potentially affected area around the 200 East Area reported incomes below that threshold. The data also show that 47,310 persons (17.3 percent of the total population) residing within the potentially affected area around the 400 Area reported incomes below the poverty threshold. Data obtained during the 1990 census also show that of the total population of the contiguous United States, 13.1 percent reported incomes below the poverty threshold, and that the figures for Washington and Oregon were 10.9 and 12.4 percent, respectively.

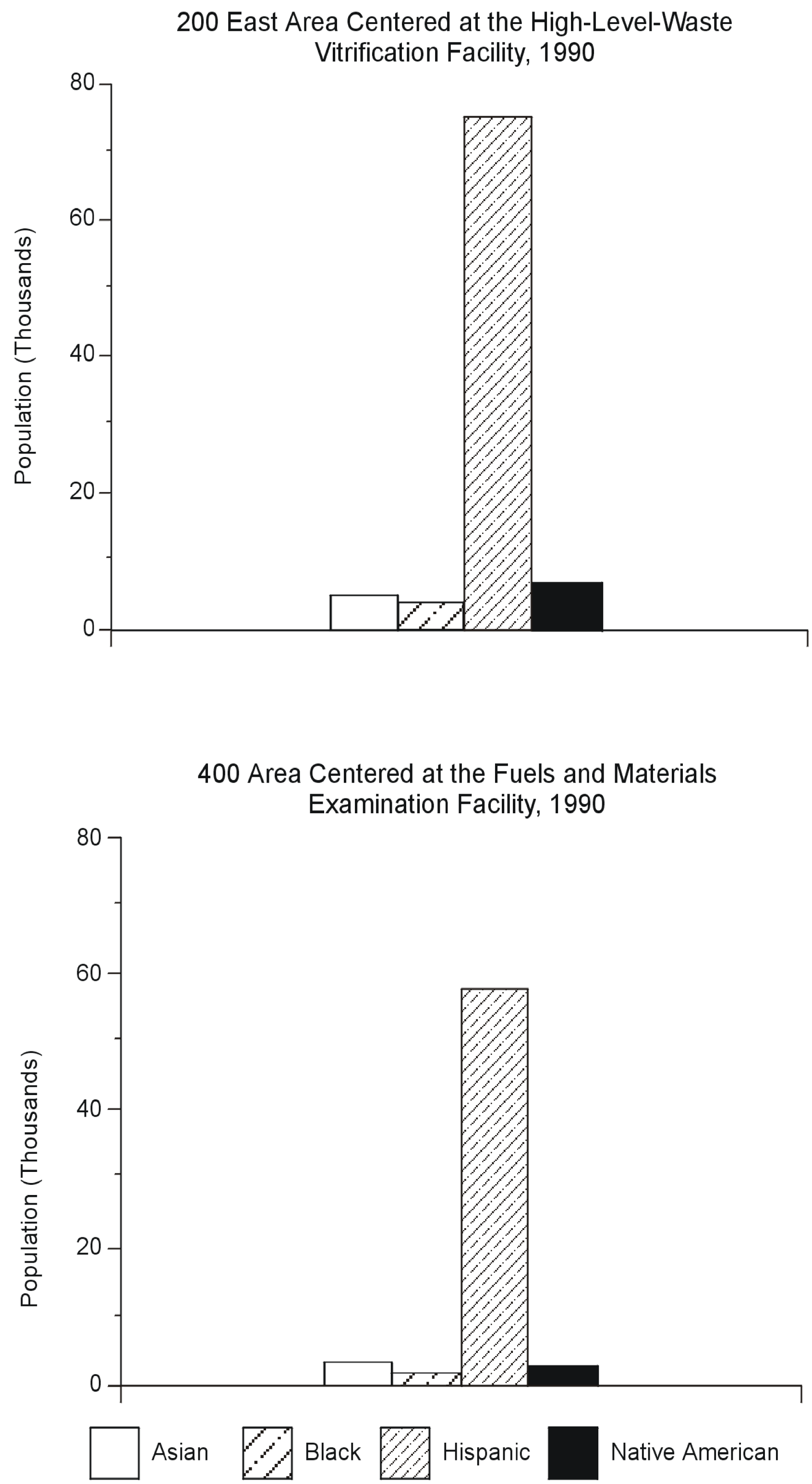
3.2.6 Geology and Soils

Geologic resources are consolidated or unconsolidated earth materials, including ore and aggregate materials, fossil fuels, and significant landforms. Soil resources are the loose surface materials of the earth in which plants grow, usually consisting of disintegrated rock, organic matter, and soluble salts.

3.2.6.1 General Site Description

The rocks beneath Hanford consist of Miocene-age and younger rocks that overlay older Cenozoic sedimentary and volcanic basement rocks. The major geologic units underlying Hanford are, in ascending order: subbasalt (basement) rocks, the Columbia River Basalt Group (with alluvial interbeds of sand, gravel, or silt of the Ellensburg Formation), the Ringold Formation, the Plio-Pleistocene unit, early "Palouse" soil, and the Hanford Formation (DOE 1996a:3-38; DOE 1996c:4-5).

Basalt outcrops are exposed on ridges at Gable Mountain, Gable Butte, and the Saddle Mountains in the northern part of Hanford, and on Rattlesnake Hills and Yakima Ridge, overlapping the western and southwestern edges of Hanford (DOE 1996a:3-38). Other than crushed rock, sand, and gravel, no economically viable geologic resources have been identified at Hanford (DOE 1996c:4-10).



Source: DOC 1992.

Figure 3–5. Racial and Ethnic Composition of Minorities Around Hanford

Known faults in the Hanford area include those on Gable Mountain and the Rattlesnake-Wallula alignment. The faults in Central Gable Mountain are considered capable, although there is no observed seismicity on or near Gable Mountain. The Rattlesnake-Wallula alignment is interpreted as possibly being capable because there appear to be active portions of the fault system 56 km (35 mi) southwest of the central part of Hanford. A capable fault is one that has had movement at or near the ground surface at least once within the past 35,000 years or recurrent movement within the past 500,000 years (Barghusen and Feit 1995:2.2-13, 2.2-14).

According to the Uniform Building Code, Hanford is in Seismic Zone 2B, meaning that moderate damage could occur as a result of an earthquake. Seismicity of the Columbia Plateau, as determined by the rate of earthquakes per area and the historical magnitude of these events, is lower than that of other regions in the Pacific Northwest (DOE 1996a:3-38, 3-39). The two largest earthquakes near Hanford occurred in 1918 and 1973; each had an approximate Richter magnitude of 4.5 and a Modified Mercalli Intensity of V. They occurred in the central portion of the Columbia Plateau north of Hanford (Neitzel 1996:4.49). An earthquake with a maximum horizontal acceleration of 0.25g is calculated to have an annual probability of occurrence of 1 in 10,000 at Hanford (Barghusen and Feit 1995:2.2-14).

There is some potential for slope failure at Hanford, although only the slopes of Gable Mountain and White Bluffs are steep enough to warrant landslide concern. White Bluffs, east of the Columbia River, poses the greatest concern because of the clay-rich nature of some beds above the river level, the discharge of large quantities of irrigation water into the ground atop the cliffs, the surface incline toward the Columbia River, and the eastward channel migration of the Columbia and its undercutting of the adjacent bluffs. A large landslide along White Bluffs could fill the Columbia River channel and divert water onto Hanford (DOE 1996a:3-40). Calculations of the potential impacts of such a landslide indicate a flood area similar to the probable maximum flood (Neitzel 1996:4.58–4.61).

Several major volcanoes are in the Cascade Range west of Hanford, including Mount Adams, 164 km (102 mi) from Hanford, and Mount St. Helens, 218 km (135 mi) west-southwest of the site (DOE 1996a:3-40). Ashfalls from at least three Cascade volcanoes have blanketed the central Columbia Plateau since the late Pleistocene epoch. Generally, ashfall layers have not exceeded more than a few centimeters in thickness, with the exception of the Mount Mazama (Crater Lake, Oregon) eruption, when as much as 10 cm (3.9 in) of ash fell over western Washington (Barghusen and Feit 1995:2.2-14).

Fifteen different soil types occur at Hanford. These soils vary from sand to silty and sandy loam. The dominant soil types are the Quincy (Rupert) sand, Burbank loamy sand, Ephrata sandy loam, and the Warden silt loam. No soils at Hanford are currently classified as prime farmlands because there are no current soil surveys, and the only prime farmland soils in the region are irrigated (DOE 1996b:4-15). The soils at Hanford are considered acceptable for standard construction techniques (DOE 1996a:3-40). More detailed descriptions of the geology and the soil conditions at Hanford are included in the *Storage and Disposition PEIS* (DOE 1996a:3-38–3-40) and the *Hanford Remedial Action EIS* (DOE 1996b).

3.2.6.2 Proposed Facility Locations

The nearest capable fault to the 200 East Area is about 10 km (6.2 mi) away (Mecca 1997a:6). The predominant soils of the 200 East Area are the Burbank loamy sand and the Ephrata sandy loam, and the soils are not subject to liquefaction or other instabilities (Mecca 1997a:6; Neitzel 1996:4-46).

The nearest capable fault to the 400 Area is about 19 km (12 mi) away (Mecca 1997a:6). The predominant soil type in the 400 Area is the Rupert sand, and the soils are not subject to liquefaction or other instabilities (Mecca 1997a:6; Neitzel 1996:4-46).

3.2.7 Water Resources

3.2.7.1 Surface Water

Surface water includes marine or freshwater bodies that occur above the ground surface, including rivers, streams, lakes, ponds, rainwater catchments, embayments, and oceans.

3.2.7.1.1 General Site Description

The major surface water features at Hanford are the Columbia River, the Yakima River, the springs along the Columbia River and on Rattlesnake Mountain, and onsite ponds. Flow of the Columbia River is regulated by several dams upstream and downstream from the site. The nearest dam upstream from Hanford is the Priest Rapids Dam, and the closest downstream dam is the McNary Dam. The Hanford Reach is the portion of the Columbia River that extends from Priest Rapids Dam to the upstream edge of the pool behind McNary Dam. Because the flows are regulated, flow rates in the Hanford Reach can vary considerably; it is the last remaining free-flowing, nontidal section of the river (DOE 1996a:3-32). The average flow rate at the Priest Rapids Dam is about 3,360 m^3/s (118,700 ft^3/s). About one-third of the Hanford Site drains into the Yakima River, which forms a portion of the southern site boundary (Neitzel 1996:4.53–4.55). The average annual flow rate for the Yakima River is about 104 m^3/s (3,670 ft^3/s). Rattlesnake Springs and Snively Springs are in the southwestern portion of the site and flow into intermittent streams. Flows received by these streams infiltrate rapidly into the surface sediments thereof (DOE 1996a:3-32).

Waters of the Columbia River are used primarily for hydroelectric power, transportation, irrigation and other agricultural purposes, recreation, and municipal domestic water. Hanford uses water from the river for domestic and industrial purposes (DOE 1996a:3-32).

Flooding of the site has occurred along the Columbia River, but chances of recurrence have been greatly reduced by the construction of dams to regulate river flow. No maps of flood-prone areas have been produced by the Federal Emergency Management Agency (FEMA). FEMA produces these maps for areas capable of being developed, and the Hanford Site is not designated for commercial or residential development (DOE 1996b:4-22). However, analyses have been completed to determine the potential for the probable maximum flood. This is determined through hydrologic factors, including the amount of precipitation within the drainage basin, snow melt, and tributary conditions. The probable maximum flood for the Columbia River below the Priest Rapids Dam has been calculated at 39,600 m^3/s (1.4 million ft^3/s). Figure 3–6 shows the elevations of the highest flood of record, the river at normal flow, the 1948 flood, and the probable maximum flood (DOE 1996b:4-23).

Potential flooding due to dam failure has been evaluated by the U.S. Army Corps of Engineers (USACE). Upstream failures could have any number of causes, the magnitude of the resultant flooding depending on the size of the breach in the dam. USACE evaluated various scenarios for failure of the Grand Coulee Dam and assumed flow conditions of about 11,300 m^3/s (400,000 ft^3/s). The worst-case scenario assumed a 50 percent breach in the dam (Figure 3–7). The flood wave from an instantaneous 50 percent breach was calculated to be 595,000 m^3/s (21 million ft^3/s). In addition to the areas affected by the probable maximum flood, the remainder of the 100 Area, the 300 Area, and nearly all of Richland, Washington, would be flooded. Determinations were not made for larger instantaneous breaches in the Grand Coulee Dam, because the 50 percent scenario was believed to be the largest conceivable flow from a natural or manmade breach. It was not considered credible that a structure as large as the Grand Coulee Dam could be 100 percent destroyed instantaneously. The analysis also assumed that the 50 percent breach would occur only as the result of direct explosive detonation, and not because of some natural event such as an earthquake (DOE 1996b:4-24).

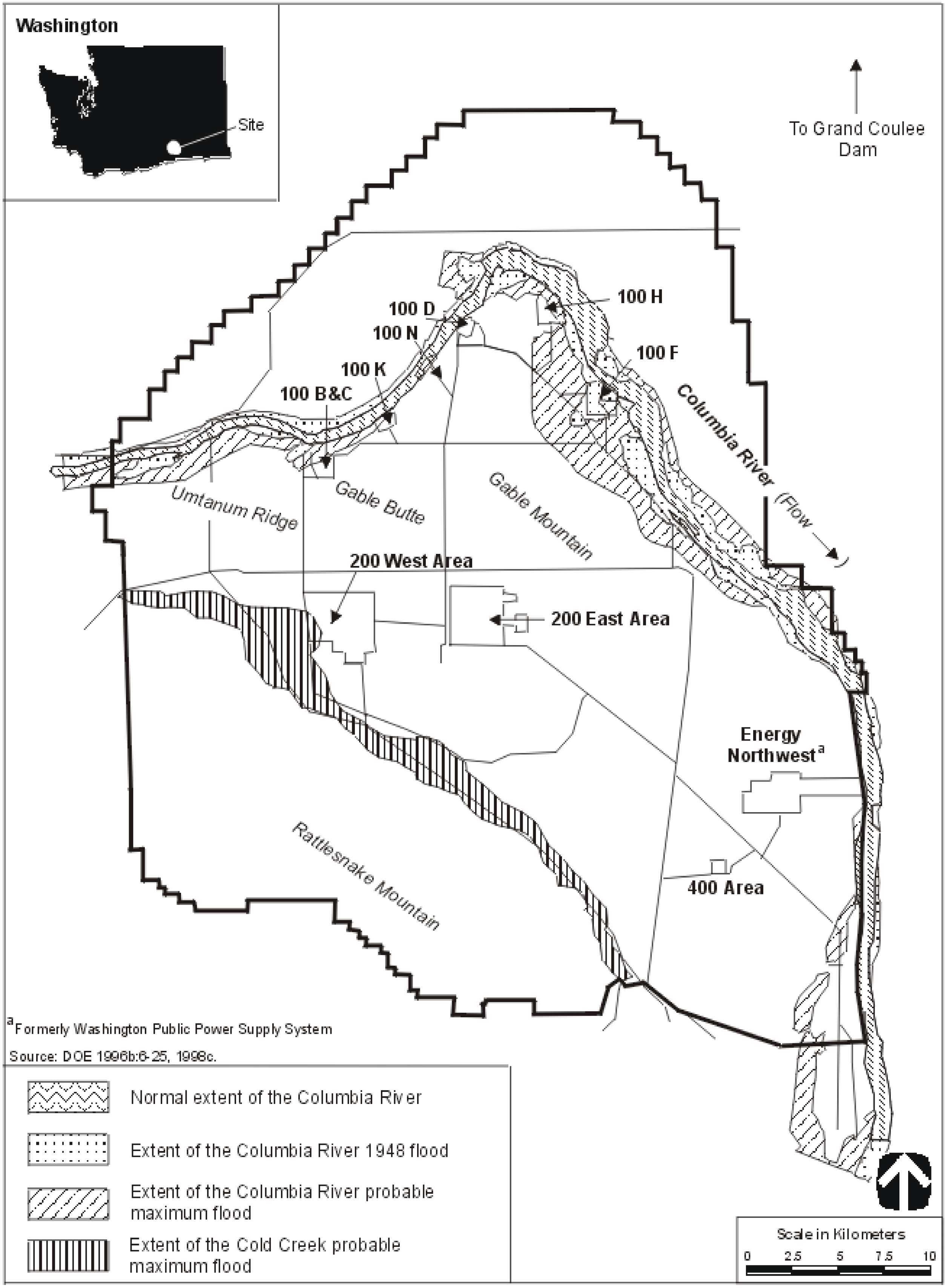


Figure 3–6. Flood Area for the Probable Maximum Flood and Columbia River 1948 Flood