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Hanford Remedial Action Preliminary Draft Environmental Impact Statement

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Volume 1 of 2

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Cover Sheet

Responsible Agencies: Lead Federal Agency: U.S. Department of Energy

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Abstract: This document analyzes the potential environmental impacts associated with establishing future land-use objectives for the U.S. Department of Energy's Hanford Site. Impact analysis is performed by examining the consequences (primarily from remediation activities) of the actions necessary to achieve a desired future land-use objective. It should be noted that site-specific decisions regarding remediation technologies and remediation activities would not be made by this document, but rather by processes specified in the *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA) and the *Resource Conservation and Recovery Act of 1976* (RCRA).

To facilitate the establishment of future land-use objectives, the Hanford Site was divided into four geographic areas: (1) the Columbia River, (2) Reactors on the River, (3) the Central Plateau, and (4) All other Areas. The alternatives considered for each of the geographic areas are as follows:

- Columbia River--Unrestricted and Restricted
- Reactors on the River--Unrestricted and Restricted
- Central Plateau--Exclusive
- All Other Areas--Restricted.

A No-Action Alternative also is included to provide a baseline against which the potential impacts of the proposed action can be assessed.

Public Comments: Public meetings on the Draft Environmental Impact Statement will be announced in February of 1996. Written and oral comments on the Draft Environmental Impact Statement will be accepted until April 3, 1996, at the Washington State address and telephone number provided above. The U.S. Department of Energy will consider these public comments in preparing the Final Environmental Impact Statement.

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Summary

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Summary

The U.S. Department of Energy (DOE) proposes to develop future land-use objectives for the Hanford Site, based primarily on the consideration of potential environmental impacts associated with remediation activities. This effort would facilitate the development of a coordinated strategy for remediation of Hanford Site hazardous and radioactive waste sites, by integrating the consideration of potential future Hanford Site uses into remediation decisions. Adoption of this coordinated strategy would ensure that remediation goals for the Hanford Site are coordinated both with DOE requirements for land and other resources needed for the remediation project and with other DOE missions. Developing future land-use objectives would help to ensure that the DOE makes the most effective use of Hanford Site resources while providing for protection of human health and the environment during remediation. A decision regarding future land-use objectives would also identify limitations or constraints on potential Hanford Site land uses that may be necessary or desirable as a result of residual contamination.

Pursuant to the requirements of the *National Environmental Policy Act of 1969* (NEPA), the DOE has determined that the proposed action to develop future land-use objectives for the Hanford Site is a major federal action that requires the preparation of an Environmental Impact Statement (EIS). This EIS has been prepared in response to those requirements, consistent with both the *Council on Environmental Quality Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act* and the *National Environmental Policy Act Implementing Procedures,* which provide DOE-specific procedures for NEPA compliance. This EIS addresses those requirements by evaluating the environmental impacts of remedial activities necessary to achieve a range of alternative future land-use objectives for the Hanford Site. Potential impacts resulting from both physical disturbance and human and wildlife exposures to radiological and chemical contaminants during remediation are evaluated for each alternative, including the No-Action Alternative. The No-Action Alternative assumes that no remedial actions take place, but that continued monitoring, maintenance, and Hanford Site security activities would occur.

During the public scoping process, in an attempt to foster participation by interested stakeholders, the Hanford Future Site Uses Working Group (Working Group) was established to develop a vision for the future of the Hanford Site. For the purposes of analysis, the Working Group members divided the Hanford Site into six distinct geographic areas and considered three cleanup scenarios for each geographic area. The *Hanford Remedial Action Environmental Impact Statement* (HRA-EIS) has adopted the geographic area and cleanup scenario concept developed by the Working Group. The alternatives for future land-use objectives are described with respect to four specific geographic areas of the Hanford Site:

- Columbia River (Hanford Reach)
- Reactors on the River (100 Areas)
- Central Plateau (200 Areas), and
- All Other Areas (300, 400, 600, and 1100 Areas).

The other two geographic areas of the Hanford Site: the North Slope and the Fitzner/Eberhardt Arid Lands Ecology (ALE) Reserve, have already been remediated under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) statute. Therefore, evaluation of potential environmental consequences of remediation of these geographic areas is unnecessary.

Purpose and Need for Action

As stated above, future land-use objectives need to be established, through the NEPA process, to assist the DOE in developing a cost-effective, technically-sound remediation strategy for the Hanford Site. In making decisions on future land-use objectives, the DOE must holistically consider the environmental and human health impacts of remediation, as well as other ongoing or planned future actions at the Hanford Site. Future land-use objectives are the basis for establishing remedial action objectives under CERCLA and for identifying the corresponding preliminary remediation goals, using existing standards, readily available risk information, and other site-specific, risk-related factors. Establishment of land-use objectives is expected to make the remedial action decision-making process more streamlined and cost-effective. In the absence of future land-use objectives, remedial activities at the Hanford Site would continue under CERCLA and the *Resource Conservation and Recovery Act of 1976* (RCRA) on a case-by-case basis.

Description of Alternatives

The proposed action for the HRA-EIS is to establish future land-use objectives for the main portion of the Hanford Site. Establishing future land-use objectives would result in a more simplified process of determining appropriate cleanup levels for a given area and minimize the likelihood of making inconsistent remediation decisions at the operable unit level. Establishing land-use objectives would ensure that remediation of the Hanford Site reduces human health risks to acceptable levels, while making the most efficient use of available\appropriate resources. The EIS will not select or recommend specific remediation technologies, because decisions to deploy specific technologies would be made through the CERCLA/RCRA regulatory processes.

The Working Group developed a range of three possible cleanup scenarios: unrestricted use, restricted use, and exclusive use. For the purposes of this analysis, the Working Group cleanup scenarios were modified to reflect the needs of the DOE's continuing mission at the Hanford Site. The cleanup scenarios used in this evaluation are defined as follows:

- Unrestricted Land Use--Contamination does not preclude any human uses. However, access or certain uses may be prohibited for other reasons (e.g. physical hazards, cultural resource protection, habitat protection).

- Restricted Land Use--Residual contamination precludes some human uses. Restrictions could apply to the surface soils, subsurface soils, surface water, or groundwater.

- Exclusive Land Use--Potential health risks limit uses and require strict controls on access. Use of the area would be limited to the management and/or disposal of radioactive and hazardous materials and similar, compatible uses. Control of the area would be maintained by the DOE. Exclusive use areas could include buffer zones around active facilities.

These categories establish broad remediation goals representing the aggregate condition of each geographic area. Although portions of the Hanford Site are uncontaminated, future uses of each geographic area would be bounded by the amount of remediation that can be achieved at waste sites rather than by the condition of uncontaminated areas.

After screening each potential future land-use alternative against five criteria developed in accordance with Council on Environmental Quality guidance (identified in Chapter 3), the following table depicts alternatives that were retained for detailed evaluation for each geographic area. The shaded areas of the table indicate future land-use alternatives determined to be unreasonable based on failure to meet one or more screening criteria.

The Affected Environment

This section describes the Hanford Site and the existing environment. The Hanford Site lies within the semiarid Pasco Basin of the Columbia Plateau in southeastern Washington and occupies an area of about 1,450 km^2 (560 mi^2), northwest of the confluence of the Yakima River with the Columbia River. The Hanford Site is about 50 km (31 mi) north to south and 39 km (24 mi) east to west. This land, with restricted public access, provides a buffer for the smaller areas formerly used for production of nuclear materials, and currently used for waste storage and disposal. The Columbia River flows through the northern part of the Hanford Site, and turning south, forms part of the eastern boundary of the site. The Yakima River runs along part of the southern boundary and joins the Columbia River below the City of Richland, which bounds the Hanford Site on the southeast. The cities of Richland, Kennewick, and Pasco, known as the Tri-Cities, constitute the nearest population centers and are located southeast of the Hanford Site.

The Hanford Site is a relatively large, predominantly undisturbed, area of shrub-steppe habitat containing numerous plant and animal species adapted to the semiarid environment of the region. The Site consists of mostly undeveloped land with widely spaced clusters of industrial buildings located along the western shoreline of the Columbia River and at several locations in the interior of the Hanford Site. The industrial buildings are interconnected by roads, railroads, and electrical transmission lines. The major facilities and activities occupy about 6% of the total available land area. The proposed actions would occur on the main portion of the Hanford Site, bounded to the south and east by State Route 240 and bounded to the north and east by the Columbia River. The scope of the EIS excludes the ALE and North Slope.

Table 3-2. Screening of Potential Future Land-Use Alternatives.

Geographic Area	Future Land-Use Alternatives		
Columbia River	U	R	
Reactors on the River	U	R	E
Central Plateau	U	R	E
All Other Areas	U	R	E

E = Exclusive
R = Restricted
U = Unrestricted.

Dominant plants on the Hanford Site are big sagebrush, rabbitbrush, cheatgrass, and Sandberg's bluegrass, with cheatgrass providing half of the total plant cover over a portion of the Site. Specialized plant communities include upland shrub-steppe habitat, characterized by sagebrush-dominated communities with grasses composing the understory; trees, which were planted by homesteaders in association with agricultural areas; riparian areas, including sloughs, backwaters, shorelines, and islands associated with the Columbia River; and relatively specialized plant communities associated with unique topographic features such as basalt outcrops, cliffs, and sand dunes.

The Hanford Site supports a variety of terrestrial and aquatic wildlife species, including federal and state listed endangered, threatened, candidate, and sensitive species. Species of concern include the fall chinook salmon, considered by tribal governments to be one of the most significant natural resources on the Hanford Site; bald eagle, American white pelican, loggerhead shrike, long-billed curlew, and sage sparrow. As unfragmented habitat disappears elsewhere in the Columbia Basin, the relatively undisturbed plant and animal communities at Hanford become increasingly valuable from a regional perspective.

Due to construction of dams elsewhere in the Columbia River system, the Hanford Reach is one of the few remaining archaeologically rich areas in the western Columbia Plateau. The Hanford Reach contains numerous well-preserved archaeological sites representing prehistoric, historic, and contact periods and is still thought of as a homeland by many Native American people. Historic period resources include sites, buildings, and structures from the pre-Hanford Site, Manhattan Project, and Cold War eras.

Benton and Franklin counties experience most of the economic and social consequences of activities at the Hanford Site. The counties, which contain the Tri-Cities, are very dependent upon Hanford Site operations for employment and revenue. Population growth in the counties is strongly influenced by actions at the Hanford Site. The two main economic sectors in these counties are Hanford Site activities and agriculture.

Land near the Hanford Site is generally flat with little relief. Rattlesnake Mountain, rising to 1,060 m (3,477 ft) above mean sea level, forms the western boundary of the Hanford Site. Gable Mountain and Gable Butte are the highest land forms within the Hanford Site. The Columbia River, flowing across the northern part of the Hanford Site and forming the eastern boundary, is generally considered scenic, contrasting blue against a background of brown basaltic rocks and desert sagebrush. The White Bluffs, steep whitish-brown bluffs adjacent to the Columbia River and above the northern boundary of the river, are a strong feature of the landscape.

Movement of contaminants through groundwater, soils, and other environmental media is routinely monitored to determine impacts to the public, workers, and the environment. The *Hanford Site Environmental Report for Calendar Year 1994* summarizes recent data on effluent monitoring and environmental surveillance. Wastewaters discharged on the Hanford Site have reached groundwater and surface waters. Constituents detected in groundwater include tritium, iodine-129, technetium-99, uranium, nitrate, carbon tetrachloride, and chromium. Columbia River water quality monitoring shows higher concentrations of tritium, iodine-129, and uranium downstream of the Hanford Site than concentrations found at upstream monitoring locations.

Environmental Consequences

Chapter 5 of the EIS analyzes potential consequences of each alternative on resource areas such as air, water, ecology, noise, socioeconomics, and cultural resources. The following sections summarize the comparison of primary impacts and provide general observations regarding tradeoffs of beneficial and adverse impacts likely to be encountered during remediation necessary to accommodate future land-use objectives at the Hanford Site.

Human Health Risks

Potential risks to a human receptor under the No-Action Alternative were estimated for four exposure scenarios: agricultural, residential, industrial, and recreational. Assumptions were made for each of these scenarios concerning the type and magnitude of contact with potentially contaminated media (soil, water, air, food). Incremental lifetime cancer risks were estimated for cancer-causing radionuclides and chemicals. The resulting values were compared to the 10^{-4} to 10^{-6} (one in ten thousand to one in 1 million) range suggested by the Environmental Protection Agency in 40 CFR 300 as a target risk level following remediation of hazardous waste sites. Noncancer risks were estimated as the hazard index, the ratio of the estimated exposure to a threshold value below which toxic effects would not be expected.

Under the No-Action Alternative, the estimated cancer risk for all scenarios is geographically concentrated in the Central Plateau and the Reactors on the River geographic areas, with only limited areas in All Other Areas geographic area above the acceptable range. The greatest estimated risks are posed by the agricultural and residential scenarios, with lower risks posed by the industrial scenario and the lowest risks posed by the recreational scenario. A similar pattern holds for noncancer effects. These differences are a direct function of the importance of various exposure pathways contributing to health risks at the Hanford Site. The primary source of potential risk is consumption of contaminated groundwater. For purposes of comparison, the hypothetical farmer and resident consume the greatest amounts of groundwater, followed by the industrial worker and recreational user. As described in Chapter 5, estimated risks remain above the target range for at least some areas of the Hanford Site for a minimum of 10,000 years for all four scenarios, primarily as a result of the contribution to risk of groundwater consumption.

These observations suggest that, to ensure protection of human health, continued control of access and use of the Hanford Site must be maintained, particularly access to groundwater. Otherwise, contamination at the Hanford Site must be completely removed or isolated. However, the remedial activities necessary to remove and/or isolate contamination are themselves not without risk, due to the potential for worker exposure to contaminants and accidents during remediation. This issue was addressed by estimating the potential consequences of several types of accidents that could occur during remediation (i.e., a shoreline excavation accident, a range fire, a soil dispersion accident, and a fire in a groundwater filtration unit). A shoreline excavation accident could occur during remediation of the Columbia River and would release contaminants to the river. A range fire, which could occur under any alternative for the other three geographic areas, would release contaminants taken up by plants. A soil dispersion accident, caused by the ignition of reactive material in a container encountered during the excavation of a waste site, would disperse contaminants through the air. A fire in a filtration unit used for treating groundwater would similarly release contaminants to the air. Only the shoreline excavation accident was considered applicable to the Columbia River geographic area; the other three accidents were evaluated for the other three geographic areas.

Accident analyses indicate that estimated cancer risks to the maximally exposed individual due to a shoreline excavation accident or a range fire would be within or below the target risk range of 10^{-4} to 10^{-6} in areas for which these accidents were evaluated. Estimated risk due to a soil dispersion accident exceeds the target range for the Central Plateau, and the groundwater treatment accident exceeds the target for the three geographic areas for which this accident was evaluated.

Consideration of tradeoffs involved in remediation to the degree required to support various alternative land-use objectives should include comparisons between the estimated risk of the No-Action Alternative, risks associated with remediation accidents, and the target risk range following remediation. This EIS assumes the target risk range (10^{-4} to 10^{-6}) would be met regardless of selected combinations of remedial technologies and use goals. In addition, potential impacts of the alternatives that are not directly related to health risk must be considered. Some of these impacts are highlighted in the following sections.

Ecological Impacts

Potential impacts on ecological resources at the Hanford Site present tradeoffs similar in nature to those for human health. Monitoring data indicate that current Hanford Site activities have only a minimal impact on ecological receptors. Potential radiological and chemical effects on ecological receptors were estimated using a methodology analogous to the methodology used for estimation of human health risk. Results were expressed as estimated radiation doses and as hazard indices for nonradioactive chemicals. The calculated radiation doses and hazard indices suggest potential future radiological and chemical hazards for ecological receptors in the Reactors on the River, Central Plateau, and All Other Areas geographic areas, but not in the Columbia River geographic area.

Conversely, potential ecological impacts of remedial activities are substantial. Major potential impacts of remediation to allow future land-use objectives include physical destruction of habitat by waste removal and construction activities, soil excavation, noise, disturbance of wildlife due to increased human presence, and potential contaminant releases during remediation. Restoration planned for remediated waste sites would reduce impacts, but would be unlikely to return disturbed habitats to their original condition in the short-term because the original habitats developed over long periods of time. Further, release of currently controlled areas of the Hanford Site for agricultural or industrial development would lead to additional habitat destruction. Impacts to biodiversity at the Hanford Site could occur as a result of habitat destruction and fragmentation.

Cultural Resources

Abundant cultural resources occur on the Hanford Site. These resources include prehistoric sites and associated artifacts representing Native American cultures, historic properties representing early settlements, and more recent structures associated with the Manhattan Project and Cold War eras. Remedial activities to facilitate the various alternative land-use objectives could have both adverse and beneficial impacts on cultural resources. Ground disturbance has the potential to destroy a wide variety of known and presently undiscovered cultural artifacts. Removal or isolation of contamination could permit tribal members safe access to traditional use areas not currently available, but might also increase the likelihood of vandalism at these sites due to general increased public access. Similarly, decommissioning of structures would effectively remove the associated radiological and chemical hazards from the Hanford Site, but certain structures have historical significance in the context of World War II and the Cold War. Mitigation measures, such as data recovery, could reduce but not completely eliminate adverse impacts to cultural resources resulting from remediation activities.

Impacts to Soils and Geologic Resources

Some impacts to soils would occur regardless of the land-use alternative selected. Soil disturbance under the No-Action Alternative would be associated with stabilization of waste sites. Soil disturbance would also occur as a result of compaction by heavy equipment. Disturbed soils would have an increased potential for erosion. Soil disturbance also could result in adverse impacts to ecological resources. Invasive nonnative plant species, such as cheatgrass, could gain a foothold in an area by colonizing disturbed areas. Furthermore, soil compaction and erosion could have an adverse effect on efforts to revegetate disturbed areas after implementation of a remedial action or stabilization of a waste site. Nevertheless, some soil disturbance will be necessary to achieve the goal of protecting human health and the environment. Soil disturbance could be mitigated by restricting heavy equipment to trample zones, using established transportation routes to minimize damage to undisturbed soil and vegetation, using silt fences and dust control measures to reduce soil erosion, and reseeding disturbed areas with native vegetation to reduce long-term soil loss from wind and water erosion. These mitigating measures would minimize, but not completely eliminate, impacts to soils.

Impacts to geologic resources potentially include destruction of some unique geologic features during remediation, restrictions on access to unique geologic features, depletion or exhaustion of geologic resources at existing or proposed borrow areas and quarry sites, and restrictions on future public access to sand and gravel resources. Implementation of the reference cap, at many or all waste sites, would require substantial volumes of geologic materials (soil, sand, gravel, and basalt). The greatest volume of a particular material used in construction of the reference cap would be basalt. Potential quarry sites include near surface basalt benches and basalt outcrops. Obtaining the basalt either would leave a large open pit that may be difficult to reclaim and would not conform to the surrounding terrain, or, depending on volume, would impact or remove a basalt outcrop that may be of religious significance to Native Americans. Caps would also alter viewscapes at the Hanford Site. Impacts to geologic resources could be mitigated, but not eliminated, through the use of alternate cap designs. For example, the requirement for basalt would be substantially reduced if a modified RCRA cap were implemented for waste sites on the Central Plateau and other waste sites.

Impacts to Air Resources

Impacts to air resources that would result from implementation of remedial activities at the Hanford Site would primarily consist of generation of fugitive dust and pollutant emissions from fuel consumption by heavy equipment. Small amounts of fugitive dust would be generated under the No-Action alternative in association with stabilization of waste sites. Dust would also be generated if waste sites were excavated. Under these scenarios, the dust generated could potentially be contaminated with radionuclides or hazardous materials. Use of protective caps to prevent contaminant migration would also lead to dust generation from excavation, hauling, and placement of cap materials. Machinery used to implement a remedial action at a waste site, either excavation or cap construction, would consume large quantities of fuel, resulting in release of atmospheric pollutants. Ambient air quality standards are not likely to be exceeded in the long term and emissions would be temporary, subsiding upon completion of the action. Various mitigation measures would be implemented to minimize emissions of fugitive dust, including use of water or surfactants to minimize releases from storage piles, gravel roads, and disturbed areas; tarping or otherwise covering all loads during hauling; or construction of temporary enclosures over excavation sites.

Water Resources

Potential impacts to surface water, specifically the Columbia River, could occur as a result of either the No-Action Alternative or a result of remediation to either restricted future land-use or unrestricted future land use in this geographic area. Under the No-Action Alternative, contaminant releases could occur as a result of natural scouring and erosion. These natural processes would continue to expose and detach river discharge pipelines and to mobilize contaminated shoreline sediments. Conducting remedial activities within the river would also have the potential to release radiological and chemical contaminants and would involve disturbance of the floodplain. Use of cofferdams within the river could increase the river stage and velocity, potentially leading to increased erosion and contaminant releases. Contaminants in unremediated soils and waste sites could be transported to groundwater which would ultimately transport these contaminants to the river. In the long-term, remedial activities would have a beneficial impact on the Columbia River either through removal of contaminants from the river and groundwater or by preventing contaminant migration.

Potential impacts to groundwater include transport of contaminants from waste sites into the groundwater; continued expansion of contaminant plumes under the No-Action Alternative; and temporary localized changes in groundwater levels and flow direction associated with pump-and-treat remedial activities. Capping of wastes sites or removal of contaminants from the vadose zone would prevent migration of those contaminants to the groundwater. Groundwater treatment strategies could be used to prevent migration of contaminated groundwater from one geographic area to another and could be protective of the Columbia River. Long-term impacts to groundwater that would occur as a result of remedial activities would be beneficial.

Potential Mitigation Measures

Several mitigation measures have been identified in Chapter 5. Most of these measures represent good engineering practices. Certain sensitive resource areas require additional measures that are summarized here.

An area of particular concern for the Hanford Site is protection of cultural resources. Disturbance of these resources would be avoided whenever possible. Mitigating measures to reduce adverse impacts to historic, cultural, or archaeological sites include educational programs for personnel involved in remediation activities and consultations with the U.S. Department of Energy, Richland Operations Office Historic Preservation Officer, the Washington State Historic Preservation Office, and concerned Native American Tribes prior to conducting remedial actions. A full survey of potentially affected areas would be conducted, including mapping and data recovery, before disturbance of the area. An archaeological monitor would be on-site during ground disturbing activities. In addition, the National Park Service (NPS) or the U.S. Fish and Wildlife Service (USFWS) would be consulted before beginning actions within the Hanford Reach Study Area.

Species of concern would be protected by prohibiting habitat disturbances during critical times of the year and by conducting surveys to verify the presence or absence of particular species at sites proposed for remediation. Disturbances within an 800-m (0.5-mi) buffer around winter roosts for bald eagles from November 15 to March 15 would be prohibited. Habitat alteration within 400 m (0.25 mi) of bald eagle roosts would be avoided to the extent practicable. A systematic survey for

candidate species such as Columbia yellowcress, the short-faced lanx, and the Columbia pebble snail would be conducted prior to implementing any remedial activities along the Hanford Reach. In addition, the NPS or the USFWS would be consulted before beginning any actions in the Hanford Reach. To the extent practicable, loggerhead shrike and sage sparrow habitat would not be disturbed from March 1 to September 30.

Wetlands disturbance would be avoided whenever possible. A review of ground disturbing activities would be requested from the U.S. Army Corps of Engineers and other interested agencies in cases where potential disturbance of wetlands may occur. Potential mitigating measures would normally be part of the agency review process and could vary from completely avoiding the wetlands to restoring disturbed wetlands by replanting with native species such as cattails, rushes, sedges, and willows. The NPS would be consulted before beginning any intrusive actions in the Hanford Reach, and the DOE would comply with regulations found in *Compliance with Floodplain/Wetlands Environmental Review Requirements*.

Cumulative Impacts

A number of present and reasonably foreseeable future actions at the Hanford Site could contribute to potential cumulative impacts of the remedial actions necessary to achieve various land-use objectives. These include the following:

- Designation of the Hanford Reach of the Columbia River and adjacent lands as a Wild and Scenic River and National Wildlife Refuge,
- Decommissioning of the eight surplus reactors in the Reactors on the River geographic area,
- Construction and operation of the Environmental Restoration Disposal Facility (ERDF) for safe disposal of waste generated during environmental restoration activities at Hanford,
- Potential continued and/or increased storage of spent nuclear fuel at Hanford, and
- Remediation of wastes currently stored in single-shell and double-shell tanks in the Central Plateau.

These and other actions potentially contributing to cumulative impacts are described in Chapter 5, Environmental Consequences. Potential cumulative impacts discussed in this EIS include the following:

- The need for quarry and borrow materials for a number of other Hanford Site actions could result in significant onsite depletion of these materials.
- The large number of ground disturbing activities in the Central Plateau and other areas could result in extensive soil compaction and erosion, destruction of near pristine shrub-steppe habitat, and impacts on species of concern such as sage sparrow, loggerhead shrike, and sage thrasher.
- Recreational use of the Columbia River geographic area due to the proposed Wild and Scenic River designation, combined with unrestricted use of the Columbia River, could significantly disturb native vegetation and wildlife (particularly bald eagles).

- Cumulative impacts on historic, cultural, and archaeological resources are potentially significant for all geographic areas. These impacts could be mitigated to the extent that surveys, and data recovery constitute mitigation, but excavation of sites would unavoidably alter their character and potential value to Native Americans.

- Cumulative impacts on visual resources would be directly proportional to the extent of Hanford Site remedial activity in the short-term and to the extent of viewscape alteration in the long-term. Potential cumulative visual impacts would be concentrated in the Central Plateau and the Reactors on the River geographic areas, as a result of ERDF construction, reactor decommissioning, and reference cap construction, if alternatives involving the latter were selected.

- The potential for cumulative socioeconomic impacts is uncertain and depends on the timespan for remedial actions. Short timespans and large numbers of concurrent actions followed by rapid shutdown and decommissioning of waste treatment facilities, could have significant adverse cumulative impacts on the Tri-Cities economy. The potential for such impacts would need to be reevaluated as project schedules are developed.

Unavoidable Adverse Impacts

The proposed remedial activities could result in the compaction of soils and increased soil erosion. Excavation in and near the Columbia River could result in increases in downstream siltation and sedimentation and destruction of salmon spawning areas. The proposed excavation of waste sites could result in the disturbance of human remains and traditional Native American cultural use sites, as well as the loss of significant prehistoric or historic resources. Permanent loss of habitat could occur for some species of concern, resulting in potential population decline and possible listing of these or additional species as endangered or threatened under the *Endangered Species Act of 1973*. Application of the reference cap would permanently alter the visual landscape.

Irreversible and Irretrievable Commitments of Resources

If a capping alternative using a reference cap is implemented, irreversible and irretrievable resource commitments include significant depletion of the total available reserves at the McGee Ranch, Pit 30, and basalt quarry sites. All borrow and quarry sites are considered to be of cultural value to Native Americans.

Excavation of waste sites has the potential to destroy cultural resources and could result in some permanent destruction of sensitive habitat or loss of sensitive species. The upper limit of habitat loss, if the alternative with the greatest disturbance were chosen for each geographic area, would be 480 ha (1,186 ac) of shrub-steppe, 28 ha (69 ac) of wetlands, and 20 ha (50 ac) of aquatic habitat.

Expenditures of public funds would be required, on the order of $5 to $10 billion, for remediation of all four geographic areas, depending on the alternatives that are selected. Significant expenditures also would be required under the No-Action Alternative (over $2 billion over a 100-year period, assuming continuation of current Hanford Site management practices).

The remedial action alternatives would require the consumption of large quantities of fuel for operation of construction equipment and transport of capping materials and waste. This quantity could be as high as 600 million L (160 million gal), if the most fuel-intensive alternative is selected for each geographic area.

Conflict with Land Use Plans of Other Federal and State Agencies and Tribal Governments

Potential future uses under the Restricted and Unrestricted Future Land-Use Alternatives for the Columbia River and Reactors on the River geographic areas could be considered inconsistent with the proposed Wild and Scenic River designation for the Hanford Reach, because these designations would limit some activities and forbid others along the Hanford Reach. The Unrestricted Future Land-Use Alternative could allow intensive recreational or other uses, which could encroach on traditional tribal fishing areas.

Some alternative uses for the geographic areas, for example exclusive use of the Central Plateau, are not consistent with Native American wishes to exercise treaty-reserved rights on the Hanford Site.

Coordination with local planning agencies (i.e., Benton, Franklin, Grant, and Adams counties, and the cities of Richland, West Richland, Pasco, and Kennewick) would be maintained, especially during the updating of the comprehensive plans for each community.

Environmental Justice

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, requires each federal agency to "make achieving environmental justice part of its mission by identifying and addressing as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations." Low income and minority populations could be disproportionately affected by actions with adverse impacts on fish and wildlife, to the degree that they are more dependent on these resources for food than are other populations. Native Americans would be disproportionately affected by any impacts on areas of traditional cultural uses, including hunting, fishing, gathering, and religious uses. The marginal socioeconomic impacts of some alternatives could have a small disproportionate impact on the cost of low-income housing and the availability of social services. Other potential impacts identified in this EIS are not expected to result in disproportionate impacts on minority groups or low income populations.

Relationship Between Near-term Use and Long-term Productivity

The near-term uses of the Hanford Site under the No-Action and future land-use alternatives would be consistent with current industrial and waste management uses. The net effect of remediation would be to enhance the overall long-term productivity of the Hanford Site by increasing the range of potential permissible uses. All four of the geographic areas currently have at least partial restrictions

on some uses. With one exception, all of the remediation alternatives would permit some of these restrictions to be relaxed, if not eliminated. The exception is the Exclusive Use Alternative for the Central Plateau. This alternative would dedicate the Central Plateau to waste management and other similar, compatible uses and thus preclude its long-term use for other purposes.

In addition, some long-term uses of the Hanford Site may be determined by other actions and decisions outside the scope of this EIS and by future needs and the outcome of the alternatives selected. The optimal alternatives would be those that effectively protect human health and the environment while using public resources effectively and minimizing environmental consequences.

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Acronyms and Helpful Information

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Acronyms and Initialisms

1,2-DCE	1,2-dichloroethylene
ACGIH	American Conference of Government Industrial Hygienists
ACHP	Advisory Council on Historical Preservation
AEA	Atomic Energy Act
AEC	Atomic Energy Commission
AHPA	Archaeological and Historical Data Preservation Act
AIRFA	American Indian Religious Freedom Act
ALE	Arid Lands Ecology
AML	Arc/Info Macro Language
ARPA	Archaeological Resources Protection Act
BCM	bank cubic meter
BCY	bank cubic yard
BLS	Bureau of Labor Statistics
BWIP	Basalt Waste Isolation Project
CAMU	corrective action management unit
CBC	Columbia Basin College
CEDE	committed effective dose equivalent
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFEST	Coupled Fluid, Energy, and Solute Transport
CFEST-SC	Coupled Fluid, Energy, and Solute Transport Supercomputer
CFR	Code of Federal Regulations
CWA	Clean Water Act
D&D	decommissioning and dismantlement
dB	decibels
dBA	A-weighted noise scale
DCG	derived concentration guide
DOE	U.S. Department of Energy
DOE/RL	U.S. Department of Energy, Richland Operations Office
DSTs	double-shell tanks
DWS	drinking water standards
EA	environmental assessment
Ecology	Washington State Department of Ecology
EDE	effective dose equivalent
EDNA	Environmental Designation for Noise Abatement
EIS	environmental impact statement
EM	Office of Environmental Management
EPA	U.S. Environmental Protection Agency

ER	environmental restoration
ERDA	Energy Research & Development Administration
ERDF	Environmental Restoration Disposal Facility
ETM	engineering test model
FEMA	Federal Emergency Management Agency
FFCA	Federal Facility Compliance Act
FFTF	Fast Flux Test Facility
FI	fraction ingested
FTE	full-time equivalent
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
GAC	granular activated carbon
GIS	geographic information system
HCRL	Hanford Cultural Resources Laboratory
HEHF	Hanford Environmental Health Foundation
HI	Hazard Index
HMS	Hanford Meteorological Station
HSBRAM	Hanford Site Baseline Risk Assessment Methodology
HSDP	Hanford Site Development Plan
HSWA	Hazardous and Solid Waste Amendments
HT	tritium gas
HTO	tritiated water vapor
HWVP	Hanford Waste Vitrification Plant
Hz	hertz
IAEA	International Atomic Energy Agency
ID	identification number
ILCR	incremental lifetime cancer rate
IRM	Interim Response Measure
ISV	in situ vitrification
IX	ion exchange
LCM	loose cubic meter
LCY	loose cubic yard
LFI	limited field investigation
LIGO	Laser Interferometer Gravitational Wave Observatory
LLW	low-level waste
MCAS	Mid-Columbia Archaeological Society
MEI	maximally exposed individual
MEPAS	Multimedia Environmental Pollutant Assessment System
MRA	Modular Risk Analysis
MSA	Metropolitan Statistical Area
MSL	mean sea level
MTCA	Model Toxics Control Act
NAAQS	National Ambient Air Quality Standards

NAGPRA	Native American Graves Protection and Repatriation Act
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NESHAPS	National Emissions Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NOAEL	no observed adverse effect level
NOI	Notice of Intent
NPAL	nearest public access location
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPS	National Park Service
NPSB	National Park Service Bulletin
NRC	Nuclear Regulatory Commission
NRHP	National Register of Historic Places
NSSFC	National Severe Storms Forecast Center
NWR	National Wildlife Refuge
O&M	operations & maintenance
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyls
PCE	perchloroethylene
PEL	permissible exposure limit
PFP	Plutonium Finishing Plant (Z-Plant)
PMF	probable maximum flood
PMOA	Programmatic Memorandum of Agreement
PNL	Pacific Northwest Laboratory
PUREX	Plutonium-Uranium Extraction (Plant)
PSZ	partially saturated zone
QA/QC	quality assurance/quality control
R&D	research and development
RAPS	Remedial Action Priority System
RARA	radiation area remedial actions
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
REDOX	Reduction Oxidation Plant (S-Plant)
RI/FS	remedial investigation/feasibility study
RL	Richland Operations Office
RO	reverse osmosis
ROD	Record of Decision
S-Plant	Reduction Oxidation Plant (REDOX)
SCS	Soil Conservation Service
SHPO	State Historic Preservation Officer
SIC	Standard Industrial Classification

SIF	summary intake factor
SMES	Superconducting Magnetic Energy Storage
SPF	standard project flood
SSE	safe-shutdown earthquake
SST	single-shell tank
SWITS	Solid Waste Information Tracking System
TCE	trichloroethylene
TEDF	Treated Effluent Disposal Facility
TLD	thermoluminescence dosimeters
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
TRU	transuranic
TSD	treatment, storage, and disposal
TWRS	Tank Waste Remediation System
UPR	unplanned release
URF	unit risk factor
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
UST	underground storage tanks
UTA	unit transport analysis
UTF	unit transport factor
VOC	volatile organic compound
WDFW	Washington Department of Fish and Wildlife
WESF	Waste Encapsulation and Storage Facility
WHC	Westinghouse Hanford Company
WIDS	Waste Information Data System
Working Group	Hanford Future Site Uses Working Group
WPPSS	Washington Public Power Supply System
WRAP	Waste Receiving and Processing Facility
WSU-TC	Tri-Cities branch campus of Washington State University
Z-Plant	Plutonium Finishing Plant (PFP)

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The following information is provided to assist the reader in understanding the *Hanford Remedial Action Environmental Impact Statement* (EIS).

Scientific Notation

Scientific notation is used in this report to express very large or very small numbers. For example, the number 1 billion could be written as 1,000,000,000 or using scientific notation as 1×10^9. Translating from scientific notation to a more traditional number requires moving the decimal point either left or right from the number. If the value given is 2.0×10^3, the decimal point should be moved three numbers (insert zeros if no numbers are given) to the RIGHT of its present location. The number would then read 2,000. If the value given is 2.0×10^{-5}, the decimal point should be moved five numbers to the LEFT of its present location. The result would become 0.00002. An alternate form of scientific notation is used in some tables in this EIS. In this form, 2.0×10^3 (2,000) is written 2.0E+03. To translate to the traditional form, the decimal point is again moved three numbers to the right, adding zeros as necessary. Similarly, 2.0×10^{-5} (0.00002) would be written as 2.0E-05, and the decimal point would be moved five places to the left to express the number in traditional form.

Metric Units

The primary units used in this EIS are metric, with English equivalents in parentheses in most locations. Table 1 summarizes and defines the terms and corres-ponding symbols (metric and nonmetric) found throughout this EIS.

Radioactivity Units

Much of this EIS deals with levels of radioactivity in various environmental media. Radioactivity in this report is usually discussed in units of curies (Ci) (Table 2). The curie is the basic unit used to describe the amount of radioactivity present, and concentrations are generally expressed in terms of fractions of curies per unit mass or volume. 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. Disintegrations generally produce spontaneous emissions of alpha or beta particles, gamma radiation, or combinations of these. In some reports, radiation values are expressed in units which belong to the International System of Units (SI). SI units are the internationally accepted units and will eventually be the standard for reporting radioactivity and radiation dose in the United States. The basic unit for discussing radioactivity, the curie, can be converted to the equivalent SI unit, the becquerel (Bq), by multiplying the number of curies by 3.7×10^{10}. One becquerel is equivalent to one nuclear disintegration per second.

Radiation Dose Units

The amount of radiation received by a living organism is expressed in terms of radiation dose. Radiation dose is the amount of energy deposited per unit mass of the organism and is

expressed in rads (grays in SI units). Doses to ecological receptors are expressed in rads in this EIS. Radiation dose to humans in this EIS is usually written in terms of effective dose equivalent and reported numerically in units of rem (Table 3). Rem (sievert in SI units) is a term that relates ionizing radiation dose and biological effect in humans. A dose of 1 millirem (one-thousandth of a rem) has a biological effect similar to the dose received from about a 1-day's exposure to natural background radiation. For a specific radionuclide depositing a radiation dose in a specific tissue (e.g., muscle, bone, etc.), a rad is approximately equal to a rem.

To convert the rad to the SI equivalent, the gray, multiply rads by 0.01. To convert the millirem to its SI equivalent, the millisievert, multiply millirem by 0.01. A list of the radionuclides discussed in this EIS and their half-lives is included in Table 4.

General information on radiation and radiation dose (as well as Hanford's Environmental Monitoring Program, Hanford's Cultural Resource Program, and Hanford's wildlife) has been compiled in informational pamphlets that can be obtained, free, by writing to Richard E. Jaquish, Manager, Public Safety and Resource Protection Program, P.O. Box 999, Richland, Washington 99352. More comprehensive readings on radiation and radiation dose can be found in most public libraries and in many local book stores.

Greater Than (>) or Less Than (<) Symbols

Greater than (>) or less than (<) symbols are used in some tables 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. An inequality symbol pointed in the opposite direction (<0.09) would indicate that the number is less than the value presented. If an inequality symbol is used in association with an underscore (≤ or ≥), this indicates that the actual value is less-than-or-equal-to or greater-than-or-equal-to the number given, respectively. Some single values in this EIS have less than symbols in front of them, for example, <0.4 ha (<1 ac). This means that the actual value is less than the stated one, but the analysis does not allow the real value to be stated with precision.

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Table 1. Names and symbols for units of measure.

Length

cm	centimeter (1×10^{-2} m)
ft	foot
in.	inch
km	kilometer (1×10^{3} m)
m	meter
mi	mile
mm	millimeter (1×10^{-3} m)
µm	micrometer (1×10^{-6} m)

Area

ha	hectare (1×10^{4} m^2)
km^2	square kilometer
mi^2	square mile
ft^2	square foot

Volume

BCM	bank cubic meters
BCY	bank cubic yards
cm^3	cubic centimeter
ft^3	cubic foot
gal	gallon
L	liter
LCM	loose cubic meters
LCY	loose cubic yards
m^3	cubic meter
mL	milliliter (1×10^{-3} L)
ppb	parts per billion
ppm	parts per million
yd^3	cubic yard

Time

d	day
h	hour
min	minute
s	second
yr	year

Temperature

°C	degrees Centigrade
°F	degrees Fahrenheit

Rate

cms	cubic meters per second
cfs	cubic feet per second
gpm	gallons per minute
kph	kilometers per hour
mph	miles per hour

Mass

g	gram
kg	kilogram (1×10^{3} g)
mg	milligram (1×10^{-3} g)
µg	microgram (1×10^{-6} g)
ng	nanogram (1×10^{-9} g)
lb	pound
wt%	weight percent

Table 2. Names and symbols for units of radioactivity.

Ci	curie
cpm	counts per minute
mCi	millicurie (1×10^{-3} Ci)
µCi	microcurie (1×10^{-6} Ci)
nCi	nanocurie (1×10^{-9} Ci)
pCi	picocurie (1×10^{-12} Ci)
aCi	attocurie (1×10^{-18} Ci)
Bq	becquerel

Table 3. Names and sumbols for units of radiation dose.

mrad	millirad (1×10^{-3} rad)
mrem	millirem (1×10^{-3} rem)
Sv	sievert
mSv	millisievert (1×10^{-3} Sv)
µSv	microsievert (1×10^{-6} Sv)
R	roentgen
mR	milliroentgen (1×10^{-3} R)
µR	microroentgen (1×10^{-6} R)
Gy	gray

Table 4. Radionuclide nomenclature.

Symbol	Radionuclide	Half-Life	Symbol	Radionuclide	Half-Life
^{3}H	tritium	12.3 yr	^{144}Ce	cerium-144	284 d
^{7}Be	beryllium-7	53.4 d	^{147}Pm	promethium-147	2.6 yr
^{14}C	carbon-14	5730 yr	^{152}Eu	europium-152	13.3 yr
^{22}Na	sodium-22	2.6 yr	^{154}Eu	europium-154	8.8 yr
^{40}K	potassium-40	1.3×10^{8} yr	^{155}Eu	europium-155	5 yr
^{41}Ar	argon-41	1.8 h	^{208}Tl	thallium-208	3.1 min
^{51}Cr	chromium-51	27.7 d	^{212}Bi	bismuth-212	61 min
^{54}Mn	manganese-54	312 d	^{212}Pb	lead-212	10.6 h
^{57}Co	cobalt-57	270.9 d	^{212}Po	polonium-212	0.3×10^{-6} s
^{60}Co	cobalt-60	5.3 yr	^{216}Po	polonium-216	0.15 s
^{63}Ni	nickel-63	96 yr	^{220}Rn	radon-220	56 s
^{65}Zn	zinc-65	243.9 d	^{222}Rn	radon-222	3.8 d
^{85}Kr	krypton-85	10.7 yr	^{226}Ra	radium-226	1600 yr
^{89}Sr	strontium-89	50.5 d	^{228}Ra	radium-228	5.8 yr
^{90}Sr	strontium-90	21.1 yr	^{232}Th	thorium-232	1.4×10^{10} yr
^{95}Nb	niobium-95	35 d	U or uranium[a]	uranium total	—
^{95}Zr	zirconium-95	64 d	^{234}U	uranium-234	2.4×10^{5} yr
^{99}Mo	molybdenum-99	66 h	^{235}U	uranium-235	7×10^{8} yr
^{99}Tc	technetium-99	2.1×10^{5} yr	^{236}U	uranium-236	2.3×10^{7} yr
^{103}Ru	ruthenium-103	39.3 d	^{238}U	uranium-238	4.5×10^{9} yr
^{106}Ru	ruthenium-106	368 d	^{238}Pu	plutonium-238	87.7 yr
^{125}Sb	antimony-125	2.8 yr	^{239}Np	neptunium-239	2.4 d
^{129}I	iodine-129	1.6×10^{7} yr	^{239}Pu	plutonium-239	2.4×10^{4} yr
^{131}I	iodine-131	8 d	^{240}Pu	plutonium-240	6.5×10^{3} yr
^{133}Ba	barium-133	10.7 yr	^{241}Pu	plutonium-241	14.4 yr
^{134}Cs	cesium-134	2.1 yr	^{241}Am	americium-241	432 yr
^{137}Cs	cesium-137	30 yr			

(a) Total uranium may also be indicated by U-natural (U-nat) or U-mass.

CONVERSION TABLE

Multiply	By	To Obtain	Multiply	By	To Obtain
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft
mi	1.61	km	km	0.621	mi
lb	0.454	kg	kg	2.205	lb
gal	3.785	L	L	.0264	gal
ft^2	0.093	m^2	m^2	10.76	ft^2
acres	0.405	ha	ha	2.47	acres
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.7	ft^3
nCi	0.001	pCi	pCi	1,000	nCi
pCi/L	10^{-9}	µCi/mL	µCi/mL	10^{9}	pCi/L
pCi/m^3	10^{-12}	Ci/m^3	Ci/m^3	10^{12}	pCi/m^3
pCi/m^3	10^{-15}	mCi/cm^3	mCi/cm^3	10^{15}	pCi/m^3
mCi/km^2	1.0	nCi/m^2	nCi/m^2	1.0	mCi/km^2
becquerel	2.7×10^{-11}	curie	curie	3.7×10^{10}	becquerel
gray	100	rad	rad	0.01	gray
sievert	100	rem	rem	0.01	sievert
ppb	0.001	ppm	ppm	1,000	ppb
°F	(°F - 32) + 9/5	°C	°C	(°C x 9/5) + 32	°F
oz	28.349	g	g	.035	oz
yd^3	0.765	m^3	m^3	1.308	yd^3
LCY	0.765	LCM	LCM	1.308	LCY
BCY	0.765	BCM	BCM	1.308	BCY

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_3	ammonia
Br	bromine	NH_4^+	ammonium
C	carbon	N	nitrogen
Ca	calcium	Na	sodium
CaF_2	calcium fluoride	Ni	nickel
CCl_4	carbon tetrachloride	NO_2^-	nitrate
Cd	cadmium	NO_3^-	nitrate
$CHCl_3$	trichloromethane	Pb	lead
Cl^-	chloride	PO_4^{-3}	phosphate
CN^-	cyanide	P	phosphorus
Cr VI	chromium (species)	Sb	antimony
Cr	chromium (total)	Se	selenium
CO_3^{-2}	carbonate	Si	silicon
Co	cobalt	Sr	strontium
Cu	copper	SO_4^{-2}	sulfate
F^-	fluoride	Ti	titanium
Fe	iron	Tl	thallium
HCO_3^-	bicarbonate	V	vanadium
Hg	mercury	Zn	zinc

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Introduction

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1.0 Introduction

The *Hanford Remedial Action Environmental Impact Statement* (HRA-EIS) considers alternatives for the development of future land-use objectives at the Hanford Site. The HRA-EIS considers several broad classifications of potential future land uses to assist the U.S. Department of Energy (DOE) in establishing a coordinated, cost-effective, and technically sound remediation strategy for the Hanford Site. Future land-use objectives are the bases for establishing remedial action objectives under the *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA) and identifying the corresponding preliminary remediation goals (using existing standards, readily available risk information, and other site-specific, risk-related factors). This allows the future remediation decisionmaking process, as established by the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989), to facilitate the evaluation of remedial actions that can meet remediation goals needed to achieve a desired future land-use objective. Overall, the HRA-EIS presents information that will assist decisionmakers in determining potential future land uses for the Hanford Site. It also provides an assessment of the impacts (primarily from remediation activities) associated with achieving a desired future land use. Site-specific decisions regarding remediation technologies and remediation activities will not be made by this Environmental Impact Statement (EIS), but by processes specified by the CERCLA and the *Resource Conservation and Recovery Act of 1976* (RCRA). This EIS uses general bounding assumptions regarding future remediation activities to assess the potential associated environmental impacts, because future remediation decisions will be made through CERCLA and RCRA processes. These conservative assumptions ensure that the range of environmental impacts, considered necessary to facilitate land-use objectives, adequately encompass probable future impacts.

1.1 Background on the Hanford Remedial Action Environmental Impact Statement

On August 21, 1992, the DOE published a Notice of Intent (NOI) in the *Federal Register* (FR) to prepare an EIS (57 FR 37959). The NOI invited members of the public and Tribal, state, and local governments to comment on the preliminary scope, content, and alternatives to be addressed in the HRA-EIS. The NOI scheduled the HRA-EIS scoping period for August 21, 1992, to November 25, 1992. At the public's request, the scoping period was extended to January 25, 1993.

As directed by the NOI, the DOE held a series of scoping meetings to facilitate public involvement in finalizing the scope of the HRA-EIS. Public scoping meetings were held at four locations in the Northwest: Spokane, Washington on September 29, 1992; Pasco, Washington on October 1, 1992; Seattle, Washington on October 5, 1992; and Portland, Oregon on October 8, 1992. Following the scoping period, the DOE prepared the *Implementation Plan for the Hanford Remedial Action Environmental Impact Statement* (IP), which provided guidance for the preparation of the HRA-EIS and recorded the results of the scoping process. In July 1995, the IP was approved, published, and distributed (DOE/RL 1995).

1.2 Hanford Future Site Uses Working Group

In April 1992, the U.S. Environmental Protection Agency (EPA), the Washington State Department of Ecology (Ecology), and the DOE initiated a process to involve interested stakeholders in the development of a vision for the future of the Hanford Site. A group of individuals comprised

of representatives from labor, environmental, governmental, Tribal, agricultural, economic development, and citizen-interest groups was established, and became known as the Hanford Future Site Uses Working Group (Working Group). The Working Group was charged with the following three tasks:

- Examine the Hanford Site and identify a range of potential future uses.
- Select appropriate cleanup scenarios necessary to make these future uses possible in light of potential exposure to contaminants, if any, after cleanup.
- Probe for convergences among the Working Group's cleanup scenarios for any priorities or criteria that could prove useful in focusing or conducting the cleanup of the Hanford Site.

The Working Group members divided the Hanford Site into six distinct geographic areas to facilitate their tasks. The Working Group developed future-use options, cleanup scenarios, and other recommendations for each of the six geographic areas. The Working Group's efforts were based on the assumption that cleanup activities at the Hanford Site would greatly benefit from having a better understanding of the range of potential future uses of the Hanford Site lands. An understanding of the possible future uses of the Hanford Site could focus the efforts of both the DOE, and the state and federal regulators, as well as Congress and the public, on what manner of cleanup is needed and what is most important to accomplish over time. The DOE, Ecology, and the EPA have committed to using the Working Group's findings to inform and guide the agencies in all relevant aspects of their cleanup decisions (HFSUWG 1992).

The HRA-EIS incorporates three cleanup scenarios (i.e., restricted use, unrestricted use, and exclusive use) and the geographic areas concept developed by the Working Group into the development of future land-use alternatives for four geographic areas of the Hanford Site: Columbia River, Reactors on the River, Central Plateau, and All Other Areas.

1.3 Scope

The scope of the HRA-EIS includes the evaluation of environmental impacts from remedial activities or from past-practice waste units, which are the responsibility of the DOE under CERCLA; and RCRA-regulated, past-practice waste sites, which are subject to provisions of the *Hazardous and Solid Waste Amendments of 1984*. In addition, decommissioning of selected surplus facilities is included. Some miscellaneous RCRA waste treatment, storage, and/or disposal (TSD) units located in or near past-practice waste sites also are within the scope of this EIS. A detailed listing and discussion of the lands and facilities within the scope of this EIS are provided in Appendix A. All chemical and radiological contaminants associated with these past-practice waste units, TSD units, and surplus facilities also are within the scope of this EIS. Contaminants of concern include, but are not limited to:

- carbon tetrachloride
- chloroform
- chromium
- cyanide
- fluoride
- nitrate
- trichloroethylene

- cesium-137
- cobalt-60
- iodine-129
- plutonium-239/240
- strontium-90
- technicium-99
- uranium.

The following geographic areas are not included in the scope of this EIS.

- **The North Slope.** Remediation of the North Slope was completed in October 1994 in accordance with the Tri-Party Agreement (Ecology et al. 1989). The single operable unit on the North Slope included 16 abandoned wells and 32 past-practice waste sites. The major contaminants associated with the North Slope were dichlorodiphenyl trichloroethane and petroleum-contaminated soils.

- **The Fitzner/Eberhardt Arid Lands Ecology (ALE) Reserve.** Remediation of the ALE Reserve, which included the 1100-IU-1 operable unit, was completed in October 1994, in accordance with the Tri-Party Agreement (Ecology et al. 1989). The 1100-IU-1 operable unit included 14 abandoned wells and 32 past-practice waste sites. The major contaminant associated with the 1100-IU-1 operable unit was dichlorodiphenyl trichloroethane.

The following wastes are excluded from impact analysis under this EIS; however, the geographic areas where these wastes are located are within the scope of this EIS.

- Wastes and the associated environmental impacts that result from a future land use implemented after remediation is complete.

- The 149 single-shell tanks (SST), 28 double-shell tanks (DST), associated piping and structures, and the associated contaminated soils. The management and TSD of tank waste is the subject of an EIS that is under preparation for the Tank Waste Remediation System (59 FR 4052).

- The waste sites included in the Hanford Site's 1100 Area CERCLA National Priorities List operable units. CERCLA removal actions for these sites have been categorically excluded from documentation requirements under the provisions of the *National Environmental Policy Act of 1969* (NEPA). The selected remedies include (1) leaving the materials in place and landfill capping, and (2) natural attenuation and monitoring of groundwater plumes for compliance.

- The Environmental Restoration Disposal Facility (ERDF), which has a separate regulatory package that consists of a CERCLA Remedial Investigation/Feasibility Study (DOE/RL 1994a) including a NEPA roadmap (DOE/RL 1994b), and a CERCLA Record of Decision (ROD) (EPA 1995).

- The major facilities, including associated wastes, scheduled for decommissioning as part of the Richland Environmental Restoration Project. These facilities include B Plant, T Plant, U Plant, Reduction Oxidation Plant, Plutonium-Uranium Extraction Plant, Plutonium Finishing Plant (PFP), Waste Encapsulation and Storage Facility, 105-N Reactor (N Reactor), and the Fast Flux Test Facility (FFTF).

- Current or planned actions covered in the *Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes Environmental Impact Statement* (DOE 1987) (e.g., the Hanford Waste Vitrification Plant, the Waste Receiving and Processing Facility, pre-1970 suspect transuranic [TRU] waste, and retrievably-stored and newly-generated TRU waste).

- Current or planned actions covered in the *Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington, Environmental Impact Statement* (DOE 1992) (i.e., B, C, D, DR, F, H, 105-KE, and 105-KW Reactors).

1.4 Site Description

The DOE's Hanford Site is situated in southeastern Washington State; occupies an area of 1,450 km^2 (560 mi^2); is owned by the U.S. Government; and is administered by the U.S. Department of Energy, Richland Operations Office (RL). The Hanford Site lies in the Pasco Basin of the Columbia Plateau (Figure 1-1), directly northwest of the confluence of the Columbia River with the Snake, Walla Walla, and Yakima rivers. The Columbia River flows through the northern part of the Hanford Site and, turning south, forms part of the Hanford Site's eastern boundary. The Yakima River runs along part of the southern boundary and joins the Columbia River below the City of Richland, which adjoins the Hanford Site on the southeast. Adjacent lands to the west, north, and east are principally range and agricultural land. The cities of Richland, Kennewick, and Pasco (known as the Tri-Cities), located southeast of the Hanford Site, constitute the nearest population centers (Cushing 1995).

The production of defense nuclear materials at the Hanford Site since the 1940s necessitates exclusion of the public and most nongovernment-related development on the Hanford Site. The Hanford Site, as a result of its past defense-related mission, also has provided *de facto* protection of the natural environment and cultural resources unparalleled in the northwest or along the Columbia River (NPS 1994). However, the defense nuclear materials production mission has left the Hanford Site with an extensive waste legacy. Nuclear weapons materials production and associated activities at the Hanford Site during the past five decades have generated a variety of radioactive, hazardous, and other wastes that have been disposed of or discharged to the air, soil, and water at the Hanford Site.

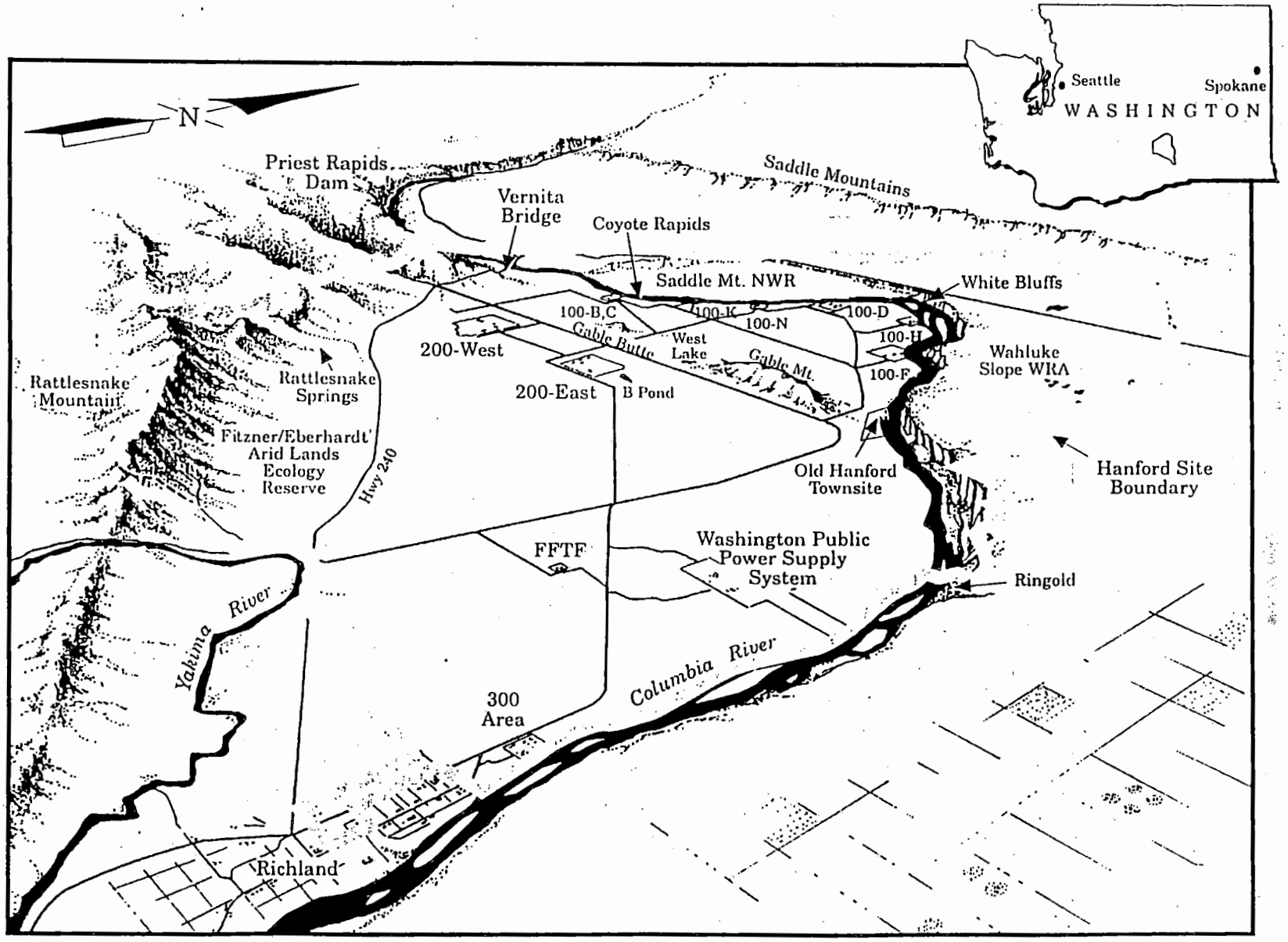


Figure 1-1. Location of the Hanford Site.

1.4.1 Waste Types Present at the Hanford Site

Radioactive wastes present on the Hanford Site include high-level waste (HLW), TRU, and low-level waste (LLW). The category that a particular radioactive waste is placed into depends on the origin and concentration of the waste, as well as the particular radioisotopes involved.

HLW is the highly radioactive waste material that results from reprocessing spent nuclear fuel (SNF), and includes liquid waste produced directly in reprocessing and solid waste derived from the liquid. HLW contains a combination of TRU waste (defined below) and fission products in concentrations high enough to require permanent isolation.

TRU waste refers to waste, without regard to source or form, that is contaminated with alpha-emitting TRU radionuclides with half-lives greater than 20 years and concentrations greater than 100 nCi/g.

LLW is radioactive waste not classified as HLW, TRU waste, SNF, or byproduct material, as defined by DOE Order 5820.2A, *Radioactive Waste Management*, (DOE 1988). These definitions are not radionuclide specific (e.g., waste contaminated with plutonium-239 could be considered either TRU waste or LLW, depending on its plutonium concentration). Principle radionuclides found on the Hanford Site include, but are not limited to:

- tritium
- cobalt-60
- strontium-90
- cesium-137
- technetium-99
- isotopes of uranium, plutonium, and europium.

Hazardous chemical waste found on the Hanford Site include:

- chromium
- mercury
- various inorganic acids
- polychlorinated biphenyls (PCB)
- nitrates
- carbon tetrachloride
- ferrocyanide
- trichloroethylene
- uranium
- petroleum compounds.

Many sites contain waste contaminated with a combination of radioactive materials and hazardous chemicals. Wastes containing both are termed mixed waste and pose complex exposure and regulatory problems.

1.4.2 Waste Sites and Geographic Areas at the Hanford Site

Radioactive, hazardous, and mixed wastes are found in various individual waste sites, referred to as waste management units, located throughout the Hanford Site. These individual waste management units include past-practice sites, surplus facilities, TSD units, and/or a combination thereof. Past-practice sites and TSD units may take the form of spills, cribs, ditches, ponds, tanks, trenches, landfills, burial grounds, pits, french drains, and other means of intentional or unintentional waste disposal. Surplus facilities include contaminated buildings, exhaust stacks, and underground transfer lines. These individual waste management units are organized into operable units, under the Tri-Party Agreement (Ecology et al. 1989), based on geographic proximity or similarity of waste disposal history.

The operable units are located primarily in the operating areas of the Hanford Site. These areas are referred to customarily as the 100, 200, 300, 400, 600, and 1100 Areas; however, for purposes of this EIS, the areas are discussed within the geographic area concept established by the Working Group (Figure 1-2).

1.4.3 Columbia River

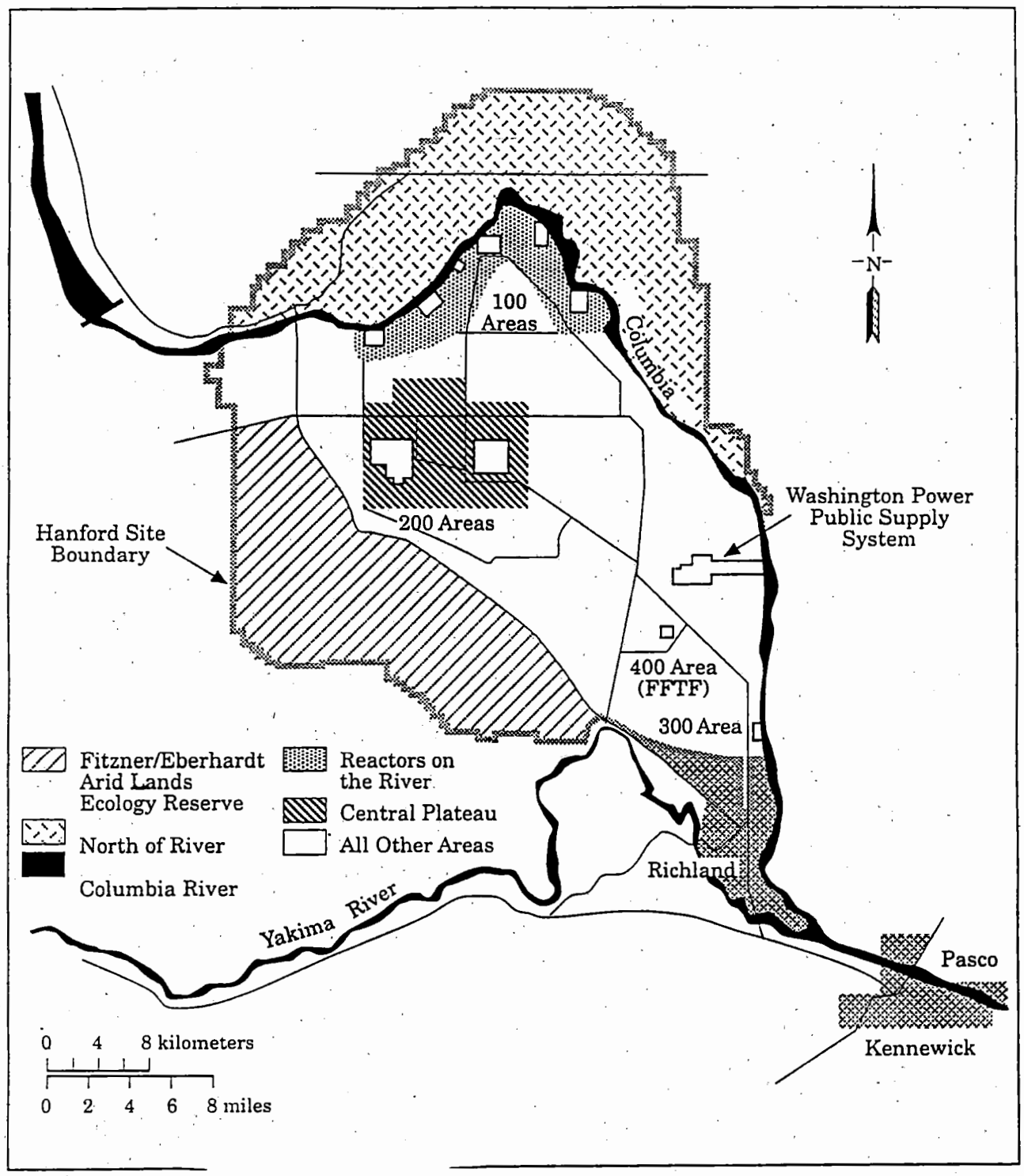
An 82 km- (51-mi) -long stretch of the Columbia River, known as the Hanford Reach of the Columbia River (Hanford Reach), borders or flows through the Hanford Site. This stretch of the river offers a unique example of the riverine and riparian (riverside) ecologies characteristic of the Columbia Basin ecosystem before construction of hydroelectric dams on the river. The Hanford Reach comprises the last unimpounded stretch of the nontidal portion of the Columbia River. Nearly 60% of the Columbia River's native wild stock of fall chinook salmon spawn in the Hanford Reach (NPS 1994). River water is used downstream from the Hanford Site by both Washington and Oregon residents for drinking water, agriculture, industry, transportation, and recreation. The riverbanks and islands provide habitat for several species of state-threatened or endangered plants (e.g., Columbia milk-vetch and Hoover's desert-parsley) and animals (e.g., bald eagles) (NPS 1994).

Future public access to the Columbia River raises concerns, because groundwater contamination from the Hanford Site reaches the river. Contamination enters the river at several locations through springs and seeps, and contamination sources also include reactor effluent lines that protrude into the river. These structures were used to discharge reactor cooling water to the river, but have been inactive since the reactors were shut down. Sediment in the river contaminated by past practices (i.e., reactor cooling water discharge) is another source of contamination. The DOE and other agencies monitor contamination in the river, both upstream and downstream from the Hanford Site. Although Hanford Site operations contribute radionuclides to the Columbia River, at this time the radiological contaminants in the river water have been found to be well below State of Washington and EPA drinking water standards (PNL 1995).

1.4.4 Reactors on the River

This geographic area is located along the southern shoreline of the Columbia River toward the north end of the Hanford Site, and contains all the facilities in the 100 Areas (including the nine reactors, associated facilities, and structures). The Reactors on the River geographic area occupies about 68 km^2 (26 mi^2).

Figure 1-2. Six Geographic Areas of the Hanford Site Established by the Hanford Future Site Uses Working Group.



Extensive contamination exists in some of the 100 Areas' surface, subsurface, and groundwater. This contamination resulted from the operation of the plutonium production reactors, which are located in this area. Groundwater contamination concentrations exceed EPA drinking water standards for some contaminants (DOE-RL 1994a). Contamination has reached the Columbia River from the 100 Areas through groundwater seepage. The major radiological contaminants present in the 100 Areas' soil and groundwater include:

- tritium
- cobalt-60
- strontium-90
- cesium-137
- isotopes of uranium and plutonium.

Chemical contaminants disposed of into the 100 Areas' soils, as part of the liquid waste streams, include, but are not limited to:

- chromium from sodium dichromate added to reactor cooling water
- decontamination fluids containing chromic, citric, oxalic, nitric, and sulfuric acids
- mercury from manometers and thermometers
- PCBs from electrical equipment.

1.4.5 Central Plateau

The Central Plateau geographic area occupies approximately 115 km^2 (44 mi^2) in the central region of the Hanford Site. Facilities in the Central Plateau, which are situated in the 200 East and 200 West Areas, were built to process irradiated fuel from the production reactors in the 100 Area. The subsequent operation of these facilities resulted in the storage, disposal, and unplanned release of radioactive and nonradioactive waste. Extensive contamination exists in the surface, subsurface, and groundwater of the Central Plateau. The Central Plateau is the most heavily contaminated area of the Hanford Site. Contaminated groundwater has moved out of the Central Plateau into adjoining areas of the Hanford Site (DOE-RL 1994a and DOE-RL 1994b). Contaminants identified in this area include, but are not limited to:

- tritium
- cobalt-60
- strontium-90
- technicium-99
- iodine-129
- cesium-137
- uranium
- plutonium
- arsenic
- carbon tetrachloride
- trichloroethylene
- tetrachloroethylene.

1.4.6 All Other Areas

The All Other Areas geographic area comprises approximately 624 km^2 (241 mi^2) in the 300, 400, 600, and 1100 Areas. A description of these areas follows.

1.4.6.1 300 Area. The 300 Area is located just north of the City of Richland and covers 1.5 km^2 (0.6 mi^2). This is where the former reactor fuel fabrication facilities were sited. The 300 Area also is the principal location of nuclear research and development (R&D) facilities serving the Hanford Site. Wastes in the 300 Area have resulted from the fuel fabrication process and various R&D projects.

1.4.6.2 400 Area. The 400 Area, located southeast of the 200 East Area, is the site of the FFTF. The DOE has announced plans to close the FFTF and its support facilities.

1.4.6.3 600 Area. The 600 Area is defined to include all of the lands within the Hanford Site not occupied by the 100, 200, 300, 400, and 1100 Areas. Lands within the ALE Reserve and North Slope are part of the 600 Area; however, these two areas of the Hanford Site are recognized as distinctly separate geographic entities by the Working Group, and are not treated as part of the All Other Areas geographic area in this EIS.

Land uses in the 600 Area include a 41-ha (100-ac) tract privately subleased from the State of Washington for the disposal of commercial LLW operated by US Ecology, Inc., and a Reference Repository Site once used as the principal borehole and exploratory shaft for a candidate Basalt Waste Isolation Program terminated in 1987.

1.4.6.4 1100 Area. The 1100 Area, located just north of the City of Richland, serves as the central warehousing, vehicle maintenance, and transportation operations center for the Hanford Site. Any existing hazardous waste is mostly the result of disposal of batteries, paints, solvents, and antifreeze. Remediation of the 1100 Area is not within the scope of this EIS (Section 1.3).

1.4.7 Fitzner/Eberhardt Arid Lands Ecology Reserve

The ALE Reserve, which is located in the southwest portion of the Hanford Site, is an area of approximately 315 km^2 (120 mi^2) that is managed as a habitat/wildlife reserve and nature research center under the DOE's National Environmental Research Park Program. This area contained small, nonradioactively contaminated sites, which have been remediated. The ALE Reserve is not included within the scope of this EIS (Section 1.3).

1.4.8 North of the River

This geographic area north of the Columbia River encompasses approximately 365 km^2 (140 mi^2) of relatively undisturbed or recovering shrub-steppe habitat. Known as the North Slope, the area is managed in part by the Washington State Department of Fish and Wildlife, as the Wahluke Slope Wildlife Area, and in part by the U.S. Fish and Wildlife Service (USFWS), as the Saddle Mountain National Wildlife Refuge. This area contained small, nonradioactively contaminated sites, which have been remediated. The North Slope is not included within the scope of this EIS (Section 1.3).

1.5 Brief History of the Hanford Site

Nuclear fuel production operations began at the Hanford Site in 1944 as part of the War Department's secret Manhattan Engineering Project. In the following 50 years, emphasis at the Hanford Site changed from secretive, defense-oriented nuclear fuel production programs, to energy research, and then to the current mission of environmental restoration. Past site administrators have included the U.S. Army Corps of Engineers (USACE), the U.S. Atomic Energy Commission (AEC), and the U.S. Energy Research and Development Administration (ERDA). The DOE is the current administrator, having controlled operations at the Hanford Site since 1977.

In January 1943, the USACE, Manhattan District, selected the Columbia Basin as the location for the nation's first full-sized plutonium production reactors. This semi-arid, isolated area in southeast Washington was chosen in part for its remoteness, favorable climate, and the availability of water from the Columbia River for use by the production reactors. Immediately following acquisition of the Hanford Site by the Federal Government, construction work began on three reactors, three chemical processing plants (for recovering plutonium from irradiated fuel), and 64 underground storage tanks (UST). A laboratory was built to support fuel fabrication and other production activities. During World War II, the Hanford Site was designated as the Hanford Engineering Works. The plutonium produced at the Hanford Site was used in the creation of the world's first nuclear weapons (Gerber 1992).

The first reactor, B Reactor, began operating in September 1944, followed within a few months by the D and F reactors. A major expansion program was initiated at the Hanford Site in the late 1940s in response to a need by the AEC to increase plutonium production. From 1947 to 1955, some 15,000 workers built five additional plutonium production reactors, two chemical processing plants, a plutonium finishing plant, and 81 additional USTs (DOE-RL 1990).

A ninth reactor, N Reactor, was built between 1959 and 1963. Unlike the preceding eight reactors, whose sole mission was producing plutonium, the N Reactor also produced steam to generate electricity. In its early years, the N Reactor was the largest electric power producer in the nation, producing over 65 billion kW in 24 years (Gerber 1992).

In 1964, activities at the Hanford Site underwent a series of dramatic changes. Plutonium production was sharply curtailed in response to the nation's changing defense needs. By 1971, eight of the nine production reactors had been shut down. The ninth reactor, N Reactor, was placed in stand-down status for an extensive maintenance and safety enhancements program in January 1987. In February 1988, the N Reactor was ordered to be placed in cold standby, which was achieved by October 1990. In July 1991, the DOE decided to cease preservation of the N Reactor, and proceed with activities leading to the ultimate decommissioning of the facility.

The shutdown of fuel production activities refocused the resources and capabilities of the Hanford Site toward development of nonmilitary applications of nuclear energy. New laboratory facilities were constructed to support this research, with programs in areas such as nuclear waste management, biological sciences, and environmental sciences (DOE-RL 1990). In the 1970s, under the ERDA, emphasis on energy research continued to grow. Major programs included:

- solar, geothermal, and advanced nuclear systems
- fossil energy
- national security

- conservation
- energy policy analysis
- resource assessment.

The 1970s also featured an upgrade of the radioactive waste management program at the Hanford Site (DOE-RL 1990). A primary objective of the upgrade was to transfer liquids from SSTs to more secure DSTs. These tanks continue to provide interim waste storage today.

The DOE has phased out defense production at the Hanford Site. Its present primary mission is to remediate the Hanford Site and minimize potential risks to the public, work force, and the environment (DOE-RL 1993).

1.6 Biodiversity in the National Environmental Policy Act Process

In January 1993, the Council on Environmental Quality (CEQ) issued a report titled *Incorporating Biodiversity Considerations into Environmental Impact Analysis Under the National Environmental Policy Act* (CEQ 1993). This report was designed to:

- provide an overview of the major issues related to biodiversity
- outline some general concepts regarding biodiversity analysis and management
- describe how biodiversity currently is addressed in NEPA analyses
- provide options for agencies undertaking NEPA analyses that consider biodiversity.

The CEQ report indicates that physical alterations resulting from land-use changes are one of the most profound causes of biodiversity loss. When natural, undisturbed lands (like much of the land at the Hanford Site) are converted to industrial, residential, or recreational use, ecosystems are disrupted and biodiversity diminished. However, it is not the intent of this EIS to assess the biodiversity impacts of future land uses. Rather, this EIS will assess the biodiversity impacts that could result from implementing the remedial actions necessary to allow for a specific future land use. For example, if a desired future land use required the removal of contaminated soil, only the biodiversity impacts resulting from the removal operations would be assessed.

1.7 Environmental Justice in the National Environmental Policy Act Process

On February 11, 1994, the President of the United States issued Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*. This Executive Order mandates that all federal agencies make achieving environmental justice part of their missions. Federal agencies must identify and address disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low-income populations.

As stated in the President's memorandum, dated February 11, 1994, "Each federal agency shall analyze the environmental effects, including human health, economic and social effects, of federal actions, including effects on minority communities and low-income communities, when such analysis is required by the *National Environmental Policy Act of 1969* (NEPA), 42 U.S.C. Section 4321 et seq. Mitigation measures outlined or analyzed in an environmental assessment, environmental impact statement, or record of decision, whenever feasible, should address significant and adverse environmental effects of proposed federal actions on minority communities and low-income

communities." The memorandum and Executive Order ensure that minority and low-income communities will have a voice in the development and implementation of any federal action that may adversely affect their lives.

In addition, the memorandum and Executive Order imply that all federal agencies are to be proactive with respect to identifying and, to the extent practicable, mitigating any potential adverse impact on minority and low-income communities that could result from a proposed federal action. In order to implement the provisions of Executive Order 12898, the DOE has drafted the *U.S. Department of Energy Public Participation Guidance for Environmental Justice Activities* (DOE 1994a) and a *Predecisional Draft: U.S. Department of Energy Proposed Environmental Justice Strategy* (DOE 1994b). Guidance and strategies provided in these publications will be used, to the extent practicable, in this EIS.

1.8 Preparation of the Comprehensive Land-Use Plan for the Hanford Site

Preparation of the *Comprehensive Land-Use Plan for the Hanford Site* (Plan), which would further define the HRA-EIS's evaluation of the future land-use alternatives, is being coordinated with the development of the HRA-EIS. The Plan will provide the basis for making land-use decisions for the orderly development and management of resources and activities on the Hanford Site. The Plan will integrate, and be consistent with, existing DOE program decisions. The DOE will maintain federal authority for planning and managing land use on all Hanford Site lands under DOE control, including implementation and maintenance of the Plan. The DOE will coordinate with the Bureau of Land Management (BLM), the Bureau of Reclamation (BOR), Tribal governments, the City of Richland, and Benton County to try and capture the shared long-term goals and objectives of the Hanford Site and stakeholders.

The Plan has the role of translating the values associated with the Hanford Site into objectives that enable implementation of future land uses. To make this translation, federal, Tribal, state, and local governments, along with stakeholder values associated with the Hanford Site, will be identified (these values have implications for future land uses of various areas at the Hanford Site). These values can be combined to formulate a vision for future land uses at the Hanford Site. This shared vision should accommodate as many of the values as possible, and include protection of public health and the environment, along with preservation of resources that are considered valuable. The vision for future land use at the Hanford Site will guide remediation planning, economic transition, and establishment of land-use management practices that are consistent with established values and regional interests.

1.9 Other Ongoing Major National Environmental Policy Act Documents

Some actions are excluded from the scope of this EIS, because they are covered under other proposed, prepared, or final EISs. The following summary of Hanford-related EISs are intended to delineate the boundaries between the EISs and show how they are interrelated.

- *Hanford Reach of the Columbia River, Comprehensive River Conservation Study and Environmental Impact Statement* (NPS 1994). The final EIS was prepared by the National Park Service and the U.S. Department of Interior, in consultation with the DOE. The purpose of that EIS is to identify and evaluate the outstanding features of the Hanford Reach, including fish and wildlife, and examine alternatives for their preservation including

potential addition of the Hanford Reach to the National Wild and Scenic Rivers System. The proposed action recommends that Congress designate federally owned lands, within 0.4 km (0.25 mi) of the Columbia River on both banks of the river from River Mile 396 to 346.5, and the portion of the Hanford Site that lies north and east of the Columbia River, as a National Wildlife Refuge to be managed by the USFWS. Also, this stretch of the Columbia River would be designated as a Recreational River under the National Wild and Scenic Rivers System. Responsibility for remediation of lands that were contaminated by DOE operations would remain with the DOE.

- *Superconducting Magnetic Energy Storage – Engineering Test Model (SMES-ETM) Environmental Impact Statement* (USACE 1992). The U.S. Department of Defense, Defense Nuclear Agency, is the lead agency on the draft EIS. The U.S. Army and the DOE are cooperating agencies in the preparation of the EIS. The EIS analyzes the impacts of siting a SMES-ETM at either the Hanford Site or four other candidate sites in the United States. The final EIS is in preparation.

- *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* (DOE 1995a). The EIS analyzes the environmental impacts of remediation and waste management activities at the Idaho National Engineering Laboratory, as well as management of DOE SNF across the DOE complex, including the Hanford Site.

- *Tank Waste Remediation System Environmental Impact Statement* (TWRS-EIS) (DOE and Ecology 1995). The EIS will evaluate the environmental impacts of retrieving and treating the wastes in the Hanford Site's DSTs and SSTs, as well as associated structures and contaminated soils. The EIS will include discussion of the waste forms and processes to be used, and it is a follow-on and update to the tanks portions of the *Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes Environmental Impact Statement* (DOE 1987). The EIS is being prepared by the DOE and Ecology to satisfy requirements of both the NEPA and the *State Environmental Policy Act of 1971* (SEPA).

- *Final Environmental Impact Statement: Safe Interim Storage of Hanford Tank Wastes, Hanford Site, Richland, Washington* (Ecology and DOE-RL 1995), previously referred to as the *Multifunction Waste Tank Facility Environmental Impact Statement*. This was an interim-action EIS prepared to resolve near-term tank safety issues for certain Hanford Site waste tanks while the larger TWRS-EIS is in preparation (DOE and Ecology 1995). This interim action EIS is consistent with the CEQ's NEPA regulations, 40 CFR 1506.1, "Limitation of Actions During the NEPA Process."

- *Disposal of Decommissioned, Defueled Cruiser, Los Angeles Class and Ohio Class, Naval Reactor Plants Environmental Impact Statement* (Navy 1995). The U.S. Navy's EIS will evaluate the environmental impacts of disposal of defueled reactor plants from decommissioned naval vessels. Continued land disposal at the Hanford Site is one of the alternatives being considered. The DOE is a cooperating agency in the preparation of the EIS.

- *Waste Management Programmatic Environmental Impact Statement*. This EIS will evaluate the environmental impacts of environmental restoration and waste management across the DOE complex (DOE 1995b).

- *Columbia River System Operation Review Draft Environmental Impact Statement* (DOE et al. 1994). The EIS is a joint project of the BOR, the USACE, and the Bonneville Power Administration. This draft EIS assesses the multipurpose management of the Columbia River System, including the Hanford Reach. Four actions are being considered with respect to the multipurpose management of the Columbia River system, and are as follows:

  1. Developing and implementing a coordinated system operating strategy for managing the multiple uses of the Columbia River system into the 21st Century.

  2. Providing interested parties with a continuing long-term role in system planning and operations through a Columbia River Regional Forum.

  3. Renegotiating and renewing the Pacific Northwest Coordination Agreement.

  4. Renewing current agreements or developing new Canadian Entitlement Allocation Agreements.

- Proposed: *Eastside Draft Environmental Impact Statement*. This EIS is being developed through a joint effort of the U.S. Department of Agriculture (Forest Service) and the BLM. The Draft EIS proposes to develop and implement a scientifically sound and ecosystem-based management strategy for the lands administered by the BLM and the Forest Service in the interior Columbia River Basin, upper Klamath Basin, and northern Great Basin.

- *Plutonium Finishing Plant Environmental Impact Statement* (PFP-EIS). On October 27, 1994, the DOE issued a NOI to prepare the PFP-EIS (59 FR 53969). The proposed would response to comments received during the 1993 public meetings on the PFP cleanout. The document would evaluate the environmental impacts of deactivating the PFP and continuing operations of the laboratories and storage vaults within the PFP.

- *Management of Spent Nuclear Fuel from the K Basins at the Hanford Site, Richland, Washington* (DOE 1995c). This EIS follows the issuance of the ROD (60 FR 28680) for the *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement* (DOE 1994a), and analyzes the environmental impacts associated with SNF management at the Hanford Site.

- *N Reactor Decommissioning Environmental Impact Statement*. A proposed EIS analyzing the environmental impacts of decommissioning the N Reactor is being considered by the DOE, the EPA Region X, and Ecology. Specific details, such as schedule and scope, are still to be determined.

The geographic boundaries between the *Hanford Reach of the Columbia River, Comprehensive River Conservation Study and Environmental Impact Statement* (NPS 1994) and the HRA-EIS in the 100 Areas overlap in the strip of land within 0.4 km (0.25 mi) of the Columbia River. If Congress does not take the action recommended by NPS (1994), the DOE must comply with the requirements of the *Comprehensive Conservation Study of the Hanford Reach of the Columbia River* (Public Law 100-605) regarding the Department of Interior's review of actions proposed within the 0.4-km (0.25-mi) -deep study area along the Columbia River until November 1996. If Congress

establishes the National Wildlife Refuge and the Recreational River, the DOE would continue to be obligated to complete the remediation of the areas under designation (NPS 1994).

The *Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington Environmental Impact Statement* (DOE 1992) included in its scope the decommissioning of eight surplus production reactors (B, C, D, DR, F, H, KE and KW), their associated nuclear fuel storage basins, and the buildings that house them. Only H Reactor is within 0.4 km (0.25 mi) of the Columbia River. If Congress recommends to designate a National Wildlife Refuge and Recreational River in the Hanford Reach, the DOE would decommission the reactors and fuel storage basins in compliance with the regulations and management plans applying to the designated areas.

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Purpose and Need

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2.0 Purpose and Need

Future land-use objectives need to be established, through the *National Environmental Policy Act of 1969* (NEPA) process, to assist the U.S. Department of Energy (DOE) in developing a cost-effective, technically sound remediation strategy for the Hanford Site. In making decisions on future land-use objectives for the Hanford Site, the DOE must consider the environmental and human health impacts of remediation, as well as other ongoing or planned future actions, at the Hanford Site. Future land-use objectives are the basis for establishing remedial action objectives under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and identifying the corresponding preliminary cleanup goals using existing standards, readily available risk information, and other site-specific, risk-related factors. This allows the future remediation decisionmaking process, as established by the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1994), to advance in the development of general response actions and ultimately remedial alternatives, such that the remedial actions evaluated are those that can meet the goals needed to achieve the selected future land-use objectives. In doing so, the decisionmaking process is streamlined and can be more cost-effective.

The DOE will use the established future land-use objectives to:

- Predict project impacts, including costs.
- Enable selection of a remedy under the Tri-Party Agreement to consider the desired future land-use objectives and more effectively weigh the cost-benefits of specific remediation decisions.
- Commit natural resources to the DOE's Richland Environmental Restoration Project through the NEPA process.

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3.0 Description of Proposed Action and Alternatives

This chapter presents a discussion of the proposed action and the alternative methods by which the proposed action could be accomplished. A comparative summary of the potential environmental impacts and mitigation measures associated with the alternative methods for achieving the proposed action also is presented. This summary should provide decisionmakers with a clear basis for choice among the alternative methods.

The proposed action is to establish future land-use objectives for the main portion of the Hanford Site. Establishing future land-use objectives would result in a simplified process for determining appropriate remediation levels for a given area, and would minimize the likelihood of making inconsistent remediation decisions at the operable unit level. Future land-use objectives are the basis for establishing remedial-action objectives and identifying corresponding preliminary remedial goals under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). Implementation of the proposed action would ensure that remediation of the Hanford Site reduces human health risks to acceptable levels, while making the most efficient use of available and appropriate resources.

To facilitate the establishment of future land-use objectives, the geographic area concept developed by the Hanford Future Site Uses Working Group (Working Group) was utilized. The following four geographic areas are addressed within the scope of this Environmental Impact Statement (EIS):

- Columbia River (Hanford Reach)
- Reactors on the River (100 Areas)
- Central Plateau (200 Areas)
- All Other Areas (300, 400, 600, and 1100 Areas).

The establishment of a future land-use objective for each geographic area on the Hanford Site requires the DOE to evaluate a range of potential future uses for each area. These potential future uses (land use alternatives) are described and analyzed in the following sections.

3.1 Development of Alternatives

Alternatives for establishing future land-use objectives at the Hanford Site were developed using input from the scoping process, including the report produced by the Working Group (HFSUWG 1992), and comments received from members of the public, interested groups, and federal, state, local, and Tribal governments (DOE-RL 1994a). *The Future For Hanford: Uses And Cleanup, A Final Report of the Hanford Future Site Uses Working Group* (HFSUWG 1992) formed a basis for developing a range of alternatives by defining the geographic areas of the Hanford Site and identifying three potential cleanup scenarios. For purposes of this EIS, the Working Group's cleanup scenarios were adopted and modified to reflect the needs of the DOE's continuing mission at the Hanford Site. The cleanup scenario definitions used in this EIS are described as follows:

Unrestricted Land Use--Contamination does not preclude any human uses; however, access or certain uses may be controlled for other reasons (i.e., physical hazards, cultural resource protection, habitat protection).

Restricted Land Use--Residual contamination precludes some human uses; restrictions could apply to the surface soils, subsurface soils, surface water, or groundwater.

Exclusive Land Use--Potential health risk limits use and requires strict controls on access. Use of the area would be limited to the management and/or disposal of radioactive and hazardous materials (or similar, compatible uses). Control of the area would be maintained by the DOE. Exclusive use areas could include buffer zones around active facilities.

Under each of the cleanup scenarios, remediation would result in risk reductions to levels protective of human health and the environment. However, the means by which risks would be reduced differ among the cleanup scenarios. In developing the alternatives, risk was assumed to be lowered to acceptable levels for unrestricted use (primarily through the removal of waste). For the restricted and exclusive use scenarios, the analyses assumed that risk would be lowered using a combination of engineering and institutional controls (in-place stabilization or immobilization of wastes, and removal of wastes).

3.1.1 Potential Future Land-Use Alternatives

The three cleanup scenarios described above were applied to each of the four geographic areas of the Hanford Site to develop a range of potential future land-use alternatives (Table 3-1). All cleanup scenarios are included in the range of potential future land-use alternatives for each geographic area, with the exception of exclusive use of the Columbia River. Exclusive use of the Columbia River is not considered a viable alternative because the DOE does not anticipate using the river for waste management activities.

The future land-use designation for each of the potential alternatives would determine the level of remediation required for each geographic area. Much of the land within the geographic areas is relatively uncontaminated (i.e., the undeveloped lands located between the operations areas) and would require little or no remediation to allow the designated land use. However, levels of contamination in some past-practice waste sites, and treatment, storage, and/or disposal or surplus facilities, could result in unacceptable risk to human heath and the environment under a given future land-use alternative. Therefore, the DOE would focus on removal of contaminants to levels that allow the designated future land-use objective across the entire geographic area.

3.1.2 Screening for Reasonable Alternatives

Table 3-1 identifies the 11 potential future land-use alternatives (e.g., Restricted Land Use for the Reactors on the River geographic area) that could be evaluated. Although all of these alternatives are possible, analyzing this range of alternatives would involve analyzing alternatives that are unreasonable or impractical to implement. As discussed in *Recommendations for the Preparation of*

Environmental Assessments and Environmental Impact Statements (DOE 1993), the Council on Environmental Quality (CEQ) considers reasonable alternatives to be those that are practical or feasible from a common sense, technical, and economic standpoint. Using the CEQ guidance, five criteria were developed and applied to screen the alternatives and eliminate from further consideration those alternatives determined to be unreasonable. The criteria are listed as follows.

1. The alternative should be technically feasible.

2. The alternative should be consistent with decisions made in other *National Environmental Policy Act of 1969* (NEPA) and CERCLA Records of Decision (ROD).

3. The alternative should be consistent with the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989).

4. Implementation of the alternative should not have major or readily-apparent, undesirable impacts.

5. Public acceptance of the alternative should be probable, as opposed to highly unlikely, based on the results of the scoping process.

Using these screening criteria, the list of potential future land-use alternatives was reduced from 11 to 6, as shown in Table 3-2. The shaded areas presented in the table identify the alternatives determined to be unreasonable based on failure to meet one or more of the screening criteria. These alternatives were eliminated from further consideration. A discussion as to why these alternatives were eliminated is presented in Section 3.4.

Table 3-1. Potential Future Land-Use Alternatives (DOE-RL 1994a).

Geographic Area	Potential Future Land-Use Alternatives		
Columbia River	U	R	NA
Reactors on the River	U	R	E
Central Plateau	U	R	E
All Other Areas	U	R	E

E = Exclusive Land Use
NA = Not Applicable
R = Restricted Land Use
U = Unrestricted Land Use.

Table 3-2. Screening of Potential Future Land-Use Alternatives.

Geographic Area	Future Land-Use Alternatives		
Columbia River	U	R	
Reactors on the River	U	R	E
Central Plateau	U	R	E
All Other Areas	U	R	E

E = Exclusive
R = Restricted
U = Unrestricted.

3.1.3 Future Land-Use Alternatives Selected for Detailed Analysis

As a result of the screening process, a list of future land-use alternatives deemed suitable for detailed analysis was compiled (represented by the unshaded areas in Table 3-2). The list of alternatives includes the following:

- Columbia River
  - Unrestricted Future Land Use
  - Restricted Future Land Use

- Reactors on the River
  - Unrestricted Future Land Use
  - Restricted Future Land Use

- Central Plateau
  - Exclusive Future Land Use

- All Other Areas
  - Restricted Future Land Use.

These alternatives would allow land uses similar to those envisioned by the Working Group (HFSUWG 1992), while allowing the DOE to fulfill its mission. Table 3-3 identifies the relationships between the future land-use alternatives and the future use options identified by the Working Group for each geographic area.

Each future land-use alternative would have an associated exposure scenario. The exposure scenarios presented in the *Hanford Site Risk Assessment Methodology (HSRAM)* (DOE-RL 1995), define the conditions under which humans could be exposed to residual contamination, and are directly related to land use. The DOE, the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) have agreed to use these exposure scenarios in the CERCLA process when establishing remediation levels for waste sites within each geographic area. Tables 3-4 through 3-6 show the exposure factors associated with each of the exposure scenarios used in this EIS.

The Working Group's options were the basis for identifying the appropriate exposure scenario(s) associated with a desired future land use (Table 3-3). An agricultural exposure scenario for the Columbia River and Reactors on the River Unrestricted Future Land-Use Alternatives would be used because it takes into consideration potential livestock grazing use by Native Americans, as well as full-time human occupancy in farm houses. The agricultural exposure scenario is the most conservative exposure scenario used in these analyses because, as illustrated in Table 3-4, the agricultural scenario involves exposures along the largest number of pathways, for the longest period of time. The recreational exposure scenario would be used for the Restricted Future Land-use Alternatives to reflect the public's desire for continued recreational use of the Columbia River, and potential future recreational use of the Reactors on the River and portions of the All Other Areas geographic areas.

Both recreational and industrial exposure scenarios would be used in the All Other Areas geographic area to reflect potential industrial use of the 300 Area, the Fast Flux Test Facility (FFTF), and the Washington Public Power Supply System (WPPSS), and nonindustrial uses of other undeveloped areas. The agricultural exposure scenario would not be used in the All Other Areas geographic area because restrictions on groundwater use would preclude most agricultural activities.

Only the industrial exposure scenario would be used for the Exclusive Future Land-Use Alternative, because this alternative assumes that only DOE waste management activities would occur, and that the buffer zone would not be available for recreational use.

The DOE land-use options presented in Table 3-3 are taken from the *Hanford Site Development Plan* (DOE-RL 1993a). The DOE is currently developing the *Comprehensive Land Use Plan for the Hanford Site*, which will recommend more specific land-use designations.

Table 3-3. Relationship Between Future-Land Use Alternatives, Hanford Future Site Uses Working Group Options, Exposure Scenarios, and Potential U.S. Department of Energy Land-Use Options

FUTURE LAND-USE ALTERNATIVES	EXPOSURE SCENARIOS	WORKING GROUP LAND-USE OPTIONS	POTENTIAL DOE LAND-USE OPTIONS
COLUMBIA RIVER			
Unrestricted	Agricultural	1. Wildlife and Recreation 2. Recreational and Related Commercial, Scenic and Economic Uses 3. Native American Uses	1. Sensitive Areas
Restricted	Recreational		
REACTORS ON THE RIVER			
Unrestricted	Agricultural	1. Native American Uses 2. Wildlife and Recreation 3. Limited Recreation, Commercial Uses, and Wildlife 4. B Reactor as a Museum/Visitor's Center	1. Sensitive Areas 2. Undeveloped Areas
Restricted	Recreational		
CENTRAL PLATEAU			
Exclusive	Industrial	1. Onsite Waste and Existing Obligations for Disposal 2. Option 1 plus Offsite DOE Waste for Treatment 3. Option 2 plus Offsite Commercial Waste for Treatment 4. Option 3 plus Offsite DOE Waste: long-term storage of TRU and HLW and Disposal of LLW 5. Option 4 plus Commercial SNF for Longterm MRS 6. Option 5 plus Compatible Commercial or Industrial Activity	1. Waste Operations 2. R&D/Engineering Development
ALL OTHER AREAS			
Restricted	Recreational and Industrial	1. Focus on Economic Development 2. Focus on Wildlife 3. Native American Uses 4. Agricultural Use	1. Operations Support 2. R&D/Engineering Development 3. Undeveloped Areas 4. Sensitive Areas 5. Administrative Support

Table 3-4. Agricultural Scenario Exposure Factors.

Pathway		Exposure Parameters		
Media	Exposure Route	Intake Rate	Exposure Frequency (d/yr)	Exposure Duration (yr)
Soil	Ingestion[a]	200 mg/d (C) 100 mg/d (A)	365	6 (C) 24 (A)
	Dermal[b]	0.2 mg/cm^2/d	180	6 (C) 24 (A)
	External[c]	24 hr/d	365	30
Air	Inhalation[a]	20 m^3/d	365	30
Groundwater	Ingestion[a]	2 L/d	365	30
	Inhalation[a]	15 m^3/d	365	30
	Dermal[b]	0.17 hr/d (shower)	365	30
Surface Water	Ingestion[a]	2 L/d	365	30
	Inhalation[a]	15 m^3/d	365	30
	Dermal[b]	0.17 hr/d (shower) 2.6 hr/d (swimming)	365 7	30
Sediment	Ingestion[a]	200 mg/d (C) 100 mg/d (A)	7	6 (C) 24 (A)
	Dermal[b]	0.2 mg/cm^2/d	7	6 (C) 24 (A)
Biota	Dairy[a]	300 g/d	365	30
	Beef[a]	75 g/d	365	30
	Game[a]	1 g/d	365	30
	Fish[a]	54 g/d	365	30
	Fruit[a]	42 g/d	365	30
	Vegetable[a]	80 g/d	365	30

[a]Exposure Factors for Radioactive and Nonradioactive Carcinogens.
[b]Exposure Factors for Nonradioactive Carcinogens.
[c]Exposure Factors for Radioactive Carcinogens.
(A) = Adult.
(C) = Child.

Table 3-5. Industrial Scenario Exposure Factors.

Pathway		Exposure Parameters		
Media	Exposure Route	Intake Rate	Exposure Frequency (d/yr)	Exposure Duration (yr)
Soil	Ingestion[a]	50 mg/d	146	20
	Dermal[b]	0.2 mg/cm^2/d	146	20
	External[c]	8 hr/d	146	20
Air	Inhalation[a]	20 m^3/d	250	20
Groundwater	Ingestion[a]	1 L/d	250	20
	Inhalation[a]	20 m^3/d	250	20
	Dermal[b]	0.17 hr/d	250	20
Surface Water	Ingestion[a]	1 L/d	250	20
	Inhalation[a]	20 m^3/d	250	20
	Dermal[b]	0.17 hr/d	250	20

[a]Exposure Factors for Radioactive and Nonradioactive Carcinogens.
[b]Exposure Factors for Nonradioactive Carcinogens.
[c]Exposure Factors for Radioactive Carcinogens.
(A) = Adult.
(C) = Child.

Table 3-6. Recreational Scenario Exposure Factors.

Pathway		Exposure Parameters		
Media	Exposure Route	Intake Rate	Exposure Frequency (d/yr)	Exposure Duration (yr)
Soil	Ingestion[a]	200 mg/d (C) 100 mg/d (A)	7	6 (C) 24 (A)
	Dermal[b]	0.2 mg/cm²/d	7	6 (C) 24 (A)
	External[c]	8 hr/d	7	30
Air	Inhalation[a]	20 m³/d	7	30
Groundwater	Ingestion[a]	2 L/d	7	30
	Dermal[b]	0.17 hr/d	7	30
Surface Water	Ingestion[a]	2 L/d	7	30
	Dermal[b]	2.6 hr/d	7	30
Sediment	Ingestion[a]	200 mg/d (C) 100 mg/d (A)	7	6 (C) 24 (A)
	Dermal[b]	0.2 mg/cm²/d	7	6 (C) 24 (A)
Biota	Waterfowl[a]	--	--	--
	Game[a]	1 g/d	365	30
	Fish[a]	54 g/d	365	30
	Plant[a]	--	--	--

[a]Exposure Factors for Radioactive and Nonradioactive Carcinogens.
[b]Exposure Factors for Nonradioactive Carcinogens.
[c]Exposure Factors for Radioactive Carcinogens.
(A) = Adult.
(C) = Child.

3.2 *Preferred Sitewide Future Land-Use Alternative*

Based on programmatic needs and stakeholder input during scoping, the DOE identified a Preferred Future Land-Use Alternative for each of the four geographic areas of the Hanford Site. The Preferred Sitewide Future Land-Use Alternative, which was developed by combining the Preferred Future Land-Use Alternatives for each geographic area, is briefly summarized below.

3.2.1 Columbia River, Restricted Future Land-Use Alternative

This alternative would rely on removal of physical hazards and contaminants, through the use of engineering and/or institutional controls, and would result in residual contaminant levels requiring some restrictions on human use. Under the Restricted Future Land-Use Alternative, current unrestricted access to the Columbia River for recreational use would be maintained. Restrictions would continue to apply to shoreline and island access, and disturbance of riverbank and river bottom sediments. Use and access restrictions would be enforced by institutional controls (i.e., fencing, signs, and deed restrictions). Engineering controls (e.g., caps) might be used to stabilize and/or isolate areas of contamination, and could be used with institutional controls to protect human health and the environment. This alternative would enable future land uses consistent with those envisioned by the Working Group (Table 3-3). The CERCLA exposure scenario associated with this alternative is recreational (Table 3-7).

3.2.2 Reactors on the River, Restricted Future Land-Use Alternative (R1)

This alternative would be achieved through excavation of contaminated soil and remediation of past-practice waste units, in conjunction with closure of treatment, storage and/or storage (TSD) facilities and decommissioning of surplus contaminated and uncontaminated facilities associated with the reactors. Under this alternative, the Reactors on the River geographic area would be remediated to levels that require restrictions on use because of residual contamination, physical hazards, and/or protection of cultural resources and sensitive wildlife habitat. Soil disturbing activities, and withdrawal and use of groundwater within this geographic area, would be controlled for an indefinite period. This alternative would enable future land uses consistent with those envisioned by the Working Group (Table 3-3). The CERCLA exposure scenario associated with this alternative is recreational (Table 3-7).

3.2.3 Central Plateau, Exclusive Future-Land Use Alternative

This alternative would achieve exclusive use primarily through the use of engineering and institutional controls, and capping of past-practice waste units and TSD facilities. The DOE would maintain institutional control, and would continue to use the area for waste management activities. Public access, withdrawal and use of groundwater, and soil disturbing activities would be controlled for an indefinite period. A temporary surface and subsurface buffer zone would surround the Central Plateau geographic area. In an effort to respond to comments made during the scoping process, the DOE would ensure that this alternative allowed certain restricted Native American uses. This alternative would enable future land uses consistent with those envisioned by the Working Group (Table 3-3). The CERCLA exposure scenario associated with this alternative is industrial (Table X.X).

3.2.4 *All Other Areas, Restricted Future Land-Use Alternative (R1)*

This alternative would achieve restricted use through the use of engineering and institutional controls, and removal and treatment of contaminants. The DOE would maintain institutional control, and would continue to use the area for activities similar to those allowable under current Site management. Restrictions would apply to activities that could disturb soil in or around revegetated excavation sites. In addition, withdrawal and use of groundwater would be restricted for an indefinite period. Monitoring and institutional controls (i.e., signs, fencing and deed restrictions) would be used, as necessary, to restrict use and access. This alternative would enable future land uses consistent with those envisioned by the Working Group (Table 3-3). The CERCLA exposure scenario associated with this alternative is industrial for the 300 Area, and recreational for the rest of the geographic area (Table 3-7).

3.3 *Description of the Alternatives*

In order to achieve the remediation goals associated with a future land-use alternative, a series of remediation activities would need to occur. These remediation activities are discussed in a generic manner throughout this EIS. This generic discussion emphasizes that specific remediation activities, technologies, and strategies would be assessed and refined through the CERCLA and/or *Resource Conservation and Recovery Act of 1976* (RCRA) processes on a case-by-case basis. This approach would not prejudice the DOE towards a specific course of action, and would allow for the development and use of innovative technologies.

3.3.1 *Description of the No-Action Alternative*

The term "no action" does not mean that the DOE would take no further action of any kind at the Hanford Site; it is defined to mean that the DOE would conduct a long-term monitoring and maintenance program instead of continuing with the current program of TSD facility unit closures, past-practice site remedial actions, and surplus facility decommissioning actions. This approach provides a definitive baseline for comparing the alternatives.

Consideration of the No-Action Alternative is required by the CEQ regulations implementing NEPA, 40 *Code of Federal Regulations* 1500-1508. Although the activities to be conducted under the No-Action Alternative provide a measure of containment and control for contaminants, they do not constitute permanent remedial actions or complete decommissioning actions. It is recognized that actual implementation of the No-Action Alternative for the Hanford Site as a whole would be contrary to the provisions of the Tri-Party Agreement (Ecology et al. 1989). A decision to implement the No-Action Alternative at any particular area of the Hanford Site would be made in accordance with the site-specific decisionmaking process specified by the Tri-Party Agreement.

The No-Action Alternative is common to all of the geographic areas, but the specific monitoring and maintenance activities conducted would vary depending on the types of waste sites and facilities found in each area. This alternative is used to establish a baseline against which the impacts of the other alternatives are compared. The potential risk to human health and the environment is considered minimal under current control and management of the Hanford Site, but future changes to the control and management of the Hanford Site could result in greater risk if the No-Action Alternative is implemented. For purposes of the analysis, the monitoring and maintenance activities conducted under the No-Action Alternative are assumed to continue for 100 years. After 100 years,

it is assumed that the DOE would relinquish institutional control of the Hanford Site. After that time, for purposes of the analysis, it assumes that safeguards associated with monitoring and maintenance activities would no longer control the release of radiological and chemical contaminants from the Hanford Site. The 100 years is assumed to represent the period of active institutional control is an arbitrary assumption with no legal significance. If the DOE should arrive at the determination that the lands are no longer needed to fulfill the DOE's current mission, a desired future land use would be identified. Following identification of a desired future land use, remediation of contaminants to risk levels allowing for that desired land use would be conducted.

Activities included in the definition of the No-Action Alternative fall into two major activity categories: (1) monitoring, and (2) maintenance. These categories are similar to activities currently conducted at the Hanford Site in accordance with the requirements of established DOE, federal, and state environmental protection programs. The types of activities conducted within each category are discussed in more detail in the following sections.

3.3.1.1 Monitoring Under the No-Action Alternative. The DOE would conduct a program of environmental monitoring similar to the program currently conducted and reported annually in the *Hanford Site Environmental Report for Calendar Year 1994* (PNL 1995). This program would continue through the period of institutional control, and would consist of monitoring environmental media (i.e., air, water, wildlife, soil, and vegetation) and external radiation levels on the Hanford Site.

3.3.1.2 Maintenance Under the No-Action Alternative. The DOE would conduct a continuing program of maintenance activities similar to those activities presently conducted under the established Site maintenance programs. These activities would consist of surveillance and maintenance of surplus facilities, stabilization of waste sites, and safeguards and security.

3.3.1.2.1 Surveillance and Maintenance of Surplus Facilities. A program of surveillance and maintenance of surplus facilities would continue throughout the period of institutional control. Activities similar to those currently conducted on surplus facilities awaiting decommissioning (WHC and USACE 1994a) would continue to ensure containment and control of radiological, environmental, and safety hazards, and to protect onsite workers and the public. No effort would be made to decommission surplus facilities under the No-Action Alternative.

Both routine and corrective activities would be conducted. Routine activities would consist of performing periodic inspections, audits, and minor repairs. Corrective activities would include performing structural repairs and/or replacements, electrical upgrades, and other physical upgrades to protect against injuries.

3.3.1.2.2 Stabilization of Waste Sites. A program of waste site stabilization activities similar to those currently performed under the Radiation Area Remedial Actions Program (WHC and USACE 1994b) would continue for the period of institutional control. This program would be conducted to minimize the spread of surface soil contamination, which could lead to worker or public exposure. The program would consist of surface decontamination and stabilization, surveillance and maintenance, and vegetation management. No effort would be made to conduct permanent remedial actions at waste sites.

Decontamination and stabilization would include consolidation of contaminated soil inside original waste site boundaries. This would include scraping or moving surface soils with heavy equipment (e.g., scrapers, bulldozers, tractors, and dump trucks). Contamination would be consolidated within the original site boundaries and stabilized by covering with clean soil. The areas would be revegetated to reduce or prevent soil erosion. Surveillance and maintenance would include routine surveying for contamination spread and weed growth, responding to reports of problem areas, and upgrading of posted signs and barricades. Vegetation management would involve using herbicides during spring and fall to prevent aggressive, deep-rooted weed species from becoming established. (This would prevent uptake of contaminants through the plant root systems and spreading of contaminants when the plants die.) Special care would be taken to avoid, or minimize any adverse impact on desired plant communities (i.e., vegetation needed for erosion control).

3.3.1.2.3 ***Safeguards and Security***. A program of safeguards and security would continue during the period of institutional control. Activities similar to those performed under the current safeguards and security program (WHC 1994) would be conducted to maintain security of materials and facilities, prevent unauthorized access, and enforce a control on uncontrolled public access to the Site. These activities would consist of patrol force operations, security systems testing, security education, security systems maintenance and engineering, security projects, and the locksmith program.

3.3.2 Columbia River Alternatives

The Columbia River geographic area encompasses 66 km (41 mi) of the Columbia River, which flows through or borders the Hanford Site, and includes the river islands and island sediments, river bottom and riverbank sediments, and the area 0.4 km (1/4 mi) inland on both shores of the river. (The delineation of this geographic area is consistent with the scope of the *Hanford Reach of the Columbia River, Comprehensive River Conservation Study and Final Environmental Impact Statement* (NPS 1994). This stretch of the river offers a unique example of riverine and riparian ecologies that characterize the Columbia Basin prior to construction of hydroelectric dams on the river. Contamination has occurred at several locations along the Columbia River. This contamination is a result of contaminated groundwater entering the Columbia River geographic area through a series of springs and seeps. The major radiological and chemical contaminants from the springs and seeps include tritium, strontium-90, technicium-99, and uranium. Additional contamination and physical hazards result from each production reactor's river discharge pipeline, which is buried beneath the riverbank and riverbottom sediment. These pipelines extend from the outfall structures into the river, and are contaminated primarily with cobalt-60, europium-152, -154 and -155 (UNI 1986). (Specific locations and concentrations of radiological and chemical contaminants will be determined by characterization activities conducted under the CERCLA process).

Table 3-7 depicts the Columbia River future land-use alternatives selected for detailed analysis, with associated actions to be implemented, exposure scenarios, and land use restrictions.

Table 3-7. Future Land-Use Alternatives for the Columbia River.

Alternatives	Actions to be Implemented	Exposure Scenario[a]	Land Use Restrictions
No-Action	• Environmental monitoring • Stabilizing waste sites • Institutional controls	Not Applicable	• Restrictions on public access to shorelines and islands • Restrictions on sediment disturbance
Unrestricted Future Land Use	• Excavating contaminated riverbank, riverbottom and island sediment • Decommissioning of river discharge pipelines • Transporting contaminated materials to an onsite disposal facility • Site reclamation • Environmental monitoring • Institutional controls	Agricultural	• Possible restrictions on public access due to physical hazards or environmental sensitivity
Restricted Future Land Use	• Stabilization of intact river discharge pipelines • Removal of detached river discharge pipeline segments; demolish and leave in place associated tie down structures • Transport of contaminated materials to onsite disposal facility • Raconteur riverbottom where needed • Environmental monitoring • Institutional controls	Recreational	• Restrictions on public access to shorelines and islands • Restrictions on sediment disturbance

[a]These exposure scenarios would be used under the CERCLA process to establish cleanup goals.

3.3.2.1 Columbia River, No-Action Alternative. The No-Action Alternative for the Columbia River geographic area would consist of continuing environmental monitoring, surveillance and maintenance, stabilization of waste sites, and the safeguards and securities program. The No-Action Alternative is described in more detail in Section 3.3.1. The DOE would maintain institutional control over the Columbia River geographic area, and would continue to allow use of the area for wildlife habitat and controlled recreation. Public access to the riverbank and islands would continue to be restricted. Restrictions on activities that disturb sediments on the riverbank, river bottom, and islands also would be maintained. These uses and restrictions would remain in place until it is determined that the lands are no longer needed to fulfill the DOE's current mission, or the DOE relinquishes institutional control of the Hanford Site (assumed to be 100 years for analyses purposes). If the DOE should arrive at the determination that the lands are no longer needed to fulfill the DOE's current mission, a

desired future land use would be identified. Following identification of a desired future land use, remediation of contaminants to risk levels allowing for that desired land use would be conducted.

3.3.2.2 Columbia River, Unrestricted Future Land-Use Alternative. For this alternative, unrestricted use of the Columbia River geographic area would be achieved through excavation of contaminated riverbank, riverbottom, and island sediments, in conjunction with decommissioning of the river discharge pipelines. Appendix A contains a complete list of past-practice waste units and surplus facilities within the scope of the Columbia River geographic area. Under this alternative, the Columbia River geographic area would be remediated to risk levels such that no human use would be precluded. However, access or certain uses could be controlled for other reasons (i.e., physical hazards or protection of cultural resources and sensitive wildlife habitat). The full nature and extent of contamination in the Columbia River geographic area has not been completely characterized. This characterization is the subject of ongoing investigations under the Tri-Party Agreement. Under this alternative, contamination detected in future characterization studies would be removed to levels that would not preclude any human use. This alternative would enable future land uses consistent with those envisioned by the Working Group (Table 3-3). The CERCLA exposure scenario associated with this alternative is agricultural.

This alternative would include excavation of contaminated sediments on riverbank areas where groundwater plumes meet the shoreline, along with excavation of contaminated island sediment to reduce contaminant exposure through the dermal, ingestion, and inhalation pathways under the agricultural exposure scenario. All excavated sediments would be segregated and classified according to waste type. Uncontaminated sediment would be stockpiled for backfill and reclamation use. Excavated contaminated sediment would be loaded into waste containers at a staging area, covered, and transported by truck or rail to the Central Plateau geographic area for storage and/or disposal. If necessary, additional backfill materials would be obtained from an onsite location. For site restoration, excavation sites would be recontoured to blend in with surrounding topography and, if needed, revegetated. Riverbank sediments are assumed to have been contaminated by groundwater during and subsequent to reactor operations. Upgradient control of groundwater plumes would be required to prevent sediment recontamination. The methodology for accomplishing remediation of the portion of the river bordering the 100 Areas is presented in the *100 Area Feasibility Study, Phases 1 and 2* (DOE-RL 1994b). To fully evaluate the need to implement this alternative for other shoreline areas outside the Reactors on the River geographic area, a detailed study would be required, and more detailed information about the nature and extent of contamination would be needed.

The Unrestricted Future Land-Use Alternative for the Columbia River geographic area also would require removal (a phase of the decommissioning process) of the river discharge pipelines. Removal of the river discharge pipelines may require use of a cofferdam and a sediment dewatering system in the river. Tie down structures for anchoring the river discharge pipelines would be demolished and left in place. As necessary, sediments overlying the river discharge pipelines also would be excavated, loaded into large waste containers at a staging area, and covered and transported by truck or rail to the Central Plateau geographic area for storage and/or disposal. Pipelines would be cut into manageable pieces, the ends sealed, and sections wrapped or placed in containers for disposal as low-level waste (LLW) or low-level mixed waste (LLMW) (DOE-RL 1994b). This waste then would be hauled by truck or rail to the Central Plateau for disposal. Uncontaminated structures would be recycled and used within the DOE complex, or compacted for disposal as solid waste in an onsite facility.

On May 22, 1995, the DOE issued the *Policy on Decommissioning of Department of Energy Facilities Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)*. This policy established the approach agreed upon by the DOE and the EPA to conduct decommissioning projects[1] consistent with CERCLA requirements. Therefore, any decision made regarding the potential fate of the river discharge pipelines in this EIS will be revisited and modified, if needed, through the CERCLA process. Prior to issuance of this policy, the DOE conducted decommissioning activities as separate and discrete projects, subject to neither CERCLA nor RCRA requirements.

Excavation and demolition would be achieved through the use of heavy earth moving and demolition equipment. As demolition and excavation activities proceed, a program of monitoring and sampling would be implemented to minimize worker exposure and determine the effectiveness of contaminant removal.

3.3.2.3 Columbia River, Restricted Future Land-Use Alternative. For this alternative, restricted use would be achieved through the removal of physical hazards and contaminants combined with engineering and/or institutional controls. This alternative would result in residual contaminant levels requiring some restrictions on human use of the Columbia River geographic area. Under a Restricted Future Land-Use Alternative, current unrestricted access to the Columbia River for recreational use would be maintained. Restrictions would apply to shoreline and island access, and to disturbance of riverbank and river bottom sediments. Use and access restrictions would be enforced by institutional controls (i.e., use permits, fencing, signs, and deed restrictions). Engineering controls (e.g., rip-rap over river discharge pipelines) might be used to stabilize areas of contamination and could be used in combination with institutional controls to protect human health and the environment. This alternative would enable future land uses consistent with those envisioned by the Working Group (Table 3-3). As described in Section 3.1.4, the CERCLA exposure scenario associated with these land uses is recreational.

The Restricted Future Land-Use Alternative for the Columbia River geographic area would include *in-situ* stabilization of intact river pipelines. Intact pipelines would be anchored to the riverbottom and covered with riprap. The terminating structures of the intact pipelines would be sealed using a grout backfill. In addition to preventing the release of contaminants from the interiors of the pipelines, this also would stabilize the pipelines and aid in preventing further shifting caused by river currents. Where necessary, the riverbed would be recontoured to reduce river turbulence and reduce scouring around discharge lines.

Some sections of pipeline have deteriorated and detached, potentially posing physical hazards or serving as a source of contamination. Tie down structures for anchoring these river discharge pipelines would be demolished and left in place. Detached pipeline segments would be cut into manageable pieces, the ends sealed, and sections wrapped or placed in containers for disposal as LLW

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[1]As defined in the *Policy on Decommissioning of Department of Energy Facilities Under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)*: "... decommissioning includes those activities that take place after a facility has been deactivated and placed in an ongoing surveillance and maintenance program. Decommissioning can include decontamination and dismantlement. Decontamination encompasses the removal or reduction of radioactive or hazardous contamination from facilities. Dismantlement involves the disassembly or demolition, and removal, of any structure, system, or component and the interim or long-term disposal of waste materials in compliance with applicable requirements.

or LLMW (DOE-RL 1994b), and then hauled by truck or rail to the Central Plateau for disposal. Uncontaminated structures would be recycled and used within the DOE complex or disposed of as solid waste in an onsite facility.

This alternative assumes that river sediment sampling and monitoring would continue. If necessary, sediments associated with detached pipeline segments would be excavated to acceptable human health and/or environmental risk levels. All excavated sediments would be dewatered, segregated and classified according to waste type. Uncontaminated sediment would be stockpiled for backfill and reclamation use. Excavated contaminated sediment would be loaded into waste containers at a staging area, covered and transported by truck or rail to the Central Plateau geographic area for storage or disposal.

3.3.3 Reactors on the River Alternatives

The Reactors on the River geographic area encompasses approximately 68 km^2 (26 mi^2) and includes past-practice waste units, TSD facilities and surplus facilities in the 100 Area listed in Appendix A. The effluent lines running from the reactor facilities to the outfall structures are included in this geographic area. The boundaries of the Reactors on the River geographic area correspond to the area which includes all of the 100 Area Operable Units (HFSUWG 1992). Extensive contamination exists in some areas of surface soils, subsurface soils and groundwater within the boundary of the Reactors on the River geographic area. This contamination is a result of past operations of the nine plutonium production reactors. The major radiological contaminants present in the Reactors on the River geographic area include tritium, cobalt-60, strontium-90, cesium-137, and isotopes of uranium and plutonium. Chemical contaminants include chromium, oxalic acid, nitric acid, sulfuric acid, mercury and PCB's. Specific locations and concentrations of radiological and chemical contaminants will be determined by characterization activities conducted under CERCLA.

Table 3-8 depicts the Reactors on the River future land-use alternatives selected for detailed analysis, with associated actions to be implemented, exposure scenarios and land-use restrictions.

3.3.3.1 Reactors on the River, No-Action Alternative. The No-Action Alternative for the Reactors on the River geographic area would consist of continuing environmental monitoring, surveillance and maintenance, stabilization of waste sites and the safeguards and security program. No remedial activities would be conducted. The No-Action Alternative is described in more detail in Section 3.3.1. The DOE would maintain institutional control of the Reactors on the River geographic area and continue to allow use of the area for waste management activities and wildlife habitat. Public access would remain restricted. These uses and restrictions would remain in place until it is determined that the lands are no longer needed to fulfill DOE's current mission, or DOE relinquishes institutional control of the Hanford Site (assumed to be 100 years from now for analyses purposes). If DOE should arrive at the determination that the lands are no longer needed to fulfill the DOE's current mission, a desired future land use would be identified. Following identification of a desired future land use, remediation of contaminants to risk levels allowing for that desired land use would be conducted.

Table 3-8. Future Land-Use Alternatives for the Reactors on the River.

Alternatives	Actions to be Implemented	Exposure Scenario[a]	Land-Use Restrictions
No-Action	• Environmental monitoring • Stabilizing waste sites • Institutional controls	Not Applicable	• Restrictions on public access • Restrictions on use of groundwater • Restrictions on soil disturbance
Unrestricted Future Land-Use	• Excavating contaminated soils and materials • Transporting contaminated materials to onsite disposal facility • Groundwater remediation • Site reclamation • Environmental monitoring	Agricultural	• Possible restrictions on public access due to physical hazards or for protection of cultural resources and/or sensitive wildlife habitat
Restricted Future Land Use (R1)	• Excavating contaminated soils and materials • Transport of contaminated materials to onsite disposal facility • Groundwater remediation • Site reclamation • Environmental monitoring • Institutional controls	Recreational	• Restrictions on public access • Restrictions on use of groundwater • Restrictions on subsurface disturbances
Restricted Future Land Use (R2)	• Capping waste units and TSDs • Groundwater remediation • Site reclamation • Environmental monitoring • Institutional controls	Recreational	• Restrictions on public access • Restrictions on use of groundwater • Restrictions on subsurface disturbances

[a]These exposure scenarios would be used under the CERCLA process to establish cleanup goals.

3.3.3.2 Reactors on the River, Unrestricted Future Land-Use Alternative. For this alternative, unrestricted use of the Reactors on the River geographic area would be achieved through excavation of contaminated soil and remediation of past-practice waste units, in conjunction with closure of TSD facilities and decommissioning of surplus contaminated and uncontaminated facilities associated with the reactors. Under this alternative, the Reactors on the River geographic area would be remediated to levels such that no human use would be precluded. However, access or certain uses may be controlled for other reasons (i.e., physical hazards or protection of cultural resources and/or sensitive wildlife habitat). This alternative would enable future land uses consistent with those envisioned by the Working Group (Table 3-3). The CERCLA exposure scenario associated with these land uses is agricultural.

Hanford's nine surplus production reactors, their associated nuclear fuel storage basins and the structures that house these systems are not within the scope of this EIS (see Chapter 1.0 for Scope Definition). However, decommissioning of these structures would be required to achieve unrestricted use of the Reactors on the River geographic area. This EIS assumes that the surplus production reactors, except B Reactor, would be dismantled and transported to the Central Plateau geographic area for disposal in accordance with the ROD for the *Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington, Environmental Impact Statement* published on September 16, 1993, in the *Federal Register* (58 FR 48509). This EIS assumes that B Reactor is decontaminated but not dismantled and is open to public viewing with safeguards to prevent unauthorized access. This EIS further assumes that N Reactor is dismantled and removed for disposal on the Central Plateau geographic area in a method similar to the other surplus reactors. Both this EIS and the Surplus Production Reactors ROD would include statements on the potential fate of facilities scheduled for decommissioning within the Reactors on the River geographic area. Following issuance of the Surplus Production Reactors ROD and development of this Draft EIS, DOE issued *Policy on Decommissioning of Department of Energy Facilities Under the Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA) (May 22, 1995)*. This policy establishes the approach agreed upon by the Department of Energy (DOE) and the Environmental Protection Agency (EPA) for the conduct of decommissioning projects consistent with CERCLA requirements. Therefore, decisions made regarding the fate of surplus facilities in this Draft EIS, as well as those made in the Surplus Production Reactors ROD, will be revisited and modified, if necessary, through the CERCLA process. Prior to issuance of this policy, DOE conducted decommissioning activities as separate and discrete projects, subject to neither CERCLA nor RCRA requirements.

This alternative would include extensive excavation of surface/subsurface past-practice waste sites and TSD facilities to reduce contaminant exposure via the dermal, ingestion and inhalation pathways under the agricultural exposure scenario. If TRU contaminated waste is identified, it would be processed and placed into interim storage until permanent disposal is available. Buried LLW and LLMW in burial grounds would be retrieved, treated (if needed), and shipped by truck or rail to the Central Plateau geographic area for storage and/or disposal. Contaminated land-based reactor effluent lines, outfall structures, and contaminated and uncontaminated surplus facilities would be demolished, treated (if needed) and also shipped to the Central Plateau geographic area for storage and/or disposal. Excavation and demolition would be achieved through the use of heavy earth-moving and demolition equipment. As demolition and excavation activities proceed, a program of monitoring and sampling would be implemented to minimize worker exposure and determine the effectiveness of contaminant removal.

All excavated waste would be segregated and classified according to waste type. Materials would be recycled or compacted (e.g., drums, piping, construction waste, rubble, and other containers). Uncontaminated materials would be reused or disposed of as solid waste. Excavated contaminated soils and materials would be loaded into large waste containers at a staging area, covered, and transported by truck or rail to the Central Plateau geographic area for disposal. Uncontaminated soils would be segregated and stockpiled for backfill and reclamation use. Volume reduction and waste minimization technologies would be applied as part of the remediation.

If necessary, additional backfill materials would be obtained from an onsite location. For site restoration, excavation sites would be recontoured to blend in with the surrounding topography, and revegetated or covered with a suitable cover material.

This alternative also would include groundwater remediation to address contaminant plumes in (and potentially entering into) the Reactors on the River geographic area. This groundwater remediation strategy would include three primary goals.

- Protect currently uncontaminated groundwater.

- Remediate currently contaminated groundwater to levels acceptable under the agricultural scenario.

- Protect the Columbia River and associated ecosystem.

These goals would be accomplished through a combination of active and passive measures designed to reduce sources of contamination, control the migration of highly contaminated groundwater towards the Columbia River and reduce contaminant concentration levels. This would include:

- Extensive excavation of past-practice waste units and TSD facilities, as described above, to reduce sources of contamination.

- Pumping and treating groundwater plumes to levels protective of the Columbia River.

- Monitoring natural attenuation of contaminated groundwater plumes.

- Maintaining institutional controls prohibiting groundwater use until such a time that groundwater sampling results indicate contaminant levels would not preclude any human use.

This strategy would be refined through the CERCLA process.

3.3.3.3 Reactors on the River, Restricted Future Land-Use Alternative (R1). As with the Unrestricted Future Land-use Alternative discussed in Section 3.3.3.2, this restricted (R1) future land-use alternative would be achieved through excavation of contaminated soil and remediation of past-practice waste units, in conjunction with closure of TSD facilities and decommissioning of surplus contaminated and uncontaminated facilities associated with the reactors. Under this alternative, the Reactors on the River geographic area would be remediated to levels such that restrictions on use of the area may be required due to residual contamination, physical hazards, and/or protection of cultural resources and sensitive wildlife habitat. Restrictions on activities that disturb soil would apply in and around revegetated excavation sites. In addition, withdrawal and use of groundwater would be restricted for an indefinite period. Monitoring and institutional controls (e.g., signs, fencing and deed restrictions) would be used as necessary to restrict use and access. This alternative would enable future land uses consistent with those envisioned by the Working Group (Table 3-3). As described in Section 3.1.4, the CERCLA exposure scenario associated with these land uses is recreational.

Restricted use of the Reactors on the River geographic area (R1) would not necessarily be applied to the entire geographic area; the restrictions would apply primarily to the areas requiring remediation. Restrictions on use of the Reactors on the River geographic area are intended to apply only to risks from residual contamination, although there may be other reasons to restrict access to portions of the Reactors on the River geographic area (e.g., physical hazards and/or protection of cultural resources and sensitive wildlife habitat).

The restricted use alternative for the Reactors on the River geographic area (R1) would include excavation of surface/subsurface past-practice waste units and TSD facilities, in conjunction with decommissioning of surplus contaminated and uncontaminated facilities. Contaminant exposure would be reduced to levels acceptable under the recreational exposure scenario. If TRU contaminated waste was identified, it would be processed and placed into interim storage until permanent disposal is available. Buried LLW and LLMW in burial grounds would be retrieved, treated (if needed), and shipped to the Central Plateau geographic area for storage and/or disposal. Contaminated reactor effluent lines, outfall structures and contaminated and uncontaminated surplus facilities would be demolished, treated (if needed) and shipped to the Central Plateau geographic area for storage and/or disposal. Excavation and demolition would be performed using heavy earth-moving and demolition equipment. As demolition and excavation activities proceed, a program of monitoring and sampling would be implemented to minimize worker exposure and determine the effectiveness of contaminant removal.

All excavated waste would be segregated and classified according to waste type. Materials would be recycled or compacted (e.g., drums, piping, construction waste, rubble, and other containers). Uncontaminated materials would be disposed of as solid waste. Excavated contaminated soils and materials would be loaded into waste containers at a staging area, covered, and transported by truck or rail to the Central Plateau geographic area for disposal. Uncontaminated soil would be segregated and stockpiled for backfill and reclamation use. Volume reduction and waste minimization technologies would be applied as part of the remediation.

If necessary, additional backfill materials would be obtained from an onsite location. For site restoration, excavation sites would be recontoured to blend with surrounding topography, and revegetated or covered with a suitable cover.

This alternative also would include groundwater remediation to address contaminant plumes in, and potentially entering the Reactors on the River geographic area. This groundwater remediation strategy would include two primary goals:

- Protecting currently uncontaminated groundwater.
- Protecting the Columbia River and associated ecosystem.

These goals would be accomplished through a combination of active and passive measures designed to reduce sources of contamination and to control the migration of highly contaminated groundwater towards the Columbia River. This would include:

- Extensive excavation of past-practice waste units and TSD facilities, as described above, to reduce sources of contamination.
- Pumping and treating groundwater plumes to levels protective of the Columbia River.
- Monitoring natural attenuation of contaminated groundwater plumes.
- Maintaining institutional controls prohibiting groundwater use until such a time that groundwater sampling results indicate contaminant levels would not preclude any human use.

This strategy would be refined through the CERCLA process.

3.3.3.4 Reactors on the River, Restricted Future Land-Use Alternative (R2). For this alternative, restricted use of the Reactors on the River geographic area would be achieved through the use of engineering and institutional controls. Past-practice waste units and TSD facilities would be stabilized using protective caps. Surplus facilities would be demolished and removed. Under this alternative, the Reactors on the River geographic area would be remediated to levels such that restrictions on use of the area would be required due to residual contamination, physical hazards, and/or protection of cultural resources and sensitive wildlife habitat. Restrictions on activities that disturb soil would apply in and around capped waste sites. In addition, withdrawal and use of groundwater would be restricted for an indefinite period. Monitoring and institutional controls (e.g., signs, fencing and deed restrictions) would be used as necessary to restrict use and access and to determine cap effectiveness. This alternative would enable future land uses consistent with those envisioned by the Working Group (Table 3-3). As described in Section 3.1.4, the CERCLA exposure scenario associated with these land uses is recreational.

The Restricted Future Land-Use Alternative (R2) for the Reactors on the River geographic area would involve leaving, in place, contaminated soils, buried LLW, and LLMW contained within past-practice waste units and TSD facilities. Human exposure to contamination would be limited through the use of protective caps. Several alternative cap designs are being considered. For purposes of this EIS, a reference cap design was used (Appendix E) to provide a bounding estimate of materials required and associated impacts and a modified RCRA cap was used in the analysis of environmental consequences in Chapter 5. Measures such as dynamic compaction and/or injection grouting would be used to minimize subsidence at burial grounds and cribs, and would enhance long-term integrity of caps. Leachate detection would be used to monitor cap performance.

The groundwater strategy for the restricted use alternative would be the same as described in the restricted (R1) land-use alternative, but would not include excavation activities. Caps would be used to prevent migration of source contaminants to the groundwater.

3.3.4 Central Plateau Alternatives

The Central Plateau geographic area is located near the center of the Hanford Site and encompasses approximately 115 km^2 (44 mi^2) of land. This area has been used for fuel reprocessing, waste management, and disposal activities and is the most extensively contaminated area of the Hanford Site. Appendix A lists the past-practice waste units and TSD facilities within the Central Plateau geographic area. Contaminants within the Central Plateau geographic area include, but are not limited to tritium, cobalt-60, strontium-90, technicium-99, iodine-129, cesium-137, uranium, plutonium, arsenic, carbon tetrachloride, trichloroethylene and tetrachloroethylene (DOE-RL 1994b, DOE-RL 1994c).

Table 3-9 depicts the Central Plateau future land-use alternatives selected for detailed analysis, with associated actions to be implemented, exposure scenarios and land-use restrictions.

Table 3-9. Future Land-Use Alternatives for the Central Plateau.

Alternatives	Actions to be Implemented	Exposure Scenario[a]	Land-Use Restrictions
No-Action	• Environmental monitoring • Stabilizing waste sites • Institutional controls	Not Applicable	• Restrictions on public access • Restrictions on use of groundwater • Restrictions on soil disturbance
Exclusive Future Land Use	• Limited excavation of contaminated soils and materials • Transportation of contaminated soils and materials to common area for consolidation • Groundwater remediation • Capping waste units and TSDs • Site reclamation • Environmental monitoring • Institutional controls	Industrial	• Restrictions on public access (buffer zone would be available for limited use) • Restrictions on use of groundwater • Restrictions on soil disturbance

[a]These exposure scenarios would be used under the CERCLA process to establish cleanup goals.

3.3.4.1 Central Plateau, No-Action Alternative. The No-Action Alternative for the Central Plateau geographic area would consist of continuing environmental monitoring, surveillance and maintenance, stabilization of waste sites and the safeguards and security program. No remedial activities would be conducted. The No-Action Alternative is described in more detail in Section 3.3.1. DOE would maintain institutional control of the Central Plateau geographic area, and would continue to use the area for waste management activities. Public access, withdrawal and use of groundwater, and soil disturbing activities would remain restricted. These uses and restrictions would remain in place until it is determined that the lands are no longer needed to fulfill the DOE's current mission, or DOE relinquishes institutional control of the Hanford Site (assumed to be 100 years for analysis purposes). If DOE should arrive at the determination that the lands are no longer needed to fulfill the DOE's current mission, a desired future land use would be identified. Following identification of a desired future land use, remediation of contaminants to risk levels allowing for that desired land use would be conducted.

3.3.4.2 Central Plateau, Exclusive Future Land-Use Alternative. For this alternative, exclusive future land use of the Central Plateau geographic area would be achieved primarily through engineering and institutional controls and capping of past-practice waste units and TSD facilities. This alternative would enable future land uses consistent with those envisioned by the Working Group (Table 3-3). As described in Section 3.1.4, the CERCLA exposure scenario associated with these land uses is industrial. The DOE would ensure that this Exclusive Future Land-Use Alternative would allow certain restricted Native American uses, in an effort to respond to comments made during the EIS scoping process for the *Hanford Remedial Action Environmental Impact Statement* (HRA-EIS). It is anticipated that DOE would maintain institutional control of the Central Plateau geographic area and continue to use the area for waste management activities. Public access,

withdrawal and use of groundwater, and soil disturbing activities in the Central Plateau geographic area would be controlled for an indefinite period. The Central Plateau geographic area would include a surface and subsurface buffer zone. The purpose of this buffer zone would be to further isolate and reduce the risks associated with contamination present in the Central Plateau geographic area. Although the buffer zone would be classified as an exclusive use area, waste management activities would not be allowed to occur within its boundaries. The boundaries of this buffer zone would be determined through conventional risk management practices and would be periodically reassessed to reflect current risk (HFSUWG 1992). It is assumed that remediation of the Central Plateau geographic area would reduce risks to levels sufficient to minimize the size of the buffer zone. As the size of the buffer zone shrinks, the excess lands would no longer be classified as exclusive use lands and could be used for other nonwaste management purposes.

An Exclusive Future Land-Use Alternative for the Central Plateau geographic area would involve leaving in place contaminated soils, buried LLW, and LLMW contained within past-practice waste units and TSD facilities, and pre-1970 TRU waste. Human exposure to contamination would be limited through the use of protective caps. Several alternative cap designs are being considered. For purposes of the HRA-EIS, a reference cap design was used (Appendix E) to provide a bounding estimate of materials required and associated impacts and a modified RCRA cap was used in the analysis of environmental consequences in Chapter 5. Measures such as dynamic compaction and/or injection grouting would be used to minimize subsidence at burial grounds and cribs, and would enhance long-term integrity of the caps. Leachate detection would be used to monitor cap performance.

Where deemed cost effective, limited excavation of past-practice waste units and TSD facilities would be conducted in order to consolidate contaminated soils and materials. For example, it may be more cost effective to excavate, consolidate and construct a single cap over the contaminated soils and materials from four past-practice waste units than it would be to construct four separate caps.

During excavation, uncontaminated soil would be segregated and stockpiled for backfill and reclamation use. As the excavation proceeds, a program of monitoring and sampling would be conducted to minimize worker exposure and determine removal effectiveness.

After remediation, excavation sites would be recontoured to blend in with the surrounding topography and revegetated or covered.

This alternative also would include groundwater remediation to address contaminant plumes in the Central Plateau as well as those plumes within the Central Plateau migrating to other geographic areas. This groundwater remediation strategy would include two primary goals:

- Protecting currently uncontaminated groundwater to the extent possible.

- Protecting the Columbia River and associated ecosystem.

These goals would be accomplished through a combination of active and passive measures designed to reduce sources of contamination and to control the migration of highly contaminated groundwater. This would include:

- Pumping and treating localized groundwater plumes.
- Pumping and treating high concentration core areas of existing plumes which have migrated outside the Central Plateau.
- Monitoring natural attenuation of contaminated groundwater plumes.
- Maintaining institutional controls prohibiting groundwater use for a period of at least 100 years following completion of remediation.

This strategy would be refined through the CERCLA process based on land use decisions made for the Reactors on the River and the Columbia River geographic areas. For the Restricted Future Land-use Alternative, the groundwater plumes originating from the Central Plateau would be remediated to levels protective of the Columbia River. For the unrestricted alternative, the groundwater plumes entering the Reactors on the River or the Columbia River geographic areas would have to be remediated to levels corresponding to acceptable risks under the agricultural exposure scenario.

3.3.5 All Other Areas Alternatives. The All Other Areas geographic area comprises an area of approximately 624 km^2 (241 mi^2) and includes the 300, 400, 600 (exclusive of the North Slope and the Fitzner/Eberhardt Arid Lands Ecology Reserve), and 1100 Areas. It is the largest of the geographic areas and portions of it have been used for research and development, fuel fabrication, physical plants, and commercial power facilities. This area contains large tracts of undeveloped land between developed sections. Interspersed among the large tracts of undeveloped land are many contaminated sites, as well as contamination in the 300 and 1100 Areas. Appendix A lists the past-practice waste units and TSD facilities within the All Other Areas.

Table 3-10 depicts the All Other Areas Future Land-Use Alternatives selected for detailed analysis, with associated actions to be implemented, exposure scenarios, and land use restrictions.

3.3.5.1 All Other Areas, No-Action Alternative. The No-Action Alternative for the All Other Areas geographic area would consist of continuing environmental monitoring, surveillance and maintenance, stabilization of waste sites and the safeguards and security program. No remedial activities would be conducted. The No-Action Alternative is described in more detail in Section 3.3.1. DOE would maintain institutional control of the All Other Areas geographic area and would continue to manage the area for industrial uses, waste management, and Native American uses. Public access would remain restricted. These uses and restrictions would remain in place until it is determined that the lands are no longer needed to fulfill the DOE's current mission, or DOE relinquishes institutional control of the Hanford Site (assumed to be 100 years for analyses purposes). If DOE should arrive at the determination that the lands are no longer needed to fulfill the DOE's current mission, a desired future land use would be identified. Following identification of a desired future land use, remediation of contaminants to risk levels allowing for that desired land use would be conducted. The 300 Area would be processed and placed into interim storage until permanent disposal is available. Appendix A contains a list of all past-practice waste units and TSD facilities within the scope of the All Other Areas geographic area.

Table 3-10. Future Land-Use Alternatives for the All Other Areas.

Alternatives	Actions to be Implemented	Exposure Scenario[a]	Land-Use Restrictions
No-Action	• Environmental monitoring • Stabilizing waste sites • Institutional controls	Not Applicable	• Restrictions on public access • Restrictions on use of groundwater • Restrictions on soil disturbance
Restricted Future Land-Use (R1)	• Excavating contaminated soils and material • Transport of contaminated materials to onsite disposal facility • Active groundwater remediation • Site reclamation • Environmental monitoring • Institutional controls	Recreational and Industrial	• Restrictions on public access • Restrictions on use of groundwater • Restrictions on subsurface disturbance
Restricted Future Land-Use (R2)	• Capping waste units and TSDs • Passive groundwater remediation • Site reclamation • Environmental monitoring • Institutional controls	Recreational and Industrial	• Restrictions on public access • Restrictions on use of groundwater • Restrictions on subsurface disturbances

[a]These exposure scenarios would be used under the CERCLA process to establish cleanup goals.

3.3.5.2 All Other Areas, Restricted Future Land-Use Alternative (R1). For this alternative, restricted use of the All Other Areas geographic area would be achieved through a combination of engineering and institutional controls, and removal and treatment of contaminants. DOE would maintain institutional control of the All Other Areas geographic area and would continue to use the area for activities similar to those allowable under current site management. Restrictions on activities that disturb soil would apply in and around revegetated excavation sites. In addition, withdrawal and use of groundwater would be restricted for an indefinite period. Engineering and institutional controls (e.g., signs, fencing, and deed restrictions) would be used as necessary to restrict use and access. This alternative would enable future land uses consistent with those envisioned by the Working Group (Table 3-3). As described in Section 3.1.4, the CERCLA exposure scenarios associated with these land uses are industrial and recreational.

This alternative includes limited excavation of surface/subsurface past-practice waste sites and TSD facilities to reduce contaminant exposure via the ingestion, dermal or inhalation pathways under the industrial and recreational exposure scenarios. Further excavation would be required where residual contamination remains in sufficient quantities to be a threat to groundwater. However, it is expected that some contamination would be left in place where exposures do not pose unacceptable risks. Retrieved pre-1970 TRU contaminated waste from the 618-11 burial ground (located north of

Contaminated soil would be excavated using heavy earth-moving equipment. Uncontaminated soil would be segregated and stockpiled for backfill and reclamation use. Contaminated soils and other materials would be placed in containers or covered and transported by truck or rail to an onsite disposal facility. As the excavation proceeds, monitoring and sampling would be conducted to minimize worker exposure and determine removal effectiveness.

Additional backfill materials, if needed, would be obtained from an onsite location as described in Appendix E. For site restoration, excavation sites would be recontoured to blend in with the surrounding topography and revegetated or covered with a suitable cover. Monitoring and institutional controls (i.e., signs and fencing) would be used, as necessary, to restrict use and access.

This alternative also would include groundwater remediation to address contaminant plumes in the All Other Areas geographic area as well as those plumes within the All Other Areas migrating to other geographic areas. This groundwater remediation strategy would include two primary goals:

- Protecting currently uncontaminated groundwater to the extent possible.
- Protecting the Columbia River and associated ecosystem.

These goals would be accomplished through a combination of active and passive measures designed to reduce sources of contamination, control the migration of highly contaminated groundwater, and reduce contaminant concentration levels. This would include:

- Limited excavation of past-practice waste units and TSD facilities, as described above, to reduce sources of contamination.
- Pumping and treating localized groundwater plumes.
- Pumping and treating high concentration core areas of existing plumes which have migrated outside the Central Plateau.
- Monitoring natural attenuation of contaminated groundwater plumes.
- Maintaining institutional controls prohibiting groundwater use for a period of at least 100 years following completion of remediation.

This strategy would be refined through the CERCLA process based on land use decisions made in the Reactors on the River and the Columbia River geographic areas. For the Restricted Future Land-Use Alternative, the groundwater plumes originating from the All Other Areas would be remediated to levels protective of the Columbia River. For the unrestricted alternative, the groundwater plumes entering the Reactors on the River geographic area would have to be remediated to levels corresponding to acceptable risks under the agricultural exposure scenario.

3.3.5.3 All Other Areas, Restricted Future Land-Use Alternative (R2). For this alternative, restricted use of the All Other Areas geographic area would be achieved through engineering and institutional controls. Public access, withdrawal and use of groundwater, and soil disturbing activities would be controlled for an indefinite period. This alternative would enable future land uses consistent with those envisioned by the Working Group (Table 3-3). As described in Section 3.1.4, the CERCLA exposure scenarios associated with these land uses are industrial and recreational.

A Restricted Future Land-Use Alternative (R2) for the All Other Areas geographic area involves leaving in place contaminated soils, buried LLW, and LLMW contained within past-practice waste units and TSD facilities. Human exposure to contamination would be limited through the use of protective caps. Several alternative cap designs are being considered. For purposes of this, a reference cap design was used (Appendix E) to provide a bounding estimate of materials required and associated impacts. Measures such as dynamic compaction and/or injection grouting would be used to minimize subsidence at burial grounds and cribs, and would enhance the long-term integrity of caps. Leachate detection would be used to monitor cap performance.

Under this Restricted (R2) Alternative, TRU waste would be retrieved from the 618-11 burial ground and would then be processed and placed into interim storage until permanent disposal is available. Groundwater strategy for the restricted use alternative would be the same as described in the restricted (R1) use alternative, but would not include excavation activities. Instead, caps would be used to prevent migration of source contaminants to the groundwater.

3.4 Future Land-Use Alternatives Considered but not Analyzed in Detail

The following paragraphs discuss the future land-use alternatives that were determined not to meet the screening criteria. These are the alternatives shaded in Table 3-2.

3.4.1 Reactors on the River, Exclusive Future Land-Use Alternative. The Exclusive Future Land-Use Alternative emphasizes leaving contamination in place. This alternative also would involve continuing waste management activities and restricting use of the area to properly-trained DOE and contractor personnel.

An Exclusive Future Land-Use Alternative for this geographic area conflicts with other RODs under NEPA. Removing the reactors as called for in the ROD for the *Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington, Environmental Impact Statement* published on September 16, 1993 (58 FR 48509), is not likely to produce benefits commensurate with costs if the surrounding surface and subsurface contamination sites are remediated only to exclusive use levels. An exclusive use area within 0.4 km (0.25 mi) of the Columbia River might be inconsistent with the recommendation stated in the *Hanford Reach of the Columbia River, Comprehensive River Conservation Study and Final Environmental Impact Statement* (NPS 1994), which designates the Hanford Reach of the Columbia River geographic area as a National Wildlife Refuge (NWR) and a Recreational River under the Wild and Scenic River System (NPS 1994). Such a designation would restrict activities associated with an Exclusive Future Land-use Alternative, including long-term or new waste management activities adjacent to the river.

In addition, the *Hanford Site Development Plan* (DOE-RL 1993a) acknowledges areas along the Hanford Reach of the Columbia River geographic area as sensitive areas because of their ecological and cultural significance. The Reactors on the River geographic area is not projected to be needed for future DOE missions involving the management and/or disposal of radioactive and hazardous materials. The B Reactor in the 100-B/C Area has been placed on the *National Register of Historic Places* (National Register), and has been proposed for preservation as a museum. An Exclusive Future Land-Use Alternative in the 100-B/C Area could preclude direct public access to the B Reactor.

An Exclusive Future Land-Use Alternative for the surface and subsurface contamination sites in these areas could be contrary to Tri-Party Agreement requirements, and is incompatible with preferences voiced by members of the public during scoping (DOE-RL 1994a) and with cleanup scenarios identified by the Working Group (HFSUWG 1992). Exclusive use of the groundwater beneath the Reactors on the River geographic area may conflict with provisions of the renegotiated Tri-Party Agreement, which puts greater emphasis on protection of the Columbia River through acceleration of groundwater treatment programs and/or subsurface caps (Ecology et al. 1994).

For these reasons, analyzing the Exclusive Future Land-Use Alternative for this geographic area is not considered reasonable at this time.

3.4.2 Central Plateau, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve remediating contaminated surface and subsurface sites, surface water, and groundwater, in the 200 East and 200 West Areas of the Hanford Site, to a level of residual contamination that would not preclude any human use.

Detailed analysis of an Unrestricted Future Land-Use Alternative was rejected because without operation of a large portion of the Central Plateau geographic area as a dedicated waste management area, the Hanford Site Environmental Restoration Project might not be feasible. As envisioned in current DOE planning documents, the success of the remediation program hinges on the ability to dedicate the Central Plateau geographic area for waste operations and disposal (DOE-RL 1993a, DOE-RL 1994c). No other area of the Hanford Site is considered viable for use in disposing of waste generated during remediation (WHC 1992). During scoping, most members of the public and the Working Group expressed a preference to have waste management activities, including disposal, consolidated on the Central Plateau geographic area. Key facilities planned or completed for the Central Plateau geographic area include the Tank Waste Remediation System Vitrification Plant and the Environmental Restoration Disposal Facility (ERDF), which would be used for permanent disposal of Hanford Site remediation waste (WHC 1992); and two treated effluent disposal facilities (TEDF), which would be used for soil-column disposal of tritiated water generated during remediation (DOE-RL 1992, 1993b, and 1993c). Unrestricted use of the Central Plateau geographic area would conflict with the function of the existing waste management facilities, and could preclude the siting of other planned facilities.

In the absence of the ERDF, the TEDFs, and other key facilities on the Hanford Site, waste generated during Hanford Site remediation would require packaging and offsite transportation for disposal. Suitable offsite disposal capacity currently does not exist, and there is no basis for assuming that it would become available within the time-frame of the Tri-Party Agreement. Based on public scoping comments, offsite disposal of Hanford Site remediation waste is likely to encounter strong public, regulator, and Tribal opposition (DOE-RL 1994a).

An Unrestricted Future Land-Use Alternative is considered impractical because it conflicts with the RODs of previous NEPA documents. These previous decisions have, in effect, already established a place for permanent waste disposal within the Central Plateau geographic area. Examples include the decisions on restart of the Plutonium-Uranium Extraction Plant (DOE 1983); near surface disposal of defueled submarine reactor compartments (Navy 1984); *in-situ* decommissioning and entombment of the Strontium Semiworks Facility (DOE 1985); and dismantlement and disposal of the cores from eight surplus production reactors (DOE 1992). For these reasons, analyzing the Unrestricted Future Land-Use Alternative for this geographic area is not considered reasonable.

3.4.3 Central Plateau, Restricted Future Land-Use Alternative. A Restricted Future Land-Use Alternative for the Central Plateau geographic area would emphasize remediating contaminated surface soils, subsurface soils and groundwater to levels that would allow certain human uses. For example, this alternative would allow limited recreation, as well as ongoing and planned waste management activities.

A Restricted Future Land-Use Alternative would allow uses other than waste management activities within the boundaries of the Central Plateau geographic area. Uses other than waste management activities for this geographic area would be contradictory to current DOE planning documents. The success of the Hanford Site's remediation program hinges on the ability to dedicate the Central Plateau geographic area for waste management and disposal operations (DOE-RL 1993b and 1994c). It has been determined that no other area of the Hanford Site is considered viable for use in disposing of waste generated during Hanford Site remediation (WHC 1992). During scoping, most members of the public and the Working Group expressed a preference to have waste management activities, including disposal, consolidated on the Central Plateau geographic area. For these reasons, analyzing the Restricted Future Land-Use Alternative for this geographic area is not considered reasonable.

3.4.4 All Other Areas, Unrestricted Future Land-Use Alternative. This alternative would involve remediating contaminated surface and subsurface sites, surface water, and groundwater in the 300, 400, and 600 Areas, to levels of residual contamination suitable for any potential human use. Although this alternative is considered achievable for certain parts of the All Other Areas geographic area, it is impractical for other parts.

The All Other Areas geographic area contains large tracts of uncontaminated and minimally disturbed land. Unrestricted surface use probably would dominate in the All Other Areas geographic area; however, most areas would remain restricted with respect to groundwater use. Site-specific determinations would be made in CERCLA/RCRA documents as outlined in the Tri-Party Agreement (Ecology et al. 1989).

Under current DOE plans, the northern and western portions of the 300 Area would be used for siting waste operations and support facilities such as the 300 Area's TEDF, which recently became operational. Such facilities would constitute restricted or exclusive use, which would require controls on public access. Because public use of these areas then would be excluded indefinitely, it should be possible to reach protective-end states without remediating the surrounding contamination sites to unrestricted levels. Detailed analysis of an Unrestricted Future Land-Use Alternative in these areas was not considered practical because remediation to an unrestricted level probably would not achieve additional protection of human health over remediation to restricted or exclusive levels. Also, a decommissioning program for the 300 Area's surplus facilities is in the early stages of addressing the numerous contaminated facilities that eventually would undergo decommissioning (Winship and Hughes 1992). Although decisions on the fate of existing contaminated facilities would be forthcoming as remediation progresses, it was assumed that contaminated surplus facilities probably would remain in place for an indefinite period. Therefore, remediating the surface and subsurface soils in the 300 Area to unrestricted use as a whole, was not considered reasonable.

The existence of reactors, with or without operating missions, is anticipated in the 400 Area at the Fast Flux Test Facility (FFTF), and in the 600 Area on the Washington Public Power Supply System (WPPSS) leasehold (DOE-RL 1993a) for an unspecified period of time. Although a shutdown order for the FFTF has been issued by the Secretary of Energy, decommissioning plans for the facility have not been prepared as of this time. Furthermore, future waste operations could take place

in the 1 mi^2 section of land in the 600 Area, which is owned by the State of Washington. The land is presently uncontaminated and no action has been taken to develop waste disposal facilities (Ecology 1993). These facilities and operations would constitute restricted or exclusive uses requiring controls on access consistent with the Safety Analysis Report for each facility. Analyzing remediation of the immediate surrounding areas to unrestricted levels is not considered practical because such remediation probably would not achieve additional protection of human health over remediation to restricted or exclusive levels.

For the reasons stated above, it is not considered reasonable to analyze an Unrestricted Future Land-Use Alternative for the All Other Areas geographic area.

3.4.5 All Other Areas, Exclusive Land-Use Alternative. This alternative would involve reserving all of the 300, 400, and 600 Areas for use in managing or disposing of radioactive and hazardous wastes. An exclusive land use for the All Other Areas geographic area also would emphasize controlling the surface, subsurface, surface water, and groundwater contamination in these areas while relying on engineering and institutional controls to minimize risk and protect human health and the environment.

In the 300 Area, because only a portion of the land is projected to be needed for the waste treatment and disposal mission (DOE-RL 1991), analyzing an Exclusive Future Land-Use Alternative of the entire area was not considered reasonable. Exclusive use of the entire 300 Area also would be contrary to requirements of the Tri-Party Agreement (Ecology et al. 1989) and incompatible with preferences voiced by members of the Working Group and the public during scoping (DOE-RL 1994a).

No projected DOE waste management and disposal missions (DOE-RL 1993a) are projected for the 400 and 600 Areas of the Hanford Site. Therefore, analyzing retention of these areas exclusively for such missions was not considered reasonable. Advanced scientific research and engineering facilities (e.g., Laser Interferometer Gravitational Wave Observatory) are planned for siting in the 600 Area (DOE-RL 1993a); exclusive use throughout the 600 Area might interfere with these plans. Land within 0.4 km (0.25 mi) of the Columbia River in the 600 Area could be used as a buffer zone for an exclusive use area, however, actual use of such land for waste management purposes is incompatible with the preferred alternative in the *Hanford Reach of the Columbia River, Comprehensive River Conservation Study and Final Environmental Impact Statement*. Exclusive use of the entire 400 and 600 Areas would be contrary to Tri-Party Agreement requirements and contrary to preferences expressed by members of the public during scoping. For these reasons, analyzing the Exclusive Future Land-Use Alternative for this geographic area is not considered reasonable.

3.5 Summary of Environmental Impacts

Chapter 5.0 presents detailed discussions of the analyses of environmental impacts for each of the future land-use alternatives. This section summarizes the environmental impacts and mitigation measures that would be a part of the future land-use decisions at the Hanford Site.

The primary impacts associated with the future land-use alternatives can be grouped into three general categories: (1) natural and cultural resources, (2) human health, and (3) projected costs. Many of the potentially significant adverse impacts would occur as a result of disturbances of natural areas on the Hanford Site. Natural plant and wildlife communities have flourished, sensitive species have been preserved, and Native American archaeological and cultural resources have been protected because large areas of the Hanford Site have been relatively undisturbed in the past and served as

buffer zones for nuclear-related activities concentrated in the northern and central portions of the Hanford Site. Many of these natural and cultural features may be impacted directly by remedial activities associated with achieving desired future land-use objectives. Also, lifting restrictions on public access to some areas of the Hanford Site may result in additional adverse impacts to some resources.

Concerns for public health and worker safety, and protection of the natural environment from exposure to radionuclides and hazardous chemicals require remediation of the Hanford Site. Exposures have been minimal under current control and management of the Hanford Site. However, exposures may become significant with changes to control of the Hanford Site or under different future land uses. Protection of human health and ecological resources from exposures would be achieved either by continued control of the Hanford Site and restrictions on uses, or by removal or isolation of contaminated areas.

Costs associated with remediation may be quite large, depending on the alternatives selected for each geographic area. Safety precautions, environmental documentation, site characterization and sampling, widespread groundwater contamination, and the number and volume of contaminated areas contribute to the costs of conducting remediation. In general, remediation costs are lowest for continued monitoring and maintenance of the Hanford Site as a whole under the No-Action Alternative. Estimated expenditures are highest for unrestricted use of the Columbia River geographic area, unrestricted use of the Reactors on the River geographic area, exclusive use for the Central Plateau geographic area, and restricted use for the All Other Areas geographic area.

Tables 3-11 through 3-14 summarize the impacts and mitigation measures discussed in Chapter 5.0 for the 11 resources that may be impacted by the proposed action.

3.6 Mitigation Measures

The DOE intends to prepare a Mitigation Action Plan (MAP) following the issuance of a ROD for this EIS. This MAP will address mitigation commitments made in the ROD. Chapter 5.0 contains discussions of the potential mitigation measures associated with the individual future land-use alternatives.

Table 3-11. Summary of Environmental Impacts and Mitigation Measures for the Columbia River Geographic Area. (5 Sheets)

Resource Areas	No-Action Alternative	Remediation to Unrestricted Future Land-Use Alternative	Remediation to Restricted Future Land-Use Alternative
Geology	Impacts No significant long- or short-term adverse impacts are expected Continued restrictions on access to geologic resources Mitigation Measures None identified	Impacts Elimination of exposure risks by removal of river discharge pipelines, contaminated riverbank sediments, riverbottom sediments and island sediments, resulting in the eventual unlimited access to geologic resources Mitigation Measures None identified	Impacts Reduction in exposure risks by stabilization of river discharge pipelines, and removing detached pipeline segments, resulting in decreased restrictions on use of geologic resources Mitigation Measures None identified
Soils	Impacts Minimal impacts caused by stabilization of waste sites Mitigation Measures None identified	Impacts Disturbance of 148 ha (370 ac) of soils; soil compaction resulting from use of earth-moving equipment; increased potential for erosion Mitigation Measures Restrict earth-moving equipment to trample zones; use existing transportation routes; employ soil, water and wind erosion measures	Impacts Disturbance of 4 ha (10 ac) of soils; soil compaction resulting from use of earth-moving equipment; increased potential for erosion; impacts would be less extensive than the unrestricted future land-use alternative Mitigation Measures Same as described for the unrestricted future land-use alternative
Water Resources	Impacts Increased contaminant releases could occur due to continued natural scouring which has begun to expose and detach buried river discharge pipelines; natural shoreline erosion could also mobilize contaminated sediments Insignificant disturbance of the Columbia River floodplain Mitigation Measures Periodic inspection of pipelines, and stabilization of pipelines when needed	Impacts Potential temporary increases in river stage and velocity from construction and use of cofferdams, resulting in resuspension of contaminants Potential for release of radiological and chemical constituents, affecting downstream water supply intakes, during remediation of riverbank, river bottom and island sediments Disturbance of 140 ha (346 ac) of the Columbia River floodplain Mitigation Measures None identified for increases in river stage and velocity For water quality impacts, mitigation measures would include installing runoff barriers, limiting areas disturbed below the high water mark, stabilization of disturbed areas, supply alternate water supply if downriver water quality is degraded None identified for disturbance of Columbia River floodplain	Impacts Potential for release of small amounts of radiological and chemical constituents, affecting downstream water supply intakes, during stabilization and removal of pipelines Disturbance of 7 ha (17 ac) of the Columbia River floodplain Mitigation Measures For water quality impacts, mitigation measures would be the same as those described for the unrestricted future land-use alternative None identified for disturbance of the Columbia River floodplain

Table 3-11. Summary of Environmental Impacts and Mitigation Measures for the Columbia River Geographic Area. (5 Sheets)

Resource Areas	No-Action Alternative	Remediation to Unrestricted Future Land-Use Alternative	Remediation to Restricted Future Land-Use Alternative
Ecological Resources	Impacts Minimal impacts are expected from continued exposure to radiological and chemical contaminants and during waste site stabilization Mitigation Measures None identified	Impacts Disturbance of 23 ha (57 ac) of wetlands, 20 ha (50 ac) of aquatic habitat, and 36 ha (90 ac) of shrub-steppe habitat Potential disturbance of perching or roosting sites for bald eagles; direct mortality; loss of sensitive habitats for several species Potential loss of aquatic plant and benthic communities Potential increase in sediment loading with impacts on fish, including anadromous species Potential for uptake in food chain caused by resuspension and transport of contaminated sediments Potential impacts on biodiversity Mitigation Measures Mitigation measures would include avoiding uncontaminated wetland areas, employing activities that would minimize disturbance of uncontaminated wetland soils, employing protocols designed to prevent the spread or establishment of undesirable species in wetlands, employing a no net-loss protocol when disturbing wetlands For Aquatic habitat disturbance, mitigation measures would include limiting activities below the high water mark during times of anadromous fish spawning or migration, avoidance of uncontaminated spawning areas, limiting total area disturbed, stabilization of disturbed areas, employing a protocol designed to prevent the establishment of undesirable species and reestablishing desirable aquatic vegetation None identified for shrub-steppe habitat disturbance Mitigation measures for disturbance of roosting/nesting sites would include limiting activities in the vicinity of the roost/nest sites during breeding seasons None identified for biodiversity	Impacts Disturbance of less than 0.4 ha (1 ac) each of aquatic habitat and wetlands Loss of aquatic plant communities and destruction of benthic community would be limited to areas adjacent to the river discharge pipelines Potential increase in sediment loading with impacts on fish, including anadromous species, during decommissioning of river discharge pipelines Potential for uptake in food chain caused by resuspension and transport of contaminated sediments Potential impacts on biodiversity Mitigation Measures For wetlands and aquatic habitats, mitigation measures would be the same as described in the unrestricted future land-use alternative Mitigation measures for the disturbance of species of concern and their habitats would be the same as described in the unrestricted future land-use alternative

Table 3-11. Summary of Environmental Impacts and Mitigation Measures for the Columbia River Geographic Area. (5 Sheets)

Resource Areas	No-Action Alternative	Remediation to Unrestricted Future Land-Use Alternative	Remediation to Restricted Future Land-Use Alternative
Air Quality	Impacts Generation of small amounts of potentially contaminated fugitive dust during environmental monitoring and maintenance activity not expected to exceed current site levels Mitigation Measures None identified	Impacts Generation of potentially contaminated fugitive dust from excavation activities Generation of dust from transportation of waste to waste disposal or treatment facilities Airborne pollutants would be generated in exhaust from equipment used for excavation, loading and hauling Mitigation Measures Mitigation measures would include rewetting storage piles and haul roads, limiting size of disturbed areas, and temporarily enclosing areas being excavated	Impacts Generation of dust from hauling pipeline capping materials from borrow sites Airborne pollutants would be generated in the exhaust from equipment used in capping activities Mitigation Measures Mitigation measures would be the same as described under the unrestricted future land-use alternative
Noise	Impacts Noise levels remain the same as current levels Mitigation Measures None identified	Impacts Temporary increases in noise levels from excavation and waste transportation Exposures occasionally may exceed applicable occupational standards for remediation workers No violations of State of Washington noise standards Mitigation Measures Mitigation measures would include issuance of hearing protection devices for remediation workers, monitoring noise levels throughout the remediation process, limiting activities near roost/nest sites during nesting season	Impacts Temporary increase in noise levels from capping activities Exposures occasionally may exceed applicable occupational standards for remediation workers No violations of State of Washington noise standards Mitigation Measures Same as those described under the unrestricted future land-use alternative

Table 3-11. Summary of Environmental Impacts and Mitigation Measures for the Columbia River Geographic Area. (5 Sheets)

Resource Areas	No-Action Alternative	Remediation to Unrestricted Future Land-Use Alternative	Remediation to Restricted Future Land-Use Alternative
Cultural Resources	Impacts Controlled access would protect resources Mitigation Measures None identified	Impacts Potential impacts on several prehistoric sites and historic sites Potential impacts on areas of cultural or spiritual significance to Native Americans Mitigation Measures Consultations with the SHPO and concerned Native American tribal groups and governments prior to ground disturbing activities; when practicable, an archeological monitor would be onsite when ground disturbing activities are taking place; avoidance, where possible, of identified cultural resource areas; surface mapping to identify resources	Impacts Impacts could be similar to those described under the unrestricted future land-use alternative, but are anticipated to be less extensive Mitigation Measures Same as those described under the unrestricted future land-use alternative
Visual and Aesthetic Resources	Impacts No significant impacts on visual and aesthetic resources are expected Mitigation Measures None identified	Impacts Temporary impacts on river users from construction activities, generation of dust plumes, and reduced visual clarity Mitigation Measures Minimization of overall area disturbed; fugitive dust control measures; recontouring remediated areas to original conditions and revegetating with native species as soon as possible following remediation	Impacts Temporary impacts on river users from construction activities, generation of dust plumes, and reduced visual clarity Mitigation Measures Same as described for the unrestricted future land-use alternative
Human Health Risk (analyzed for accident scenarios and the removal of institutional controls. Impacts resulting from routine exposure are not assessed.)	Impacts Although no current hazards are known to exist, long-term impacts are considered significant due to lack of characterization data Mitigation Measures Continue existing institutional controls, and environmental monitoring activities	Impacts Potential for a 1.0 mrem dose to the an individual and 3.0 person-rem dose to the public from a shoreline excavation accident Long-term risk expected to decrease upon completion of remediation Mitigation Measures Use of appropriate engineering and administrative controls to reduce exposures to remediation workers and the general public	Impacts Likelihood of remediation accident less than that of the unrestricted future land-use alternative, but the resulting impacts to workers and the public would be the same Long-term risk expected to decrease upon completion of remediation Mitigation Measures Same as described under the unrestricted future land-use alternative
Occupational impacts	Impacts No labor hour estimates are available for the No-Action Alternative, therefore no occupational losses were calculated Mitigation Measures None identified	Impacts Potential for 354 occupational loss cases and 2,374 estimated lost workdays (DOE statistics) Mitigation Measures Continued emphasis on safety awareness and worker training	Impacts Potential for 8 occupational loss cases and 50 estimated lost workdays (DOE statistics) Mitigation Measures Same as described under the unrestricted future land-use alternative

Table 3-11. Summary of Environmental Impacts and Mitigation Measures for the Columbia River Geographic Area. (5 Sheets)

Resource Areas	No-Action Alternative	Remediation to Unrestricted Future Land-Use Alternative	Remediation to Restricted Future Land-Use Alternative
Volumes and Costs	<u>Impacts</u> No disturbed areas Estimated total cost is $2.4 billion[1] <u>Mitigation Measures</u> Use of less expensive methods of institutional controls [1]Costs for 100 years of institutional control for the Hanford Site - not broken down by geographic area	<u>Impacts</u> Excavated volume of contaminated soil is 1.1×10^7 BCM (1.4×10^7 BCY) Area of disturbance is 177 ha (437 ac) Estimated total cost is $4.7 billion with truck haul or $2.7 billion with rail haul <u>Mitigation Measures</u> Soil washing to reduce the amount of waste to be transported	<u>Impacts</u> Volume of capping materials required is 3.4×10^5 LCM (4.4×10^5 LCY) Area of disturbance is 4.1 ha (10 ac) Estimated total cost is $93 million with truck haul or $46 million with rail haul <u>Mitigation Measures</u> Use of alternate cap design

BCM = bank cubic meter.
BCY = bank cubic yard.
LCM = loose cubic meter.
LCY = loose cubic yard.

Table 3-12. Summary of Environmental Impacts and Mitigation Measures for the Reactors on the River Geographic Area. (6 sheets)

Resource Areas	No-Action Alternative	Remediation to Unrestricted Future Land-Use Alternative	Remediation to Restricted Future Land-Use Alternative (R1)	Remediation to Restricted Future Land-Use Alternative (R2)
Geology	Impacts No significant long- or short-term adverse impacts are expected Continued restrictions on access to geologic resources Mitigation Measures None identified	Impacts Features relevant to the study of regional glacial flood events (i.e., bergmounds and giant ripple marks) could be destroyed Continued restrictions on access to geologic resources during remediation Mitigation Measures None identified	Impacts Features relevant to the study of the regions glacial flood events (i.e., bergmounds and giant ripple marks) could be destroyed Continued restrictions on access to geologic resources Mitigation Measures None identified	Impacts Features relevant to the study of the regions glacial flood events (i.e., bergmounds and giant ripple marks) could be destroyed Continued restrictions on access to geologic resources Mitigation Measures None identified
Soils	Impacts Disturbance of 85 ha (213 ac) of soil; soil compaction resulting from use of earth-moving equipment during stabilization activities; increased potential for erosion Mitigation Measures employ soil, water and wind erosion reduction measures	Impacts Disturbance of 410 ha (1,026 ac) of soil; soil compaction resulting from use of earth-moving equipment; increased potential for erosion Mitigation Measures Restrict earth-moving equipment to trample zones; where available, use existing transportation routes; employ soil, water and wind erosion reduction measures	Impacts Disturbance of 365 ha (912 ac) of soil; soil compaction resulting from use of earth-moving equipment; increased potential for erosion Mitigation Measures Same as described for the unrestricted future land-use alternative	Impacts Disturbance of 371 ha (915 ac) of soil; soil compaction resulting from use of earth-moving equipment; increased potential for erosion Mitigation Measures Same as described for the unrestricted future land-use alternative
Water Resources	Impacts Groundwater would remain contaminated Disturbance of 4 ha (10 ac) of Columbia River floodplain Mitigation Measures None identified	Impacts Temporary restrictions on withdrawal and use of groundwater due to residual contamination; changes in groundwater flow characteristics by operation of pump-and-treat system Beneficial long-term impacts on the Columbia River due to elimination of contaminated groundwater reaching the River Disturbance of 14 ha (35 ac) of Columbia River floodplain Mitigation Measures None identified	Impacts Restrictions on withdrawal and use of groundwater due to residual contamination; changes in groundwater flow characteristics by operation of pump-and-treat systems Disturbance of 15 ha (36 ac) of Columbia River floodplain Mitigation Measures None identified	Impacts Restrictions on withdrawal and use of groundwater due to residual contamination; changes in groundwater flow characteristics by operation of pump-and-treat systems Disturbance of 9 ha (21 ac) of Columbia River floodplain Mitigation Measures None identified

Table 3-12. Summary of Environmental Impacts and Mitigation Measures for the Reactors on the River Geographic Area. (6 sheets)

Resource Areas	No-Action Alternative	Remediation to Unrestricted Future Land-Use Alternative	Remediation to Restricted Future Land-Use Alternative (R1)	Remediation to Restricted Future Land-Use Alternative (R2)
Ecological Resources	<u>Impacts</u> Disturbance < 0.4 ha (1 ac) of wetlands and 3 ha (7 ac) of shrub-steppe habitat Potential impacts on biodiversity from continued exposure to contaminants, and waste site stabilization activities Potential exposure of plants and wildlife to radionuclides and hazardous chemicals <u>Mitigation Measures</u> None identified for impacts to wetlands and shrub-step habitat Mitigation measures for impacts to species of concern include limiting or avoiding activities in the vicinity of the species habitat None identified for impacts on biodiversity	<u>Impacts</u> Disturbance of 5 ha (12 ac) of wetlands and 40 ha (101 ac) of shrub-steppe habitat Potential impacts on biodiversity resulting from excavation activities Reduction in potential for exposure of plants and wildlife to radionuclides and hazardous chemicals <u>Mitigation Measures</u> Mitigation measures for wetlands would include avoiding uncontaminated areas, employing activities that would minimize disturbance of uncontaminated wetland soils, prevent the spread or establishment of undesirable species in wetlands, employing a no net-loss protocol when disturbing wetlands For shrub-steppe habitat, mitigation measures would include restricting earthmoving equipment to trample zones; where available, use existing transportation routes; revegetation with native species Mitigation measures for impacts to species of concern include limiting or avoiding activities in the vicinity of the species habitat None identified for impacts on biodiversity	<u>Impacts</u> Disturbance of 4 ha (11 ac) of wetlands and 39 ha (98 ac) of shrub-steppe habitat Potential impacts on biodiversity resulting from excavation activities Reduction in potential for exposure of plants and wildlife to radionuclides and hazardous chemicals <u>Mitigation Measures</u> Same as described for the unrestricted future land-use alternative	Disturbance of 3 ha (7 ac) of wetlands Disturbance of 38 ha (94 ac) of shrub-steppe habitat Potential impacts on biodiversity resulting from excavation activities Reduction in potential for exposure of plants and wildlife to radionuclides and hazardous chemicals <u>Mitigation Measures</u> Same as described for the unrestricted future land-use alternative

Table 3-12. Summary of Environmental Impacts and Mitigation Measures for the Reactors on the River Geographic Area. (6 sheets)

Resource Areas	No-Action Alternative	Remediation to Unrestricted Future Land-Use Alternative	Remediation to Restricted Future Land-Use Alternative (R1)	Remediation to Restricted Future Land-Use Alternative (R2)
Air Quality	Impacts Generation of small amounts of potentially contaminated fugitive dust from surface decontamination and waste site stabilization activities Mitigation Measures None identified	Impacts Generation of potentially contaminated fugitive dust from remediation activities Generation of pollution by fuel combustion in equipment used for remediation activities Mitigation Measures Dust suppression measures; temporary enclosure of the area being remediated	Impacts Generation of potentially contaminated fugitive dust from remediation activities Generation of pollution by fuel combustion in equipment used for excavation, loading and hauling Mitigation Measures Same as described for the unrestricted future land-use alternative	Impacts Generation of dust from waste capping activities Generation of pollution by fuel combustion in equipment used for capping activities Mitigation Measures Same as those described for the unrestricted future land-use alternative
Noise	Impacts Noise levels remain the same as current levels Mitigation Measures None identified	Impacts Temporary increase in noise levels from excavation and waste transportation could impact wildlife (i.e., startle behavior resulting in abandonment of nest or den sites) Exposures occasionally may exceed applicable occupational standards for remediation workers No violations of State of Washington noise standards Mitigation Measures Mitigation measures would include issuance of hearing protection devices for remediation workers, monitoring noise levels, limiting activities near roost/nest sites during nesting season	Impacts Temporary increase in noise levels from excavation and waste transportation could impact wildlife (i.e., startle behavior resulting in abandonment of nest or den sites) Exposures occasionally may exceed applicable occupational standards for remediation workers No violations of State of Washington noise standards Mitigation Measures Same as those described under the unrestricted future land-use alternative	Impacts Temporary increase in noise levels from cap construction could impact wildlife (i.e., startle behavior resulting in abandonment of nest or den sites) Exposures occasionally may exceed applicable occupational standards for remediation workers No violations of State of Washington noise standards Mitigation Measures Same as those described under the unrestricted future land-use alternative

Table 3-12. Summary of Environmental Impacts and Mitigation Measures for the Reactors on the River Geographic Area. (6 sheets)

Resource Areas	No-Action Alternative	Remediation to Unrestricted Future Land-Use Alternative	Remediation to Restricted Future Land-Use Alternative (R1)	Remediation to Restricted Future Land-Use Alternative (R2)
Cultural Resources	<u>Impacts</u> Potential impacts on several prehistoric and historic sites. Continued restrictions on Tribal access <u>Mitigation Measures</u> Consultations with the SHPO and Native American tribal groups and governments prior to any ground disturbing activities; avoidance, where possible, of resource areas; When possible, a full resource survey would be conducted; surface mapping and material and data recovery activities would be employed; where practicable, resource awareness programs would be developed and presented to remediation personnel Mitigation measures for the buildings and facilities would include building construction surveys; documentation of all structures deemed historic; restriction of access to historic buildings/facilities	<u>Impacts</u> Potential impacts on several prehistoric and historic sites Potential impacts on areas of cultural or spiritual significance to Native Americans <u>Mitigation Measures</u> Same as described under the No-Action future land-use alternative	<u>Impacts</u> Potential impacts on several prehistoric and historic sites Potential impacts on areas of cultural or spiritual significance to Native Americans Continued restrictions on Tribal access <u>Mitigation Measures</u> Same as described under the No-Action future land-use alternative	<u>Impacts</u> Potential impacts on several prehistoric and historic sites Potential impacts on areas of cultural or spiritual significance to Native Americans Continued restrictions on Tribal access <u>Mitigation Measures</u> Same as described under the No-Action future land-use alternative

Table 3-12. Summary of Environmental Impacts and Mitigation Measures for the Reactors on the River Geographic Area. (6 sheets)

Resource Areas	No-Action Alternative	Remediation to Unrestricted Future Land-Use Alternative	Remediation to Restricted Future Land-Use Alternative (R1)	Remediation to Restricted Future Land-Use Alternative (R2)
Visual and Aesthetic Resources	<u>Impacts</u> No significant impacts to visual and aesthetic resources in vicinity of decontamination and/or stabilization of waste sites <u>Mitigation Measures</u> None identified	<u>Impacts</u> Temporary impacts on river users from excavation activities, generation of dust plumes, and reduced visual clarity <u>Mitigation Measures</u> Minimize the overall area of disturbance to the extent practicable; employ dust suppression activities; raconteur remediated areas as close to original conditions as possible, and revegetate with native species as soon as possible following remediation	<u>Impacts</u> Temporary impacts on river users from excavation activities, generation of dust plumes, and reduced visual clarity <u>Mitigation Measures</u> Same as described under the unrestricted future land-use alternative	<u>Impacts</u> Permanent alteration of landscape from capped waste sites Temporary impacts on river users from construction activities, generation of dust plumes, and reduced visual clarity <u>Mitigation Measures</u> Same as described under the unrestricted future land-use alternative, as well as using surface waste markers that would blend in with the natural surrounding, and using natural materials for cap construction
Human Health Risk (analyzed for accident scenarios and the removal of institutional controls. Impacts resulting from routine exposure are not assessed.)	<u>Impacts</u> Potential high risk resulting from exposure to contaminants in the absence of institutional controls Much of the area exceeds target risk range for agricultural, residential, industrial or recreational exposures without restrictions and controls Range fire could result in radiation doses up to 3 mrem for workers and 2.6 mrem for offsite individuals <u>Mitigation Measures</u> Continue existing institutional controls, and environmental monitoring activities	<u>Impacts</u> Greatest impact from accidents that could occur during remedial activities. Pump-and-treat accident could result in radiation doses up to 620 mrem for workers and 510 mrem for offsite individuals Long-term risk expected to decrease upon completion of remediation <u>Mitigation Measures</u> Use of appropriate engineering and administrative controls to reduce exposures to remediation workers and the general public	<u>Impacts</u> Impacts from accidents are the same as described under the unrestricted alternative. Likelihood of accidents occurring during remediation are less than or equal to that for unrestricted alternative Long-term risk expected to decrease upon completion of remediation <u>Mitigation Measures</u> Same as described under the unrestricted future land-use alternative	<u>Impacts</u> Impacts from accidents are the same as described under the unrestricted alternative. Likelihood of accidents occurring during remediation are less than or equal to that for the unrestricted alternative Long-term risk expected to decrease upon completion of remediation <u>Mitigation Measures</u> Same as described under the unrestricted future land-use alternative

Table 3-12. Summary of Environmental Impacts and Mitigation Measures for the Reactors on the River Geographic Area. (6 sheets)

Resource Areas	No-Action Alternative	Remediation to Unrestricted Future Land-Use Alternative	Remediation to Restricted Future Land-Use Alternative (R1)	Remediation to Restricted Future Land-Use Alternative (R2)
Occupational Impacts	Impacts No labor hour estimates are available for the No-Action Alternative, therefore no occupational losses were calculated Mitigation Measures None identified	Impacts Potential for 233 occupational loss cases and 1,560 lost workdays (DOE statistics) Mitigation Measures Continued emphasis on worker safety and training	Impacts Potential for 167 occupational loss cases and 1,122 lost workdays (DOE statistics) Mitigation Measures Same as described under the unrestricted future land-use alternative	Impacts Potential for 421 occupational loss cases and 2,824 lost workdays (DOE statistics) Mitigation Measures Same as described under the unrestricted future land-use alternative
Volumes and Cost	Impacts Area of disturbance is 87 ha (215 ac) Estimated total cost for No Action is $2.4 billion[1] Mitigation Measures Alternate means of institutional control that would result in cost reduction [1]Costs for 100 years of institutional control for the Hanford Site - not broken down by geographic area	Impacts Excavated volume of noncontaminated soil is 7.0×10^6 BCM (9.2×10^6 BCY) Excavation volume of contaminated soil is 6.7×10^6 BCM (8.8×10^6 BCY) Cost for groundwater remediation is $205 million Area of disturbance is 420 ha (1,038 ac) Estimated total cost is $3.9 billion with truck haul or $2.8 billion with rail haul Mitigation Measures Continued emphasis on development and implementation of technologies that would reduce volumes, levels of disturbance and costs associated with remediation	Impacts Excavated volume of noncontaminated soil is 5.7×10^6 BCM (7.5×10^6 BCY) Excavated volume of contaminated soil is 4.6×10^6 BCM (6.0×10^6 BCY) Groundwater remediation cost is $205 million Area of disturbance is 390 ha (964 ac) Estimated total cost is $2.8 billion with truck haul or $2.1 billion with rail haul Mitigation Measures Same as described under the unrestricted future land-use alternative	Impacts Volume of capping materials required is 19×10^6 LCM (25×10^6 LCY) Groundwater remediation cost is $205 million Area of disturbance is 373 ha (921 ac) Estimated total cost is $4.6 billion with truck haul or $2.0 billion with rail haul Mitigation Measures Same as described under the unrestricted future land-use alternative, as well as: increased site characterization (potentially reduce the number and size of waste sites needed to be remediated); and use of alternate cap designs

BCM = bank cubic meter.
BCY = bank cubic yard.
LCM = loose cubic meter.
LCY = loose cubic yard.

Table 3-13. Summary of Environmental Impacts and Mitigation Measures for the Central Plateau Geographic Area. (4 sheets)

Resource Areas	No-Action Alternative	Remediation to Exclusive Future Land-Use Alternative
Geology	Impacts No significant long- or short-term adverse impacts are expected Continued restrictions on access to geologic resources Mitigation Measures None identified	Impacts Potential destruction of unique geologic features as a result of remediation Continued restrictions on access to geologic resources Mitigation Measures None identified
Soils	Impacts Minimal impacts caused by stabilization of waste sites; increased potential for erosion Mitigation Measures Mitigation measures could include spraying areas to reduce amount of fugitive airborne dust, construction of fences to control wind erosion, and revegetating disturbed areas with native species	Impacts Disturbance of 475 ha (1,174 ac) of soil; soil compaction resulting from use of earthmoving equipment; increased potential for erosion Mitigation Measures Same as described in the no-action alternative, as well as restricting earthmoving equipment to trample zones and using existing transportation routes where possible
Water Resources	Impacts Groundwater would remain contaminated Continued groundwater migration down gradient of the Central Plateau geographic area would result in a gradual decrease in contaminant concentration within the Central Plateau Mitigation Measures Maintain restrictions on groundwater use	Impacts Withdrawal and use of groundwater would be restricted due to residual contamination Movement of contaminants from the Central Plateau geographic area to down gradient areas would be minimized Capping would prevent contaminants in the vadose zone from migrating into the groundwater Changes in the groundwater levels and flow direction from operation of pump-and-treat system Mitigation Measures None identified
Ecological Resources	Impacts Disturbance of 0.7% of shrub-steppe habitat in the Central Plateau geographic area Minimal impact on biodiversity Potential exposure of plants and wildlife to radionuclides and hazardous chemicals Mitigation Measures Mitigation measures would include: Limit areas disturbed to the immediate waste site; revegetate disturbed areas with native plant species; and continue ecological monitoring	Impacts Disturbance of 6.0% of shrub-steppe habitat in the Central Plateau geographic area Potential impacts on biodiversity due to loss of shrub-steppe habitat Permanent loss or alteration of shrub-steppe habitat could result in long-term population declines and habitat degradation. Potential fragmenting of existing habitats could result disruption of connectivity among different habitats. Reduction in potential for exposure to radionuclides and hazardous chemicals Mitigation Measures Mitigation measures would include: Limit areas disturbed to the immediate waste site; use existing transportation routes where possible; employ erosion control measure; revegetate disturbed areas with native plant species; and avoid disturbance of known nesting/roosting sites for species of concern

Table 3-13. Summary of Environmental Impacts and Mitigation Measures for the Central Plateau Geographic Area. (4 sheets)

Resource Areas	No-Action Alternative	Remediation to Exclusive Future Land-Use Alternative
Air Quality	Impacts Generation of small amounts of potentially contaminated fugitive dust from surface decontamination and waste site stabilization Mitigation Measures None identified	Impacts Generation of dust from capping activities Generation of pollution by fuel combustion in equipment used for capping activities Mitigation Measures Dust suppression measures, covering haul trucks, and temporary enclosures for areas being remediated
Noise	Impacts Noise levels remain the same as current levels Mitigation Measures None identified	Impacts Temporary increase in noise levels from cap construction could impact wildlife (i.e., startle behavior resulting in abandonment of nest or den sites) Exposures occasionally may exceed applicable occupational standards for remediation workers No violations of State of Washington noise standards are anticipated Mitigation Measures Mitigation measures would include issuance of hearing protection devices for remediation workers, monitoring noise levels throughout the remediation process, limiting activities near roost/nest sites during nesting season
Cultural Resources	Impacts Controlled access would protect resources Potential impacts on known prehistoric sites, historic sites, and numerous isolated occurrences of historic and prehistoric materials Potential impacts on areas of cultural or spiritual significance to Native Americans due to continued restriction on Tribal access Mitigation Measures Prior to any ground disturbing activities, there would be consultations with the SHPO and Native American tribal groups and governments; avoidance, where possible, of resource areas; When possible, a full resource survey would be conducted; surface mapping and material and data recovery activities would be employed where practicable resource awareness programs would be developed and presented to remediation personnel Mitigation measures for historic buildings would include building construction surveys; documentation; and access restrictions	Impacts Potential impacts on several prehistoric sites, historic sites, and numerous isolated occurrences of historic and prehistoric materials Potential impacts on areas of cultural or spiritual significance to Native Americans Mitigation Measures Same as described under the no-action alternative

Table 3-13. Summary of Environmental Impacts and Mitigation Measures for the Central Plateau Geographic Area. (4 sheets)

Resource Areas	No-Action Alternative	Remediation to Exclusive Future Land-Use Alternative
Visual and Aesthetic Resources	Impacts No significant impact to visual and aesthetic resources in vicinity of waste sites and facilities Mitigation Measures None identified	Impacts Permanent alteration of landscape from caps Construction activities visible to nearby viewers. Most not visible from site boundaries Temporary impacts from fugitive dust plumes reducing visual clarity Mitigation Measures Minimize the overall area of disturbance to the extent practicable employ dust suppression activities; raconteur remediated areas as close to original conditions as possible, use surface waste markers that would blend in with the natural surrounding, use natural materials for cap construction, and reseed with native species
Human Health Risk (analyzed for accident scenarios and the removal of institutional controls. Impacts resulting from routine exposure are not assessed.)	Impacts Potential high risk in the absence of institutional controls Much of the area exceeds target risk range for allowing agricultural, residential, industrial, and recreational exposures without restrictions and controls Range fire could result in radiation doses up to 1.4 mrem for workers and 3×10^{-3} mrem for offsite individuals Mitigation Measures Continue existing institutional controls and environmental monitoring activities	Impacts Potential impacts from pump-and-treat accidents include radiation doses up to 280 mrem to workers and up to 0.6 mrem for offsite individuals Mitigation Measures Use of appropriate engineering and administrative controls to reduce exposures to remediation workers and the general public
Occupational Impacts	Impacts Labor hour estimates were not available, no occupational losses were estimated Mitigation Measures None identified	Impacts Potential for 144 occupational loss cases and 966 estimated lost workdays (DOE statistics) Mitigation Measures Continued emphasis on safety awareness and worker training
Volumes and Costs	Impacts Area of disturbance is 280 ha (692 ac) Estimated total cost is $2.4 billion[1] Mitigation Measures Alternate means of institutional control that would result in cost reduction [1]Costs for 100 years of institutional control for the Hanford Site - not broken down by geographic area	Impacts Volume of capping materials required is 17.5×10^6 LCM (22.93×10^7 LCY) Area of disturbance is 475 ha (1,173 ac) Groundwater remediation cost is $411 million Estimated total cost is $1.5 billion Mitigation Measures Continued emphasis on development and implementation of technologies that would reduce volumes, levels of disturbance and costs associated with remediation. Increased site characterization (potentially reduce the number and size of waste sites needed to be remediated); and use of alternate cap designs

Table 3-13. Summary of Environmental Impacts and Mitigation Measures for the Central Plateau Geographic Area. (4 sheets)

Resource Areas	No-Action Alternative	Remediation to Exclusive Future Land-Use Alternative

BCM = bank cubic meter.
BCY = bank cubic yard.
LCM = loose cubic meter.
LCY = loose cubic yard.

Table 3-14. Summary of Environmental Impacts and Mitigation Measures for the All Other Areas Geographic Area. (5 sheets)

Resource Areas	No-Action Alternative	Remediation to Restricted Future Land-Use Alternative (R1)	Remediation to Restricted Future Land-Use Alternative (R2)
Geology	Impacts No significant long- or short-term adverse impacts are expected Continued restrictions on access to geologic resources Mitigation Measures None identified	Impacts Continued restrictions on access to geologic resources Some destruction of unique geologic features during remediation Mitigation Measures None identified	Impacts Continued restrictions on access to geologic resources Some destruction of unique geologic features during remediation Depletion of geologic resources for cap construction Mitigation Measures None identified
Soils	Impacts Minimal impacts caused by stabilization of waste sites; increased potential for erosion Mitigation Measures Employ soil, wind and water erosion reduction measures	Impacts Disturbance of 301 ha (753 ac) of soil; soil compaction resulting from use of earthmoving equipment; increased potential for erosion Mitigation Measures Restrict earthmoving equipment to trample zones; use existing transportation routes; employ soil, wind and water erosion reduction methods	Impacts Disturbance of 380 ha (939 ac) of soil; soil compaction resulting from use of earthmoving equipment; increased potential for wind erosion Mitigation Measures Same as those described under the restricted future land-use (R1) alternative
Water Resources	Impacts Groundwater would remain contaminated Contaminants in vadose zone are a potential source of groundwater contamination Disturbance of >1 ha (2.5 ac) of the Columbia River floodplain Mitigation Measures Maintain existing restrictions on withdrawal and use of groundwater None identified for disturbance of Columbia River floodplain	Impacts Restrictions on withdrawal and use of groundwater due to residual contamination; changes in groundwater levels and flow direction by operation of pump-and-treat system; mounding of water table in vicinity of reinjection facilities; reduction of contaminant flow to the Columbia River Disturbance of 10 ha (25 ac) of the Columbia River floodplain and approximately 1 ha (2.5 ac) of the Cold Creek floodplain Mitigation Measures Employ engineering measures designed to prevent further contamination of the groundwater and/or the Columbia River None identified for disturbance of Columbia River floodplain	Impacts Groundwater impacts would be similar to those described under the R1 restricted alternative Caps over waste sites would prevent contaminants in the vadose zone from entering the groundwater Disturbance of 7 ha (17 ac) of the Columbia River floodplain and 3 ha (7 ac) of the Cold Creek floodplain Mitigation Measures Same as described under the restricted future land-use (R1) alternative

Table 3-14. Summary of Environmental Impacts and Mitigation Measures for the All Other Areas Geographic Area. (5 sheets)

Resource Areas	No-Action Alternative	Remediation to Restricted Future Land-Use Alternative (R1)	Remediation to Restricted Future Land-Use Alternative (R2)
Ecological Resources	Impacts Disturbance of 5 ha (12 ac) of shrub-steppe habitat Potential exposure of plants and wildlife to radionuclides and hazardous chemicals Mitigation Measures Mitigation measures would include: Limit areas disturbed to the immediate waste site; revegetate disturbed areas with native plant species; and continue ecological monitoring	Impacts Disturbance of 115 ha (287 ac) of shrub-steppe habitat Possible nest abandonment by the Swainson's hawk; possible nest destruction, nesting habitat destruction, and loss of prey base for the loggerhead shrike; possible destruction of Columbia milk-vetch and northern wormwood habitat Reduction in potential for exposure to radionuclides and hazardous chemicals Potential impacts on biodiversity due to additional loss of shrub-steppe habitat Mitigation Measures Limiting disturbance to not exceed trample zone around each waste site; revegetation of disturbed areas with native plant species; limit unnecessary off-road travel and use existing transportation routes; use engineering controls to reduce potential for erosion and avoid disturbance of known nesting/roosting sites for species of concern	Impacts Disturbance of 134 ha (329 ac) of shrub-steppe habitat Possible nest destruction, nesting habitat destruction, and loss of prey base for the loggerhead shrike; possible destruction of Columbia milk-vetch and northern wormwood habitat Reduction in potential for exposure to radionuclides and hazardous chemicals Potential impacts on biodiversity due to additional loss of shrub-steppe habitat Mitigation Measures Same as described in the Restricted Future Land-Use (R1) Alternative
Air Quality	Impacts Generation of small amounts of potentially contaminated fugitive dust from surface decontamination and waste site stabilization activities Mitigation Measures Use of engineering controls to reduce dust generation	Impacts Generation of potentially contaminated fugitive dust exceeding standards and guidelines Generation of pollution by fuel combustion in equipment used for excavation, loading and hauling Mitigation Measures Use of engineering controls to reduce dust generation; use of temporary enclosures over excavation sites; monitoring of air quality	Impacts Generation of potentially contaminated fugitive dust from capping activities Generation of pollution by fuel combustion in equipment used for capping activities Mitigation Measures Same as described for the Restricted Future Land-Use (R1) Alternative

Table 3-14. Summary of Environmental Impacts and Mitigation Measures for the All Other Areas Geographic Area. (5 sheets)

Resource Areas	No-Action Alternative	Remediation to Restricted Future Land-Use Alternative (R1)	Remediation to Restricted Future Land-Use Alternative (R2)
Noise	Impacts Noise levels would remain the same as current levels Mitigation Measures None identified	Impacts Temporary increases in noise levels from excavation and waste transportation No violations of State of Washington noise standards Mitigation Measures Mitigation measures would include issuance of hearing protection devices for remediation workers, monitoring noise levels throughout the remediation process; limiting activities near roost/nest sites during nesting season	Impacts Temporary increase in noise levels from waste site capping activities No violations of State of Washington noise standards Mitigation Measures Same as described for the Restricted Future Land-Use (R1) Alternative
Cultural Resources	Impacts Controlled access would protect resources Potential impacts on known prehistoric and historic sites from surface decontamination and stabilization activities Potential impacts on areas of cultural or spiritual significance to Native Americans due to continued restriction on Tribal access Mitigation Measures Prior to any ground disturbing activities, there would be consultations with the SHPO and Native American tribal groups and governments; avoidance, where possible, of resource areas; When possible, a full resource survey would be conducted; surface mapping and material and data recovery activities would be employed where practicable resource awareness programs would be developed and presented to remediation personnel Mitigation measures for historic buildings and facilities would include building construction surveys; documentation of all structures deemed historic; restriction of access to historic buildings/facilities	Impacts Potential impacts on known prehistoric and historic sites due to excavation activities Potential impacts on areas of cultural or spiritual significance to Native Americans from encroachment on traditional tribal areas Mitigation Measures Same as described for the No-Action Alternative	Impacts Potential impacts on known prehistoric and historic sites from waste site capping activities Potential impacts on areas of cultural or spiritual significance to Native Americans from encroachment on traditional tribal areas Mitigation Measures Same as described in the No-Action Alternative

Table 3-14. Summary of Environmental Impacts and Mitigation Measures for the All Other Areas Geographic Area. (5 sheets)

Resource Areas	No-Action Alternative	Remediation to Restricted Future Land-Use Alternative (R1)	Remediation to Restricted Future Land-Use Alternative (R2)
Visual and Aesthetic Resources	Impacts No significant impacts to visual and aesthetic resources in vicinity of waste site stabilization and surface decontamination activities Mitigation Measures None identified	Impacts Construction and excavation activities visible to nearby viewers Pump-and-treat systems would be visible to nearby viewers Potential for fugitive dust plumes to reduce visual clarity Mitigation Measures Minimize the overall area of disturbance to the extent practicable; employ dust suppression activities; recontouring remediated areas as close to original conditions as possible, and revegetating with native species as soon as possible following remediation	Impacts Permanent alteration of landscape from capped waste sites Construction activities and pump-and-treat systems visible to nearby viewers Potential for fugitive dust plumes to reduce visual clarity Mitigation Measures Same as described under the restricted future land-use (R1) alternative, as well as using surface waste markers that would blend in with the natural surrounding, and using natural materials for cap construction
Human Health Risk (analyzed for accident scenarios and the removal of institutional controls. Impacts resulting from routine exposure are not assessed.)	Impacts Potential high risk in some portions of area in absence of institutional controls Portions of area within or below target risk range for agricultural, residential, or industrial exposures without restrictions or controls. Most of area meets target risk range for recreational exposures Range fire could result in radiation dose up to 1.7 mrem for workers and 0.95 mrem for offsite individuals Mitigation Measures Continue existing institutional controls	Impacts Impacts of routine remedial activities minimal, as long as appropriate engineering and administrative measures applied Potential accidents occurring during remediation could result in radiation doses of up to 350 mrem for workers and up to 190 mrem for offsite individuals Long-term risk expected to decrease upon completion of remediation Mitigation Measures Use of appropriate engineering and administrative controls to reduce exposures to remediation workers and the general public	Impacts Impacts of routine remedial activities minimal, as long as appropriate engineering and administrative measures applied Impacts resulting from accidents during remediation are similar to those described under the R1 restricted alternative. However, there is a lower likelihood of accidents occurring during remediation under the R2 restricted use alternative Long-term risk expected to decrease upon completion of remediation Mitigation Measures Same as described for the restricted future land-use (R1) alternative
Occupational Impacts	Impacts Labor hour estimates were not available, no occupational losses were estimated Mitigation Measures None identified	Impacts Potential for 72 occupational injury loss cases and 482 estimated lost workdays (DOE statistics) Mitigation Measures Continued emphasis on safety awareness and worker training	Impacts Potential for 335 occupational loss cases and 2,244 estimated lost workdays (DOE statistics) Mitigation Measures Same as described for the restricted future land-use (R1) alternative

Table 3-14. Summary of Environmental Impacts and Mitigation Measures for the All Other Areas Geographic Area. (5 sheets)

Resource Areas	No-Action Alternative	Remediation to Restricted Future Land-Use Alternative (R1)	Remediation to Restricted Future Land-Use Alternative (R2)
Volumes and Costs	<u>Impacts</u> Area of disturbance is 43 ha (106 ac) Estimated total cost is $2.4 billion[1] <u>Mitigation Measures</u> efforts to reduce cost of institutional control [1]Costs for 100 years of institutional control for the Hanford Site - not broken down by geographic area	<u>Impacts</u> Excavated volume of noncontaminated soil is 1.6 x 10^3 BCM (2.1 x 10^3 BCY) Excavation volume of contaminated soil is 1.6 x 10^3 BCM (2.0 x 10^3 BCY) Area of disturbance is 309 ha (765 ac) Groundwater remediation cost is $31 million Estimated total cost is $1 billion with truck haul or $670 million with rail haul <u>Mitigation Measures</u> Monitor excavated soils to prevent excavation of non-contaminated soil; continued emphasis on development and implementation of technologies that would reduce volumes, levels of disturbance and costs associated with remediation	<u>Impacts</u> Volume of capping materials required is 8,700 x 10^3 LCM (11,300 x 10^3 LCY) Area of disturbance is 384 ha (948 ac) Groundwater remediation cost is $31 million Estimated total cost is $3.2 billion with truck haul or $790 million with rail haul <u>Mitigation Measures</u> Same as described under the restricted future land-use (R1) alternative, as well as: increased site characterization (potentially reduce the number and size of waste sites needed to be remediated); and use of alternate cap designs

BCM = bank cubic meter.
BCY = bank cubic yard.
LCM = loose cubic meter.
LCY = loose cubic yard.

Affected Environment

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4.0 Affected Environment

The U.S. Department of Energy's (DOE) Hanford Site lies within the semiarid Pasco Basin of the Columbia Plateau in southeastern Washington State (Figure 4-1). The Hanford Site occupies an area of about 1,450 km^2 (~560 mi^2) north of the confluence of the Yakima River with the Columbia River. The Hanford Site is about 50 km (30 mi) north to south and 40 km (24 mi) east to west. This land, with restricted public access, provides a buffer for the smaller areas currently used for storage of nuclear materials, waste storage, and waste disposal; only about 6% of the land area has been disturbed and is actively used. The Columbia River flows through the northern part of the Hanford Site and, turning south, forms part of the Hanford Site's eastern boundary. The Yakima River runs near the southern boundary and joins the Columbia River below the City of Richland, which bounds the Hanford Site on the southeast. Rattlesnake Mountain, Yakima Ridge, and Umtanum Ridge form the southwestern and western boundaries. The Saddle Mountains form the northern boundary of the Hanford Site. Two small east-west ridges, Gable Butte and Gable Mountain, rise above the plateau of the central part of the Hanford Site. Adjoining lands to the west, north, and east are principally range and agricultural land. The cities of Richland, Kennewick, and Pasco (Tri-Cities) constitute the nearest population center and are located southeast of the Hanford Site.

The production of defense nuclear materials at the Hanford Site since the 1940s has necessitated the exclusion of public access and most nongovernment-related development on the Hanford Site. The Hanford Site, as a result of its defense-related mission, also has provided *de facto* protection of the natural environment and cultural resources (NPS 1994); however, the defense nuclear production mission has left the Hanford Site with an extensive waste legacy. Nuclear weapons materials production and associated activities at Hanford during the past five decades have generated a variety of radioactive, hazardous, and other wastes that have been disposed or discharged to the air, soil, and water at the Hanford Site. The DOE Environmental Restoration Project focuses on remediation of contaminated soils and water resources.

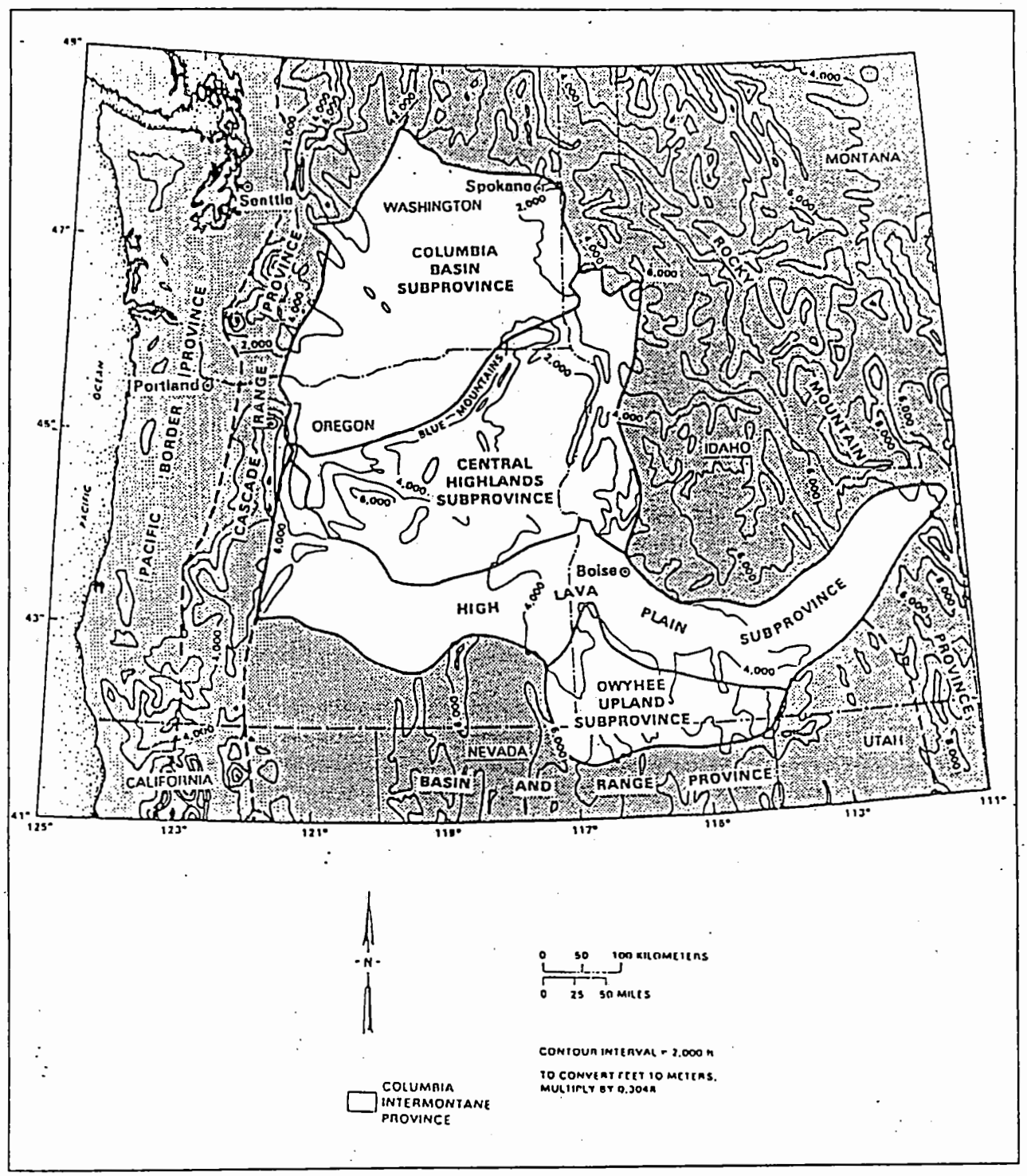
This chapter describes the environmental setting and the existing conditions associated with current operations on the Hanford Site for each of the four geographic areas within the scope of the HRA-EIS. Available information was used to establish a set of baseline conditions against which potential environmental impacts associated with the proposed action and the alternatives were analyzed.

4.1 Geology

Geologic considerations for the Hanford Site include physiography, stratigraphy, structural geology, seismic and volcanic hazards, and soil characteristics.

Depositional processes associated with lakes and rivers in the ancestral Columbia River system, including the ancestral Snake and Yakima rivers, have been active since the late Miocene. Deposits of these rivers and lakes are represented by the Ringold Formation, and indicate that deposition was almost continuous from about 10.5 million years before present until about 3.9 million years before present (DOE 1988). At some time before 900,000 years ago, a major change in regional base level resulted in fluvial incision (down cutting) of as much as 150 m (500 ft). The post-Ringold erosional

Figure 4-1. Geographic Setting and General Structural Geology of the Pasco Basin and Hanford Site (WHC 1992a).



surface was partially filled with locally derived alluvium and fluvial sediment before and possibly between periods of Pleistocene flooding. However, in most areas of the Columbia Basin subprovince, the record of Pleistocene fluvial activity was destroyed by cataclysmic flooding. Loess (buff-colored silt) occurs in sheets that mantle much of the upland areas of the Columbia Basin subprovince.

Quaternary[1] volcanism has been limited to the extreme western margin of the Columbia Basin subprovince and is associated with the Cascade Range Province. Airfall tephra[2] from at least three Cascade volcanoes has blanketed the central Columbia Plateau since the late Pleistocene. This tephra includes material from several eruptions of Mount St. Helens before the May 1980 eruption. Other volcanoes have erupted less frequently: Glacier Peak had two closely spaced eruptions about 11,200 years ago, and Mount Mazama erupted about 6,600 years ago. Generally tephra layers have not exceeded more than a few centimeters in thickness, with the exception of the Mount Mazama eruption when as much as 10 cm (3.9 in.) of tephra fell over eastern Washington (DOE 1988).

4.1.1 Physiography

The Hanford Site, located within the Pasco Basin of the Columbia Plateau, is defined generally by a thick accumulation of basaltic lava flows that extend laterally from central Washington, eastward into Idaho, and southward into Oregon (DOE 1995).

The Hanford Site overlies the structural low point of the Pasco Basin near the confluence of the Yakima and Columbia rivers. The boundaries of the Pasco Basin are defined by anticlinal structures of basaltic rock. These structures are the Saddle Mountains to the north; the Umtanum Ridge, Yakima Ridge, and Rattlesnake Hills to the west; and the Rattlesnake Hills and a series of doubly plunging anticlines merging with the Horse Heaven Hills to the south. The terrain within the Pasco Basin is relatively flat (Figure 4-2). Its surface features were formed by catastrophic floods and have undergone little modification since, with the exception of more recently formed sand dunes (DOE 1995).

The elevation of the alluvial plain that covers much of the Hanford Site varies from 105 m (345 ft) above mean sea level in the southeast corner to 245 m (803 ft) in the northwest. The Central Plateau varies in elevation from 190 to 245 m (623 to 803 ft).

4.1.2 Stratigraphy

The stratigraphy of the Hanford Site consists of Miocene-age and younger rocks. Older Cenozoic sedimentary and volcaniclastic rock underlie the Miocene and younger rocks but are not exposed at the surface. The Hanford Site stratigraphy is summarized in Figure 4-3 and described in the following paragraphs.

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[1]Quaternary--A geologic period beginning approximately 2 million years ago and extending to the present.

[2]Tephra--A collective term for all clastic materials ejected from a volcano and transported through the air.

Figure 4-2. Topography of the Hanford Site (WHC 1991a).

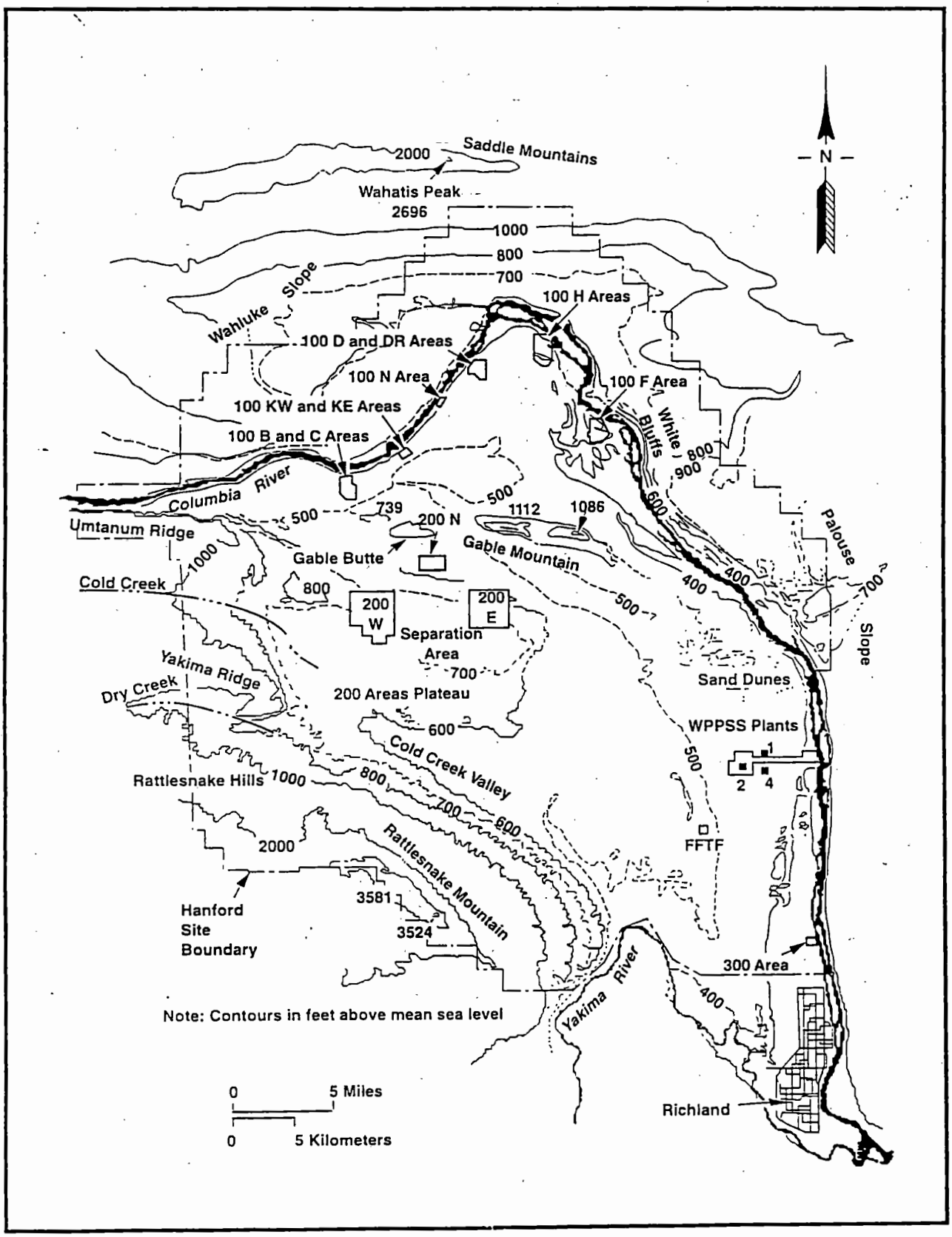

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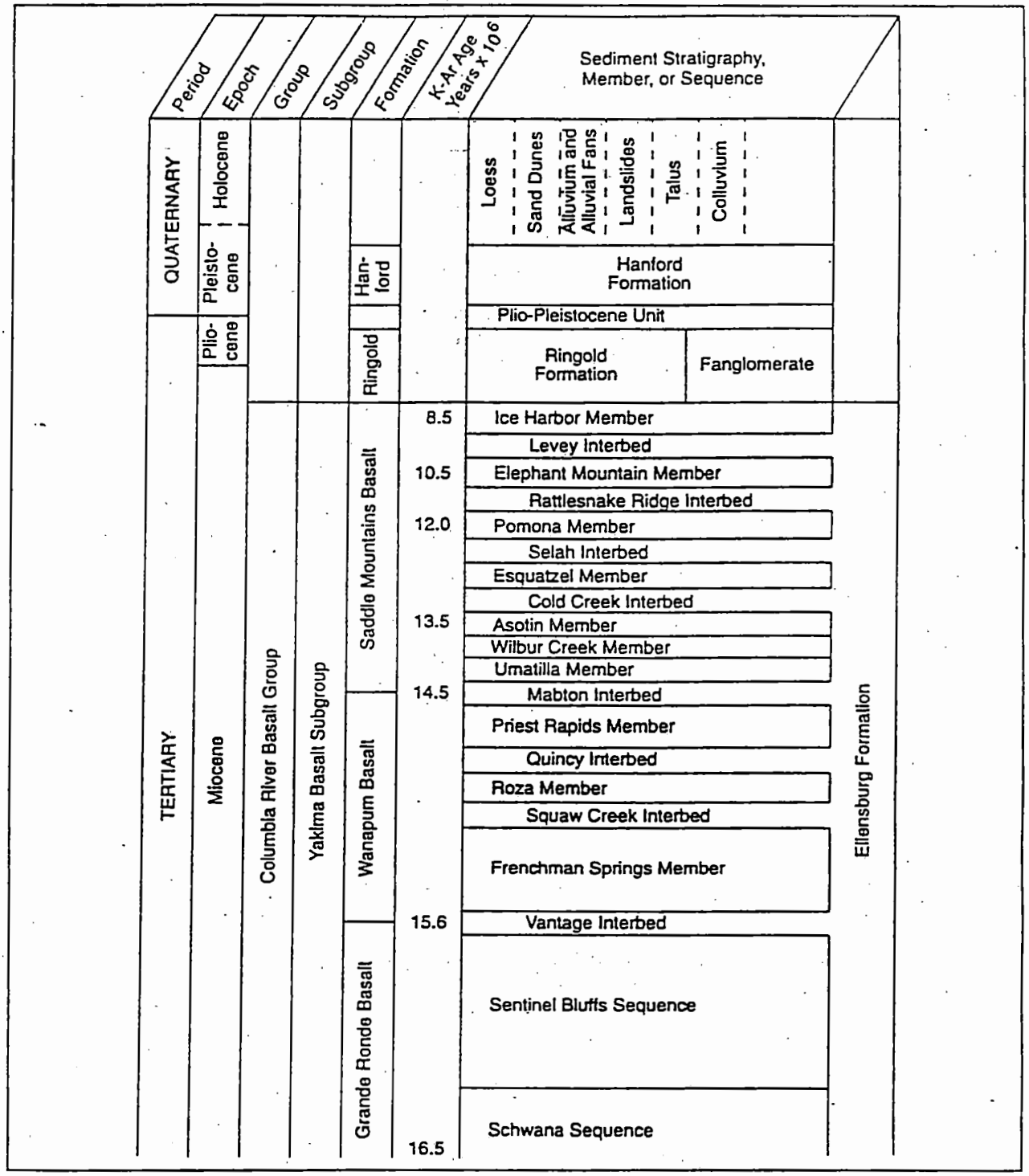
Figure 4-3. A Generalized Stratigraphic Column of the Major Geologic Units of the Hanford Site.



Knowledge of the subbasalt rocks is limited to studies of exposures along the margin of the Columbia Plateau and to a few deep boreholes drilled in the interior of the plateau (DOE 1988). No subbasalt rocks are exposed within the central interior of the Columbia Plateau, including the Pasco Basin. Interpretation of data from wells drilled by Shell Oil Company in the 1980s (in the northwestern Columbia Plateau) indicates that, in the central part of the Columbia Plateau, the Columbia River Basalt Group is underlain predominantly by Tertiary continental sediments (DOE 1995).

The Hanford formation lies on the eroded surface of the Plio-Pleistocene unit, on the Ringold Formation, or locally on the basalt bedrock. The Hanford formation consists of catastrophic flood sediments that were deposited when ice dams in western Montana and northern Idaho were breached and massive volumes of water spilled abruptly across eastern and central Washington. The floods scoured the land surface, locally eroding the Ringold Formation, the basalts, and sedimentary interbeds, leaving a network of buried channels crossing the Pasco Basin (DOE 1995). Thick sequences of sediments were deposited by several episodes of flooding, with the last major flood sequence dated at about 13,000 years before the present, and during the Pleistocene Epoch. Anastomosing flood channels, giant current ripples, bergmounds, and giant flood bars are among the landforms created by the floods. The 200 East and 200 West Area's waste management activities are located on one prominent flood bar, the Cold Creek bar (Cushing 1995).

Since the end of the Pleistocene, winds have reworked the flood sediments, depositing dune sands in the lower elevations and loess (windblown silt) around the margins of the Pasco Basin. Many sand dunes have been stabilized by anchoring vegetation, except where they have been reactivated by disturbing the vegetation (Cushing 1995).

4.1.3 Structure

The Hanford Site is located near the junction of the Yakima Fold Belt and the Palouse structural subprovinces (DOE 1988). These structural subprovinces are defined on the basis of their structural fabric, unlike the physiographic provinces that are defined on the basis of landforms. The Palouse subprovince primarily is a regional paleoslope that dips gently toward the central Columbia Plateau and exhibits only relatively mild structural deformation. The Palouse Slope is underlain by a wedge of Columbia River basalt that thins gradually toward the east and north and laps onto the adjacent highlands.

The principal characteristics of the Yakima Fold Belt are a series of segmented, narrow, asymmetric anticlines that have wavelengths between 5 and 31 km (3 and 19 mi) and amplitudes commonly less than 1 km (0.6 mi) (Cushing 1995). These anticlinal ridges are separated by broad synclines or basins that, in many cases, contain thick accumulations of Neogene- to Quaternary-age sediments. The deformation of the Yakima Folds occurred under north-south compression. The fold belt was growing during the eruption of the Columbia River Basalt Group and continued to grow into the Pleistocene and probably into the present (Cushing 1995).

Thrust or high-angle reverse faults with fault planes that strike parallel or subparallel to the axial trends are found principally along the limbs of the anticlines (Figure 4-4) (Cushing 1995). The amount of vertical stratigraphic offset associated with these faults varies, but commonly exceeds hundreds of meters.

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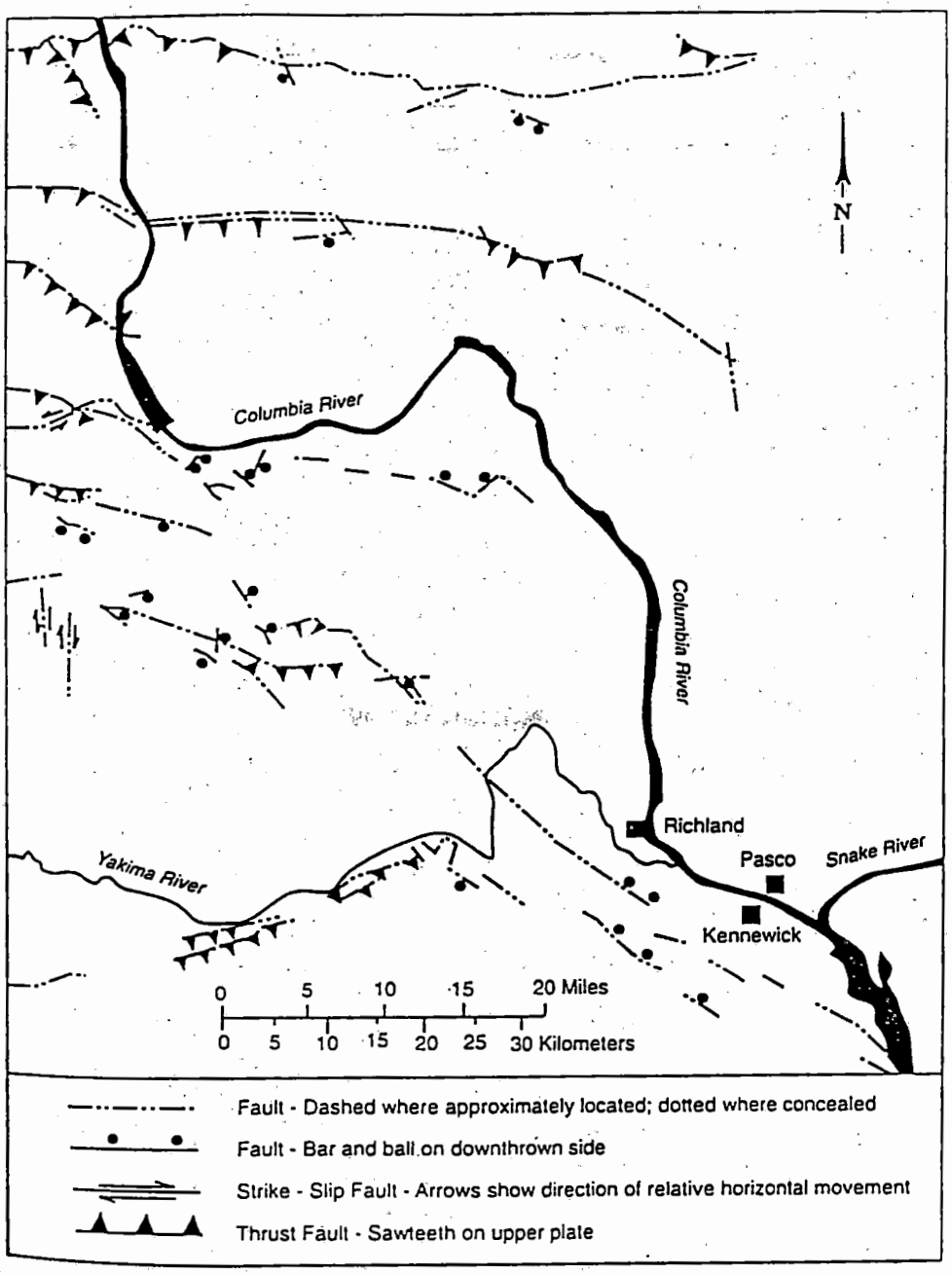
Figure 4-4. Map of the Columbia River Region Showing the Known Faults.



The Saddle Mountains uplift is a segmented anticlinal ridge extending from near Ellensburg to the western edge of the Palouse Slope. This ridge forms the northern boundary of the Pasco Basin and the Wahluke syncline (Figure 4-5). It is generally steepest on the north, with a gently dipping southern limb. A major thrust or high-angle reverse fault occurs on the north side (Cushing 1995).

The Umtanum Ridge-Gable Mountain uplift is a segmented, asymmetrical anticlinal ridge extending 137 km (85 mi) in an east-west direction forming the northern boundary of the Cold Creek syncline and the southern boundary of the Wahluke syncline. Three segments of this structure are located on or adjacent to the Hanford Site. From the west, Umtanum Ridge plunges eastward toward the basin, and merges with the Gable Mountain-Gable Butte segment. The latter segment then merges with the Southeast Anticline, which trends southeast before dying out near the Columbia River eastern boundary of the Gable Mountain-Gable Butte segment.

There is a major thrust to high-angle reverse fault on the north side that dies out as it plunges eastward past the Gable Mountain-Gable Butte segment. Gable Mountain and Gable Butte are two topographically isolated, anticlinal ridges composed of a series of northwest-trending, doubly plunging, echelon anticlines, synclines, and associated faults. The potential for present-day faulting has been identified on Gable Mountain (Cushing 1995).

The Yakima Ridge uplift extends from west of Yakima to the center of the Pasco Basin, where it forms the southern boundary of the Cold Creek syncline (DOE 1988) (see Figure 4-5). The Yakima Ridge anticline plunges eastward into the Pasco Basin, where it continues on a southeastern trend mostly buried beneath sediments. A thrust to high-angle reverse fault is thought to be present on the north side of the anticline, dying out as the fold extends to the east.

Rattlesnake Mountain is an asymmetrical anticline with a steeply dipping and faulted northern unit that forms the southern boundary of the Pasco Basin (see Figure 4-4). It extends from the structurally complex Snively Basin area southeast to the Yakima River, where the uplift continues as a series of doubly plunging anticlines. At Snively Basin, the Rattlesnake Mountain structure intersects the Rattlesnake Hills anticline, which extends beyond Yakima and has an east-west trend.

The Cold Creek syncline (see Figure 4-5) lies between the Umtanum Ridge-Gable Mountain uplift and the Yakima Ridge uplift. The Cold Creek syncline is an asymmetric and relatively flat-bottomed structure (DOE 1988). The Wahluke syncline lies between Saddle Mountains and the Umtanum Ridge-Gable Mountain uplifts. It, too, is asymmetric and relatively flat-bottomed, and is broader than the Cold Creek syncline.

The Cold Creek Fault (previously called the Yakima Barricade geophysical anomaly) (see Figure 4-5) occurs on the west end of the Cold Creek syncline and coincides with a west-to-east change in hydraulic gradient. The data suggest that this feature is a high-angle fault that has faulted the basalts and, at least, the older Ringold units. This fault apparently has not affected younger Ringold units or the Hanford formation (Cushing 1995).

Another fault, informally called the May Junction fault, is located nearly 4.5 km (3 mi) east of the 200 East Area. Like the Cold Creek fault, this fault is thought to be a high-angle fault that has offset the basalts and the older Ringold units. It does not appear to have affected the younger Ringold units or the Hanford formation.

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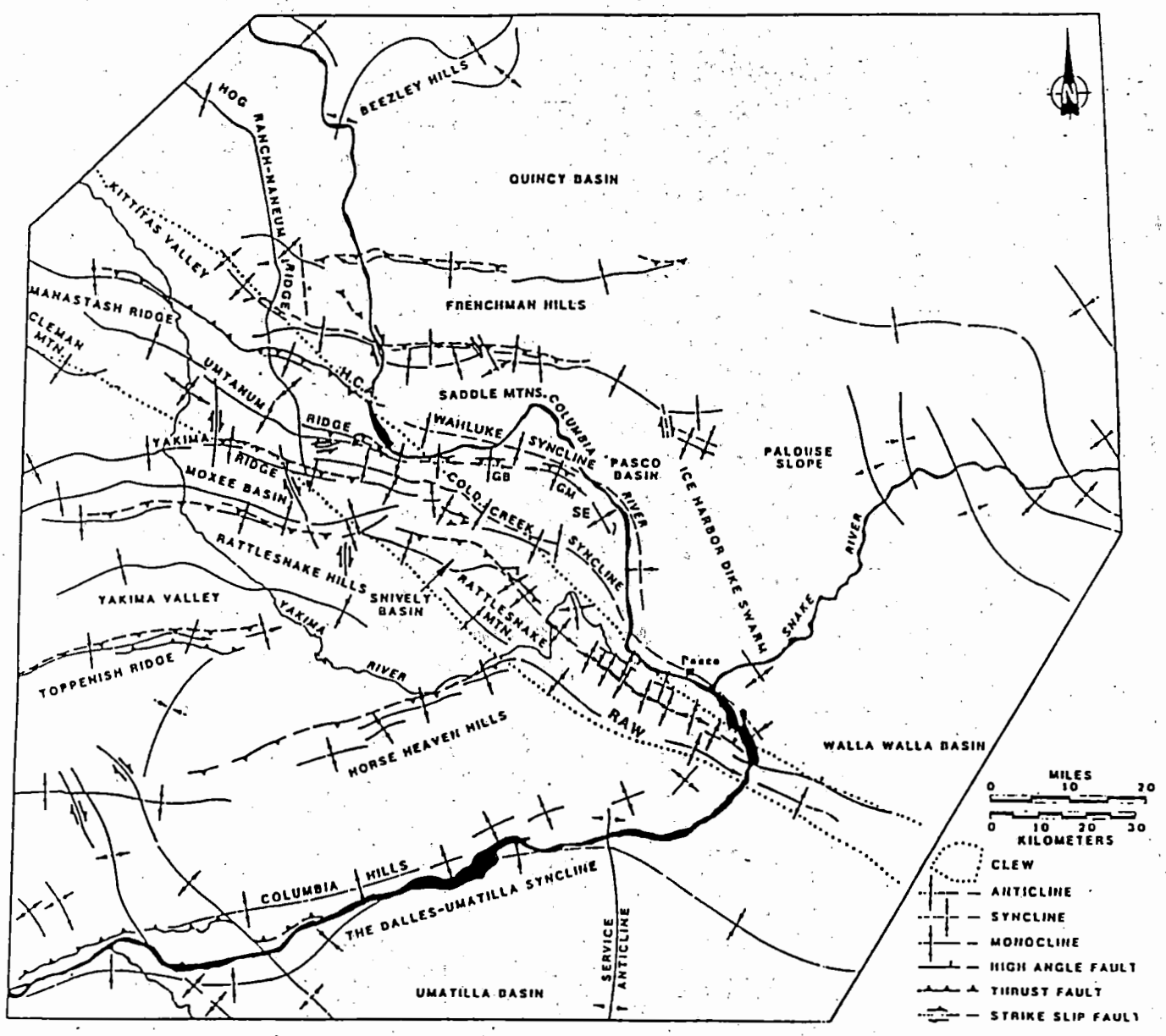
Figure 4-5. Location of Structural Features (Cushing 1995).



4.1.4 Geologic Summaries of the Geographic Areas

The following sections summarize the geologic characteristics of the Reactors on the River, Central Plateau, and All Other Areas. A geologic summary is not considered pertinent for the Columbia River geographic area.

4.1.4.1 Reactors on the River. All of the areas included within the Reactors on the River geographic area, except the 100-B/C Area, are situated on the north limb of the Wahluke syncline. The 100-B/C Area lies over the axis of the syncline. The top of basalt in the 100 Areas ranges in elevation from 46 m (150 ft) near the 100-H Area to 64 m (210 ft) below mean sea level near the 100-B/C Area. The Ringold and Hanford formations occur throughout this area; pre-Missoula gravels may be present near the 100-B/C and 100-K Areas, but are not readily distinguished from Ringold and Hanford sediments. The Plio-Pleistocene unit and early Palouse soils have not been recognized in the 100 Areas.

The sedimentary section above basalt in the Reactors on the River geographic area consists of (in ascending order) the Ringold Formation, the Hanford formation, and the Holocene surficial deposits. The Ringold Formation is variable throughout this area. Ringold strata are approximately 180 m (590 ft) thick near the 100-B/C Area. The strata become thinner (80 m, 260 ft) near 100-H and thicker (100 m [330 ft]) near 100-F. Near the 100-B/C, 100-K, and 100-F Areas, the Ringold Formation consists of interbedded, fluvial gravel-dominated intervals, and paleosol- and lacustrine-dominated intervals. The gravel-dominated intervals become finer and thinner to the north, towards the 100-N, 100-D, and 100-H Areas. In these areas, Ringold strata are dominated by lacustrine deposits of the lower mud sequence at the base, and paleosols above. No significant gravel-dominated intervals are found in the Ringold Formation in the vicinity of 100-H Area (WHC 1992a). Post-Ringold/pre-Hanford units are not encountered in this area.

The Hanford formation ranges in thickness from 10 to 35 m (32 to 115 ft), and is dominated by an open framework consisting of granule-to-cobble gravel (WHC 1992a). Boulder-rich strata are most abundant in the 100-B/C and 100-K Areas. In these areas, the entire Hanford formation may consist of boulder-dominated deposits with boulders up to 2 m (6 ft) across. Horizons consisting of the sand-dominated facies are locally present. The slack water or graded rhythmite facies have not been identified in this area.

Holocene deposits are dominated by Columbia River and eolian (wind-borne) deposits. Eolian deposits consist of thin, silty sands that blanket much of the area and form small dunes locally. The river deposits consist of gravels and coarse-grained sands deposited in channels, overbank silts, and fine sands.

4.1.4.2 Central Plateau. The Central Plateau is situated on the generally southward-dipping north limb of the Cold Creek syncline, where a succession of basalts and suprabasalt sediments dip gently to the south and southwest (WHC 1991a, 1992b).

4.1.4.2.1 200 West Area. In the 200 West Area, the uppermost basalt unit is the Elephant Mountain Member of the Saddle Mountains Basalt (WHC 1991a). The Elephant Mountain Member is continuous beneath the area and shows no indication of erosional "windows" through the basalt into the underlying Rattlesnake Ridge interbed. The Elephant Mountain Member is overlain by the Ringold Formation. In this area, the formation ranges in thickness from 75 to 180 m (250 to 600 ft) and consists of gravel unit A, the lower mud sequence, gravel unit E, and the upper unit.

Beneath most of the 200 West Area, the Ringold Formation is overlain by the Plio-Pleistocene unit and Early Palouse soil. Both units display variable thicknesses. The Hanford formation is the uppermost significant stratigraphic unit in the 200 West Area, and consists of 15 to 61 m (50 to 200 ft) of interstratified gravel, sand, and silt. Holocene eolian deposits overlie the Hanford formation and form a thin, discontinuous veneer of sand and silt.

4.1.4.2.2 200 East Area. In most of the 200 East Area and the area between the 200 East and 200 West Areas, the uppermost basalt unit is the Elephant Mountain Member. In the area northwest of the 200 East Area, the Elephant Mountain Member has been removed by erosion caused by cataclysmic flooding. The silts, sands, and tuffaceous deposits of the Rattlesnake Ridge interbed of the Ellensburg Formation are in direct contact with overlying suprabasalt sediments (WHC 1992b).

The Ringold Formation in the vicinity of the 200 East Area ranges in thickness from 0 to 105 m (0 to 350 ft) and consists primarily of gravel unit A, the lower mud sequence, and gravel unit E. Ringold strata are found throughout the southern two-thirds of the 200 East Area where they overlie basalt. Ringold strata are absent from the north-central part of the area where sediments of the overlying Hanford formation directly overlie basalt or sedimentary interbeds in the basalt. The Plio-Pleistocene unit and the Early Palouse soil do not occur beneath the 200 East Area, and are encountered only near the eastern boundary of the 200 West Area (WHC 1992b).

The Hanford formation is the uppermost significant stratigraphic unit in the vicinity of the 200 East Area and consists of approximately 15 to 64 m (50 to 210 ft) of interstratified gravel, sand, and silt. Strata typical of the gravel facies dominate the Hanford formation in the northern part of the area, but pinch out to the south where sand-dominated and slack water facies predominate. Holocene eolian deposits overlie the Hanford formation and form a thin, discontinuous veneer of sand and silt (WHC 1992b).

4.1.4.3 All Other Areas. The portions of All Other Areas adjacent to the Central Plateau and Reactors on the River geographic areas contain successions of basalt and suprabasalt sediments similar to those found within these two areas. Basalt flows of the Saddle Mountains Basalt are exposed on Gable Mountain and Gable Butte. Toward the southeast part of this area, in the vicinity of the 300 Area, the Ice Harbor Member of the Saddle Mountains Basalt is the uppermost basalt unit (Cushing 1995).

In the vicinity of the 300 Area, the Ice Harbor Member is overlain by the Ringold Formation. In this area the formation is 29 to 44 m (95 to 145 ft) thick, and consists of the lower mud sequence and an upper gravelly sequence containing gravel units (WHC 1992c). Two mud-dominated intervals are found locally within the upper gravel sequence. The Ringold Formation is overlain by the Hanford formation. The Hanford formation is 24 to 35 m (80 to 115 ft) thick, and is dominated by the gravel and sand facies. Post-Ringold pre-Hanford deposits are absent from the 300 Area. Holocene surficial deposits consisting of eolian silts and sands are found as thin sheets and thicker dunes (up to 4.5 m [15 ft]) in the southeastern portions of this geographic area.

4.1.5 Seismic and Volcanic Hazards

The following discussion briefly summarizes the seismic and volcanic hazards on the Hanford Site.

4.1.5.1 Seismic Hazards. The historic record of earthquakes in the Pacific Northwest dates from about 1840. The early part of this record is based on newspaper reports of structural damage and human perception of the shaking, as classified by the Modified Mercalli Intensity (MMI) scale, and is probably incomplete because the region was sparsely populated. Seismograph networks did not start providing earthquake locations and magnitudes of earthquakes in the Pacific Northwest until about 1960. A comprehensive network of seismic stations that provides accurate locating information for most earthquakes larger than a magnitude of 2.5 was installed in eastern Washington in 1969.

Large earthquakes (Richter magnitude >7) in the Pacific Northwest have occurred near Puget Sound, Washington, and near the Rocky Mountains in eastern Idaho and western Montana. One of these events occurred near Vancouver Island in 1946, and produced a maximum MMI of VIII, and a Richter magnitude of 7.3. Another large event occurred near Olympia, Washington, in 1949 at a maximum MMI of VIII, and a Richter magnitude of 7.1. The two largest events near the Rocky Mountains were the 1959 Hebgen Lake earthquake in western Montana, which had a magnitude of 7.5 Richter and an MMI X; and the 1983 Borah Peak earthquake in eastern Idaho, which had a MMI IX Richter magnitude of 7.3.

A large earthquake of uncertain location occurred in north-central Washington in 1872. This event had an estimated maximum MMI ranging from VIII to IX, and an estimated Richter magnitude of approximately 7. The distribution of intensities suggests a location within a broad region between Lake Chelan, Washington, and the British Columbia border.

Seismicity of the Columbia Plateau, as determined by the rate of earthquakes per area and the historical magnitude of these events, is relatively low when compared to other regions of the Pacific Northwest, the Puget Sound area and western Montana/eastern Idaho. Figure 4-6 shows the locations of all earthquakes that occurred in the Columbia Plateau between 1850 and 1969, with an MMI of IV or larger, and a Richter magnitude of 3 or larger. Figure 4-7 shows the locations of all earthquakes that occurred from 1969 to 1989 with Richter magnitudes of 3 or greater. The largest known earthquake had a magnitude of 5.75 and an MMI of VII, and was followed by a number of after shocks that indicate a northeast-trending fault plane. Other earthquakes with Richter magnitudes of 5 or larger and/or MMIs of VI are located along the boundaries of the Columbia Plateau in a cluster near Lake Chelan extending into the northern Cascade Range; in northern Idaho and Washington, and along the boundary between the western Columbia Plateau and the Cascade Range.

In the central portion of the Columbia Plateau, the largest earthquakes near the Hanford Site occurred in 1918 and 1973. These two earthquakes had Richter magnitudes of 4.4 and a MMI of V. Earthquakes often occur in spatial and temporal clusters in the central Columbia Plateau, and are termed earthquake swarms. The region north and east of the Hanford Site is a region of concentrated earthquake swarm activity; however, earthquake swarms also have occurred in several locations within the Hanford Site.

Earthquakes in a swarm tend to gradually increase and decay in frequency of events, and usually no one outstanding large event is present within the sequence. These earthquake swarms occur at shallow depths, with 75% of the events located at depths less than 4 km (2.5 mi). Each earthquake swarm typically lasts several weeks to months, consists of several to greater than 100 earthquakes, and is clustered in an area 5 to 10 km (3 to 6 mi) in lateral dimension. Often, the longest dimension of the swarm area is elongated in an east-west direction. However, detailed locations of swarm earthquakes indicate that the events occur on fault planes of variable orientation, and not on a single fault plane.

9613470.0379

Figure 4-6. Historical Seismicity of the Columbia Plateau and Surrounding Areas (Cushing 1995).

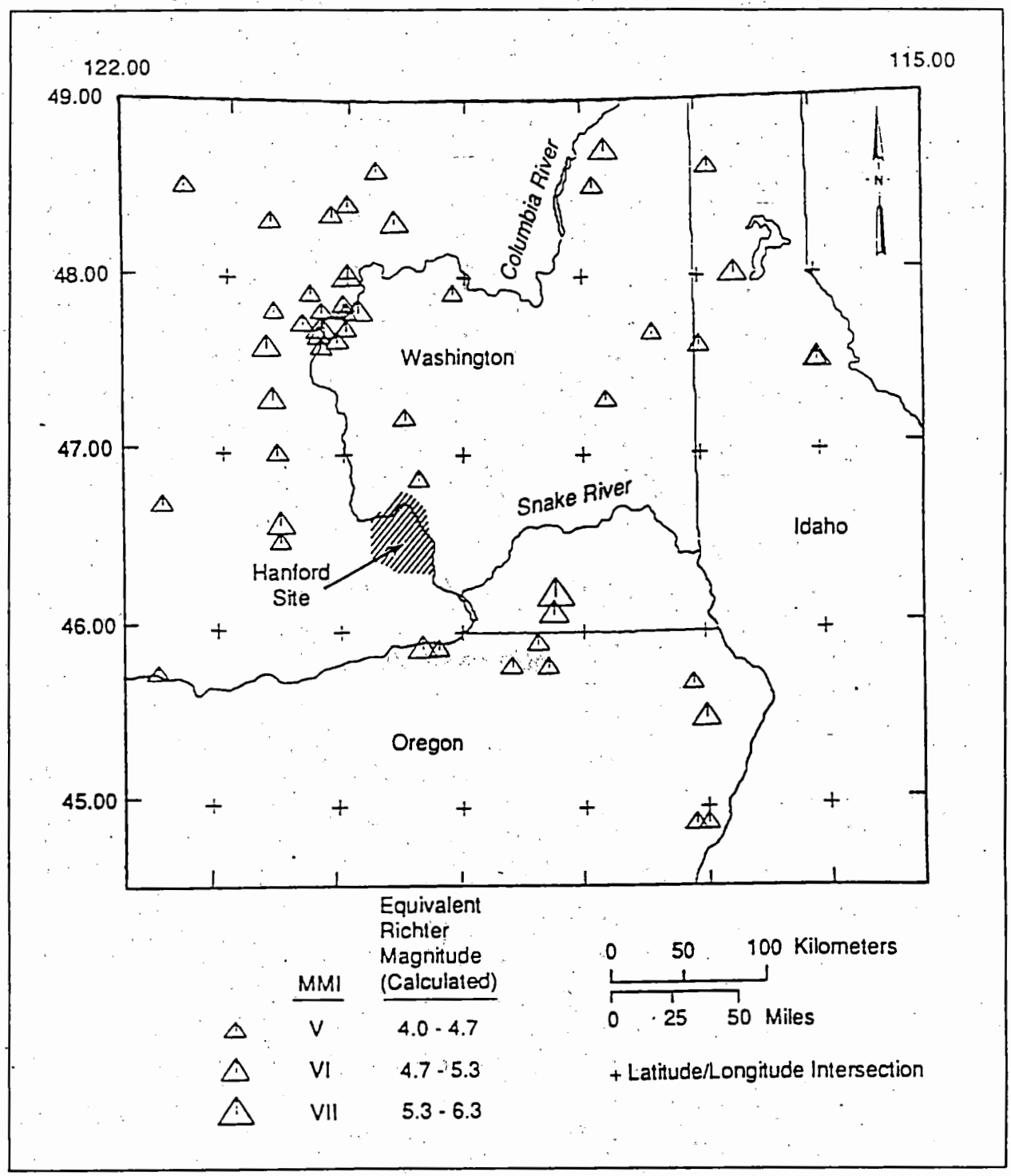
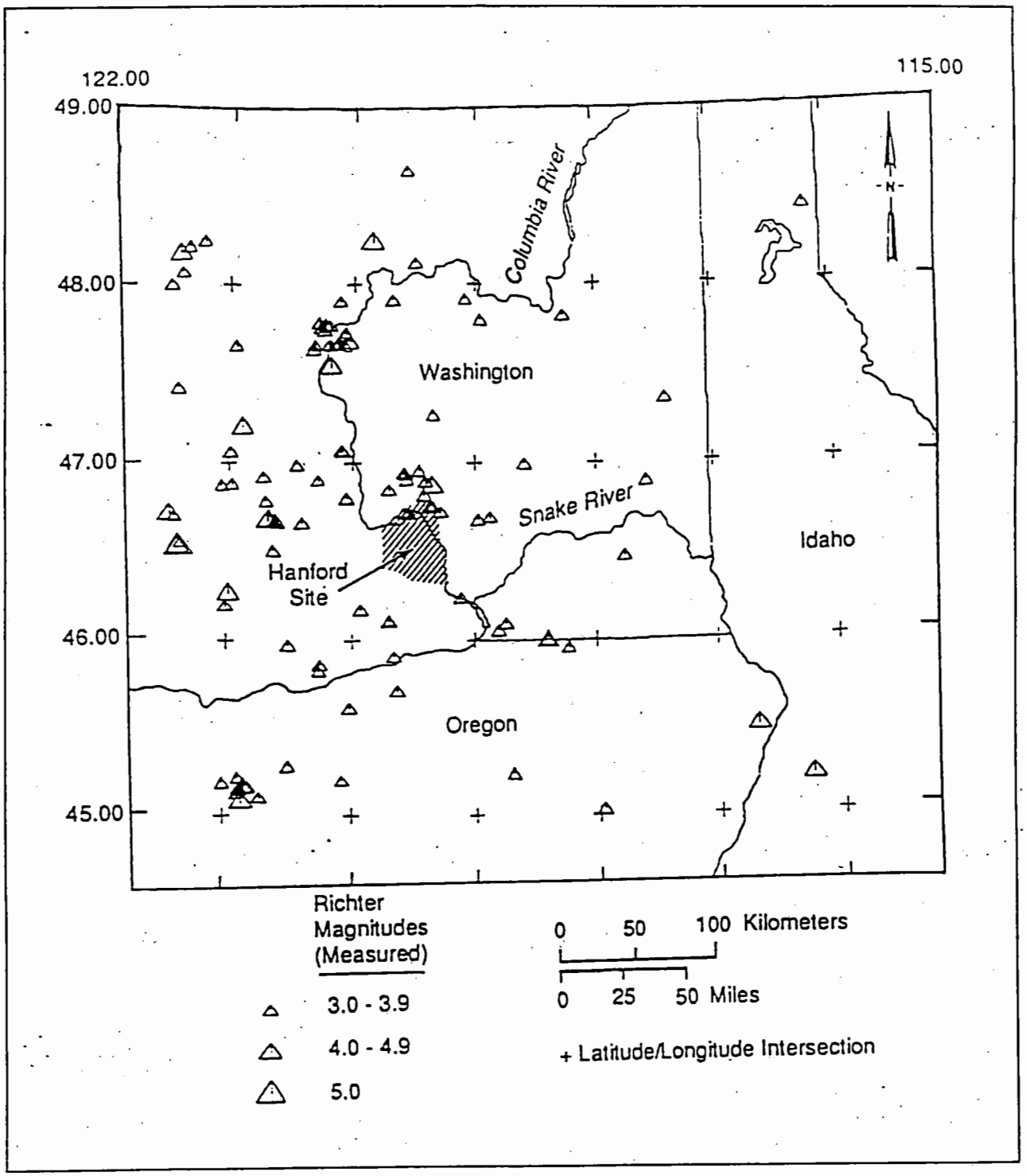


Figure 4-7. Recent Seismicity of the Columbia Plateau and Surrounding Areas as Measured by Seismographs (Cushing 1995).



Earthquakes in the central Columbia Plateau also occur to depths of about 30 km (18 mi). These deeper earthquakes are less clustered and occur more often as single, isolated events. Based on seismic refraction surveys in the region, the shallow earthquake swarms are occurring in the Columbia River Basalts, and the deeper earthquakes are occurring in crustal layers below the basalts.

4.1.5.2 Volcanic Hazards. Several major volcanoes are located in the Cascade Range, west of the Hanford Site. The nearest volcano, Mount Adams, is about 165 km (102 mi) from the Hanford Site, and the most active is Mount St. Helens, approximately 220 km (136 mi) west-southwest from the Hanford Site.

Because of their close proximity, the volcanic mountains of the Cascades are the principle volcanic hazard at the Hanford Site. The major concern is that ash fall might affect the Hanford Site's communications equipment and electronic devices, as well as the movement of truck and automobile traffic in and out of the area.

4.1.6 Soils

Hajek (1966) describes 15 different soil types on the Hanford Site, varying from sand to silty and sandy loam (Figure 4-8). Various classifications, including land use, also are given in Hajek (1966). The soil classifications given in Hajek (1966) have not been updated to reflect current reinterpretations of soil classifications. Until soils on the Hanford Site are resurveyed, the descriptions presented in Hajek (1966) will continue to be used (Table 4-1).

The parent material for predominant soil types at the Hanford Site consists of the Hanford formation and Holocene surficial deposits (Cushing 1992). Soils with well-developed profiles occur only where fine and poorly-drained sediments have been deposited, and typically are low in organic matter (PNL 1991a). Wind erosion has been a key factor in modifying developed soil profiles on the Hanford Site, resulting in the loss of soil down to parent material in some areas, and the creation of large active sand dunes in other areas of the Hanford Site.

4.1.6.1 Columbia River. The land areas along the Hanford Reach of the Columbia River (Hanford Reach) included in this geographic area are the numerous islands between the City of Richland and the Vernita Bridge, and shoreline areas along the river. The predominant soil types in this area are the Quincy sands (29%), Ephrata stony loam (18%), and river wash (41%). Other soil types occurring in this area include Burbank loamy sand, Ephrata sandy loam, Pasco silt loam, and dune sand.

4.1.6.2 Reactors on the River. The predominant soil types in this geographic area are Burbank loamy sand (34%), Ephrata sandy loam (23%), Ephrata stony loam (23%), and Quincy sand (17%). Other soil types include Pasco silt loam, Kiona silt loam, and river wash.

4.1.6.3 Central Plateau. The predominant soil types in this geographic area are Quincy sand (40%), Burbank loamy sand (39%), and Ephrata sandy loam (14%). Other soil types found on the Central Plateau are Kiona silt loam, Koehler sand, Hezel sand, and Esquatzel silt loam. Hajek (1966) reported that Quincy sand is one of the most widely distributed soil types on the Hanford Site. Active sand dunes on the Hanford Site are mapped as Quincy sand.

Figure 4-8. Soil Map of the Hanford Site (Cushing 1995).

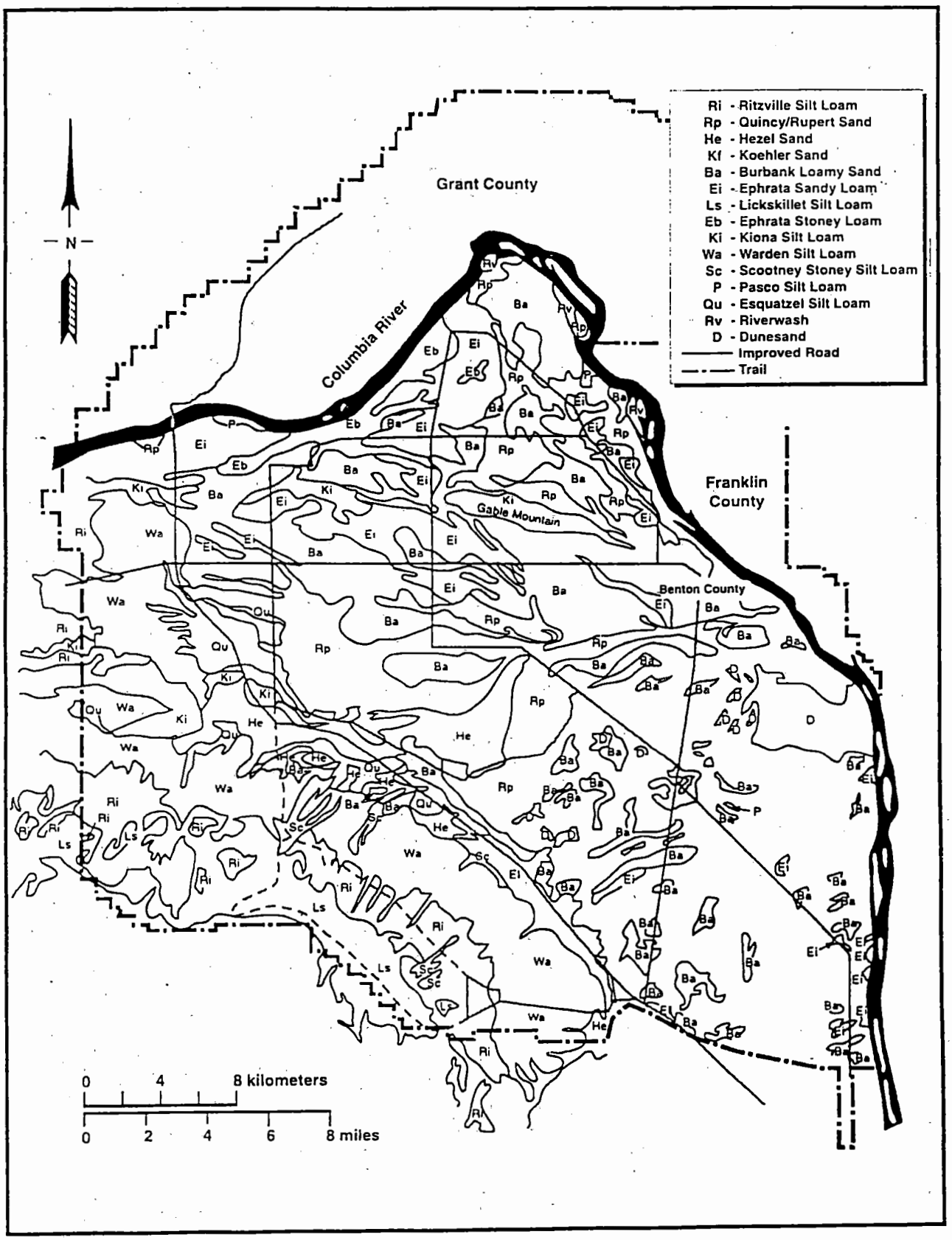


Table 4-1. Soil Types on the Hanford Site (Cushing 1995).

Name (symbol)	Description
Ritzville Silt Loam (Ri)	Dark-colored silt loam soils midway up the slopes of the Rattlesnake Hills. Developed under bunch grass from silty wind-laid deposits mixed with small amounts of volcanic ash. Characteristically greater than 150 cm (59 in.) deep, but bedrock may occur at less than 150 cm (59 in.) but greater than 75 cm (30 in.).
Rupert Sand (Rp)	One of the most extensive soils on the Hanford Site. Brown to grayish-brown coarse sand grading to dark grayish-brown at approximately 90 cm (35 in.). Developed under grass, sagebrush, and hopsage in coarse, sandy, alluvial deposits that were mantled by wind-blown sand. Hummocky terraces and dune-like ridges.
Hezel Sand (He)	Similar to Rupert sands; however, a laminated grayish-brown strongly calcareous silt loam subsoil usually is encountered within 100 cm (39 in.) of the surface. Surface soil is very dark brown and was formed in wind-blown sands that mantled lake-laid sediments.
Koehler Sand (Kf)	Similar to other sandy soils on the Hanford Site. Developed in a wind-blown sand mantle. Differs from other sands in that the sand mantles a lime-silica-cemented layer "hardpan." Very dark grayish-brown surface layer is somewhat darker than Rupert Sand. Calcareous subsoil usually is dark grayish-brown at approximately 45 cm (18 in.).
Burbank Loamy Sand (Ba)	Dark, coarse-textured soil underlain by gravel. Surface soil usually is 40 cm (16 in.) thick but can be 75 cm (30 in.) thick. Gravel content of subsoil ranges from 20 to 80%.
Kiona Silt Loam (Ki)	Located on steep slopes and ridges. Surface soil is very dark grayish-brown and approximately 10 cm (4 in.) thick. Dark brown subsoil contains basalt fragments 30 cm (12 in.) and larger in diameter. Many basalt fragments found in surface layer. Basalt rock outcrops present. A shallow stony soil normally occurring in association with Ritzville and Warden soils.
Warden Silt Loam (Wa)	Dark grayish-brown soil with a surface layer usually 23 cm (9 in.) thick. Silt loam subsoil becomes strongly calcareous at approximately 50 cm (20 in.) and becomes lighter in color. Granitic boulders are found in many areas. Usually greater than 150 cm (59 in.) deep.
Ephrata Sandy Loam (El)	Surface is dark colored and subsoil is dark grayish-brown medium-textured soil underlain by gravelly material, which may continue for many meters (feet). Level topography.
Ephrata Stony Loam (Eb)	Similar to Ephrata sandy loam. Differs in that many large hummocky ridges presently are made up of debris released from melting glaciers. Areas between hummocks contain many boulders several meters (feet) in diameter.
Scootney Stony Silt Loam (Sc)	Developed along the north slope of Rattlesnake Hills; usually confined to floors of narrow draws or small fan-shaped areas where draws open onto plains. Severely eroded with numerous basaltic boulders and fragments exposed. Surface soil usually is dark grayish-brown grading to grayish-brown in the subsoil.
Pasco Silt Loam (P)	Poorly drained, very dark grayish-brown soil formed in recent alluvial material. Subsoil is variable, consisting of stratified layers. Only small areas found on Hanford Site, located in low areas adjacent to the Columbia River.
Esquatzel Silt Loam (Qu)	Deep dark-brown soil formed in recent alluvium derived from loess and lake sediments. Subsoil grades to dark grayish-brown in many areas, but color and texture of the subsoil vary because of the stratified nature of the alluvial deposits.
Riverwash (Rv)	Wet, periodically flooded areas of sand, gravel, and boulder deposits that make up overflowed islands in the Columbia River and adjacent land.
Dune Sand (D)	Miscellaneous land type that consists of hills or ridges of sand-sized particles drifted and piled up by wind and are either actively shifted or so recently fixed or stabilized that no soil horizons have developed.
Lickskillet Silt Loam (Ls)	Located on ridge slopes of Rattlesnake Hills and slopes greater than 765 m (2,509 ft) elevation. Similar to Kiona series except surface soils are darker. Shallow over basalt bedrock, with numerous basalt fragments throughout the profile, suggests a location within a broad region between Lake Chelan, Washington, and the British Columbia border.

4.1.6.4 All Other Areas. The predominant soil types in this area are Quincy sand (50%) and Burbank loamy sand (24%). Other soil types occurring in this area include Ritzville silt loam, dune sand, Kiona silt loam, river wash, Pasco silt loam, Warden silt loam, Esquatzel silt loam, Ephrata sandy loam, Hezel sand, Koehler sand, and Ephrata stony loam.

4.2 Water Resources

This section provides an overview of the Hanford Site's hydrologic setting, which includes surface water and groundwater resources.

4.2.1 Surface Water

The Pasco Basin occupies about 4,900 km^2 (1,900 mi^2), and is located centrally within the Columbia Basin. Elevations within the Pasco Basin generally are lower than other parts of the Columbia Plateau, and surface drainage enters the Pasco Basin from other basins. Within the Pasco Basin, the Columbia River is joined by three major tributaries: the Yakima River, the Snake River, and the Walla Walla River.

A network of dams and multipurpose water resources projects is located along the course of the Columbia River. The principal dams are shown in Figure 4-9. Water storage behind Grand Coulee Dam, combined with storage upstream in Canada, totals 3.1×10^{10} m^3 (1.1×10^{12} ft^3) of usable storage to regulate the Columbia River for power, flood control, and irrigation.

The Hanford Site occupies approximately one-third of the land area within the Pasco Basin. Primary surface-water features associated with the Hanford Site are the Columbia and Yakima rivers. Several surface ponds and ditches are present, which are generally associated with fuel- and waste-processing activities. Several small spring-fed streams occur on the Fitzner/Eberhart Arid Lands Ecology (ALE) Reserve on the western side of the Hanford Site.

The flow of the Columbia River has been inventoried and described in detail by the U.S. Army Corps of Engineers (USACE) (DOE 1995). Flow along the Hanford Reach is controlled by the Priest Rapids Dam. Several drains and intakes are present along the Hanford Reach. These include irrigation outfalls from the Columbia Basin Irrigation Project and Hanford Site intakes for the onsite water export system.

Recorded flow rates of the Columbia River have ranged from 4,500 to 18,000 m^3 (~158,900 to 635,600 ft^3) per second during the runoff in spring and early summer, to 1,000 to 4,500 m^3 (35,300 to 158,900 ft^3) per second during the low flow period of late summer and winter. The average annual Columbia River flow in the Hanford Reach, based on records from 65 years, is about 3,400 m^3 (120,100 ft^3) per second. Normal river elevations range from 120 m (394 ft) above mean sea level where the river enters the Hanford Site near Vernita, to 104 m (341 ft) where it leaves the site near the 300 Area. Vertical fluctuations of approximately 1.5 m (greater than 5 vertical ft) are not uncommon along the Hanford Reach (Cushing 1995). The width of the river varies from approximately 300 m to 1000 m (984 to 3281 ft) within the Hanford Site.

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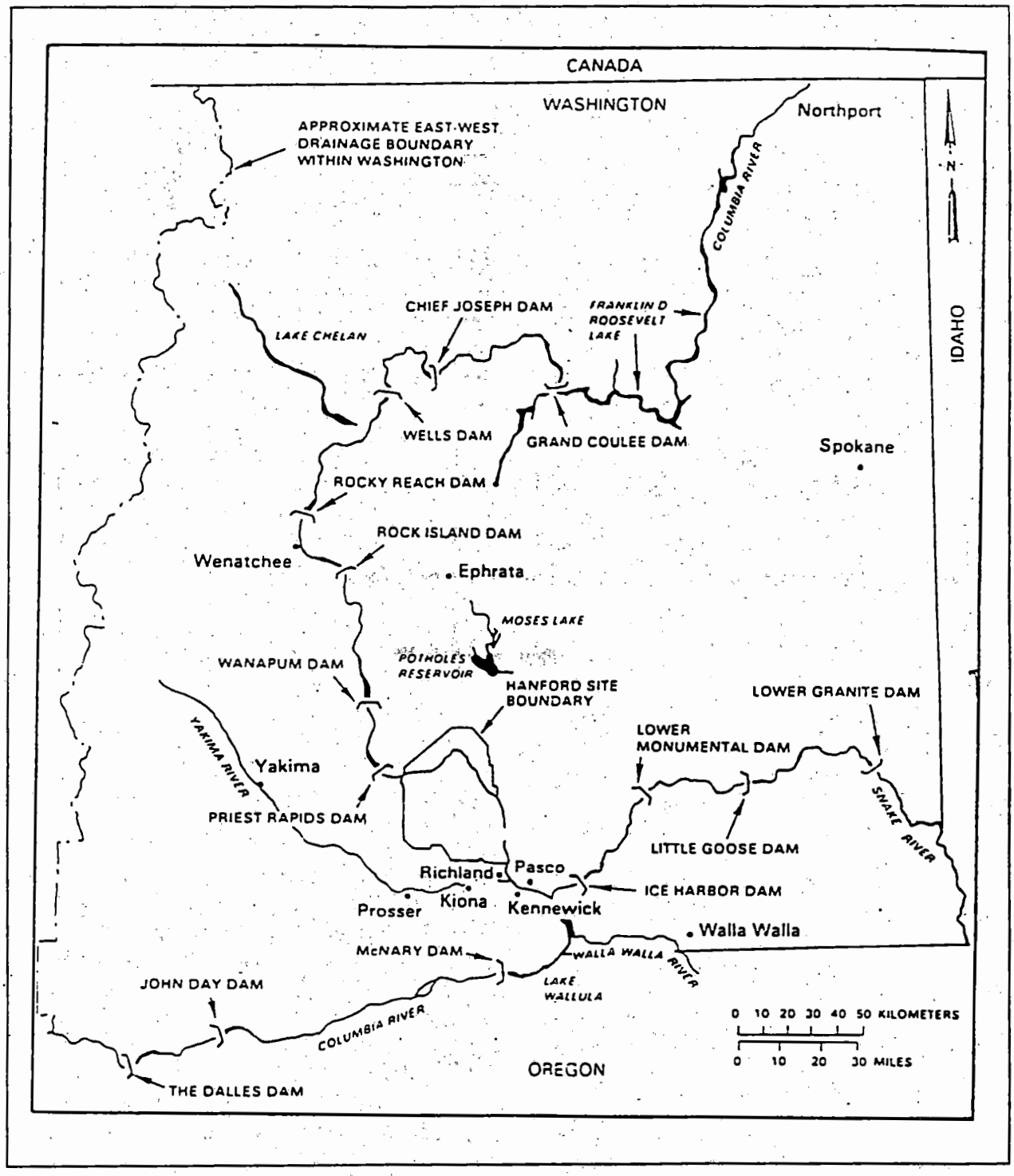
Figure 4-9. Location of Principal Dams Within the Columbia Plateau (Cushing 1995).



The Yakima River, bordering the southern portion of the Hanford Site, has a low annual flow compared to the Columbia River. For 57 years of record, the average annual flow of the Yakima River is about 104 m^3 (3,673 ft^3) per second with monthly maximum and minimum flows of 490 m^3 and 4.6 m^3 (162 ft^3 and 17,305 ft^3) per second, respectively.

Cold Creek and its tributary, Dry Creek, are ephemeral streams within the Yakima River drainage system along the southern boundary of the Hanford Site. Both streams drain areas to the west of Hanford Site.

Surface flow, when it occurs, infiltrates and disappears into the surface sediments in the western part of the Hanford Site. Rattlesnake Springs, located on the western part of the site, forms a small surface stream that flows for about 3 km (1.8 m) before disappearing into the ground.

West Lake is located north of the 200 East Area and is recharged from groundwater (Cushing 1995). West Lake has not received direct effluent discharges from Hanford Site facilities; rather, its existence is caused by the intersection of the elevated water table with the land surface in the topographically low area south of Gable Mountain (and north of the 200 East Area). The artificially elevated water table occurs under much of the Hanford Site and reflects the artificial recharge from Hanford Site operations.

The seepage of groundwater, or springs, into the Columbia River has been known to occur for many years. Riverbank spring discharges were documented along the Hanford Reach long before Hanford operations began during the Second World War (Cushing 1995). These relatively small springs flow intermittently, apparently influenced primarily by changes in river level. Hanford-origin contaminants have been documented in these groundwater discharges along the Hanford Reach (Cushing 1995).

In the 200 West Area, the West Powerhouse Pond, the 216-T-1 Ditch, the 216-T-4-2 Ditch, and the 216-Z-21 Basin are active. In the 200 East Area, only the East Powerhouse Ditch and the 216-B-3C Pond are active. The 216-B-3C Pond originally was excavated in the mid-1950s for disposal of process cooling water and other liquid wastes occasionally containing low levels of radionuclides. The Fast Flux Test Facility (FFTF) Pond is located near the 400 Area, and was excavated in 1978 for the disposal of cooling and sanitary water from various facilities in the 400 Area (Cushing 1995).

The ponds are not accessible to the public, and did not constitute a direct offsite environmental impact during 1993 (Cushing 1995). However, the ponds are accessible to migratory waterfowl, creating a potential pathway for the dispersion of contaminants. Periodic sampling provides an independent check on effluent control and monitoring systems (Cushing 1995).

Other than rivers and springs, no naturally occurring bodies of surface water are present on the Hanford Site. However, artificial wetlands, caused by irrigation, exist on the North Slope, which lies north of the Columbia River. Hatcheries and canals associated with the Columbia Basin Irrigation Project constitute the only other artificial surface water expressions in the area. The Ringold Hatchery is the only local hatchery and is located just south of the Hanford Site boundary on the east side of the Columbia River (just northeast of the 300 Area).

Total estimated precipitation over the Pasco Basin is about 9×10^8 m^3 annually, averaging less than 20 cm/yr (approximately 8 in./yr). Mean annual runoff from the Pasco Basin is estimated at less than 3.1×10^7 m^3/yr, or approximately 3% of the total precipitation. The basin-wide runoff

coefficient is zero for all practical purposes. The remaining precipitation is assumed to be lost through evaporation, with less than 1% recharging the groundwater system. However, studies suggest that precipitation may contribute recharge to the groundwater in areas where soils are coarse-textured and bare of vegetation (Cushing 1995).

4.2.1.1 Flooding. Large Columbia River floods have occurred in the past, but the likelihood of recurrence of large-scale flooding has been reduced by the construction of several flood control/water storage dams upstream of the Hanford Site. Major floods on the Columbia River typically result from rapid melting of the winter snowpack over a wide area augmented by above-normal precipitation. The maximum historical flood on record occurred June 7, 1894, with a peak discharge at the Hanford Site of 21,000 m^3 (742,000 ft^3) per second. The floodplain associated with the 1894 flood is shown in Figure 4-10. The largest recent flood took place in 1948 with an observed peak discharge of 20,000 m^3 (706,280 ft^3) per second at the Hanford Site (Cushing 1995).

The Federal Emergency Management Agency has not prepared floodplain maps for the Hanford Reach because that Agency prepares maps only for developing areas (a criteria that specifically excludes the Hanford Reach).

Evaluation of flood potential is conducted, in part, through the concept of the probable maximum flood, determined from the upper limit of precipitation falling on a drainage area and other hydrologic factors, such as antecedent moisture conditions, snowmelt, and tributary conditions, that could result in maximum runoff. The probable maximum flood for the Columbia River below Priest Rapids Dam has been calculated to be 40,000 m^3 (1.4 million ft^3) per second (Figure 4-11) and is greater than the 500-year flood. This flood would inundate parts of the 100 Areas located adjacent to the Columbia River, but the central portion of the Hanford Site would remain unaffected (Cushing 1995). Floodplains issues are further discussed in Appendix J, Floodplain/Wetlands Assessment, in accordance with 10 *Code of Federal Regulations* (CFR) 1022.

The USACE has derived the Standard Project Flood with both dam-regulated and -unregulated peak discharges given for the Columbia River below Priest Rapids Dam (Cushing 1995). The regulated Standard Project Flood for this part of the river is given as 15,200 m^3 (54,000 ft^3) per second and the 100-year regulated flood as 12,400 m^3 (440,000 ft^3) per second.

Potential dam failures on the Columbia River have been evaluated (Cushing 1995). Upstream failures could arise from a number of causes, with the magnitude of the resulting flood depending on the degree of breaching at the dam. The USACE evaluated a number of scenarios on the effects of failures of Grand Coulee Dam, assuming flow conditions of 11,000 m^3 (400,000 ft^3) per second. For purposes of emergency planning, they hypothesized that 25% and 50% breaches (the instantaneous disappearance of 25% or 50% of the center section of the dam) would result from the detonation of nuclear explosives in sabotage or war. The discharge or floodwave resulting from such an instantaneous 50% breach at the outfall of the Grand Coulee Dam was determined to be 600,000 m^3 (21 million ft3) per second. In addition to the areas inundated by the probable maximum flood (Figure 4-11), the remainder of the 100 Areas, the 300 Area, and nearly all of Richland, Washington, would be flooded (Cushing 1995). Determinations were not made for failures of dams upstream, for associated failures downstream of Grand Coulee, or for breaches greater than 50% of Grand Coulee. This is because the 50% scenario was believed to represent the largest realistically conceivable flow resulting from either a natural or human-induced breach (DOE 1995); that is, it was not considered credible that a structure as large as the Grand Coulee Dam would be 100% destroyed instantaneously.

Figure 4-10. Flood Area During the 1894 Flood (Cushing 1995).

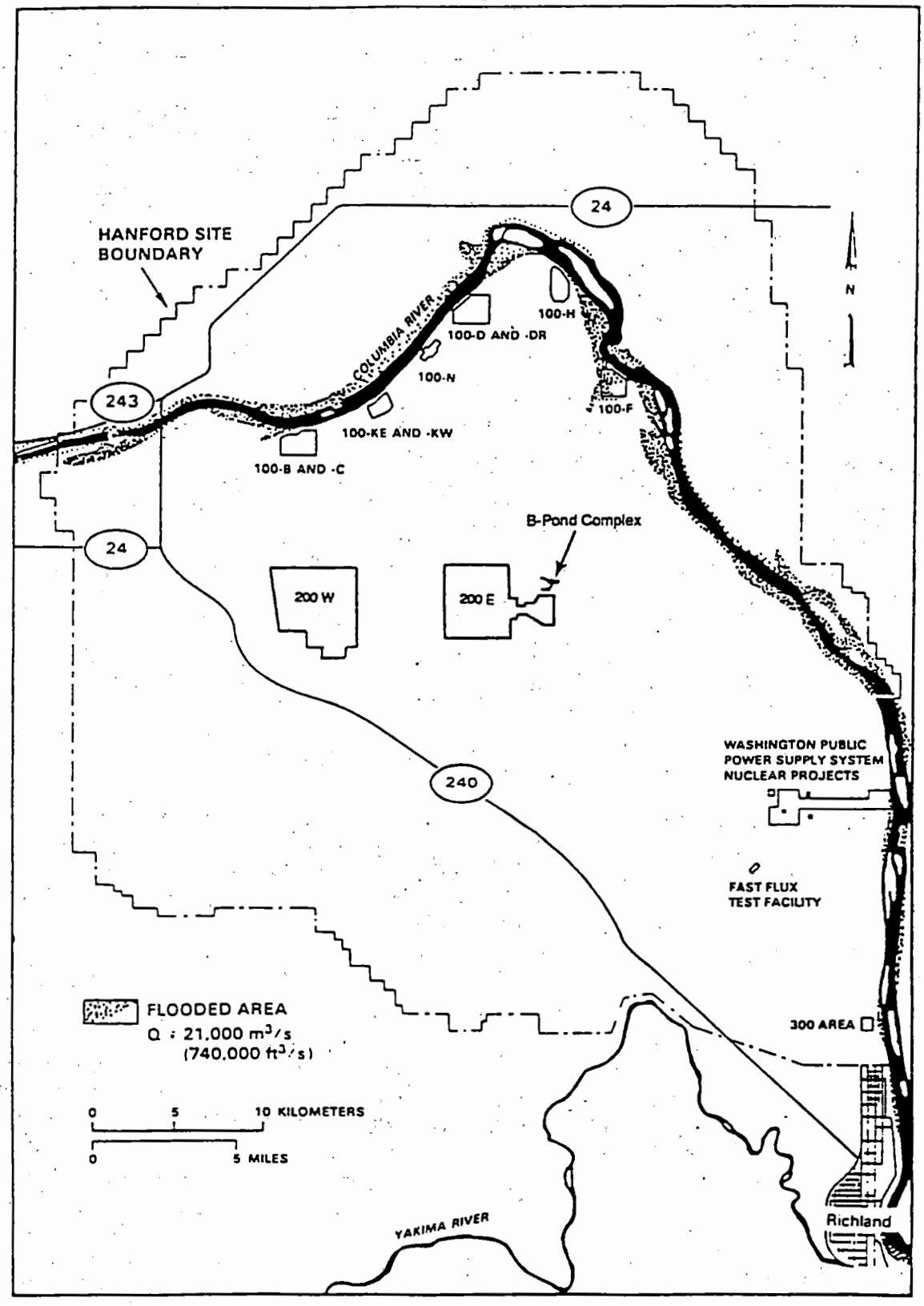
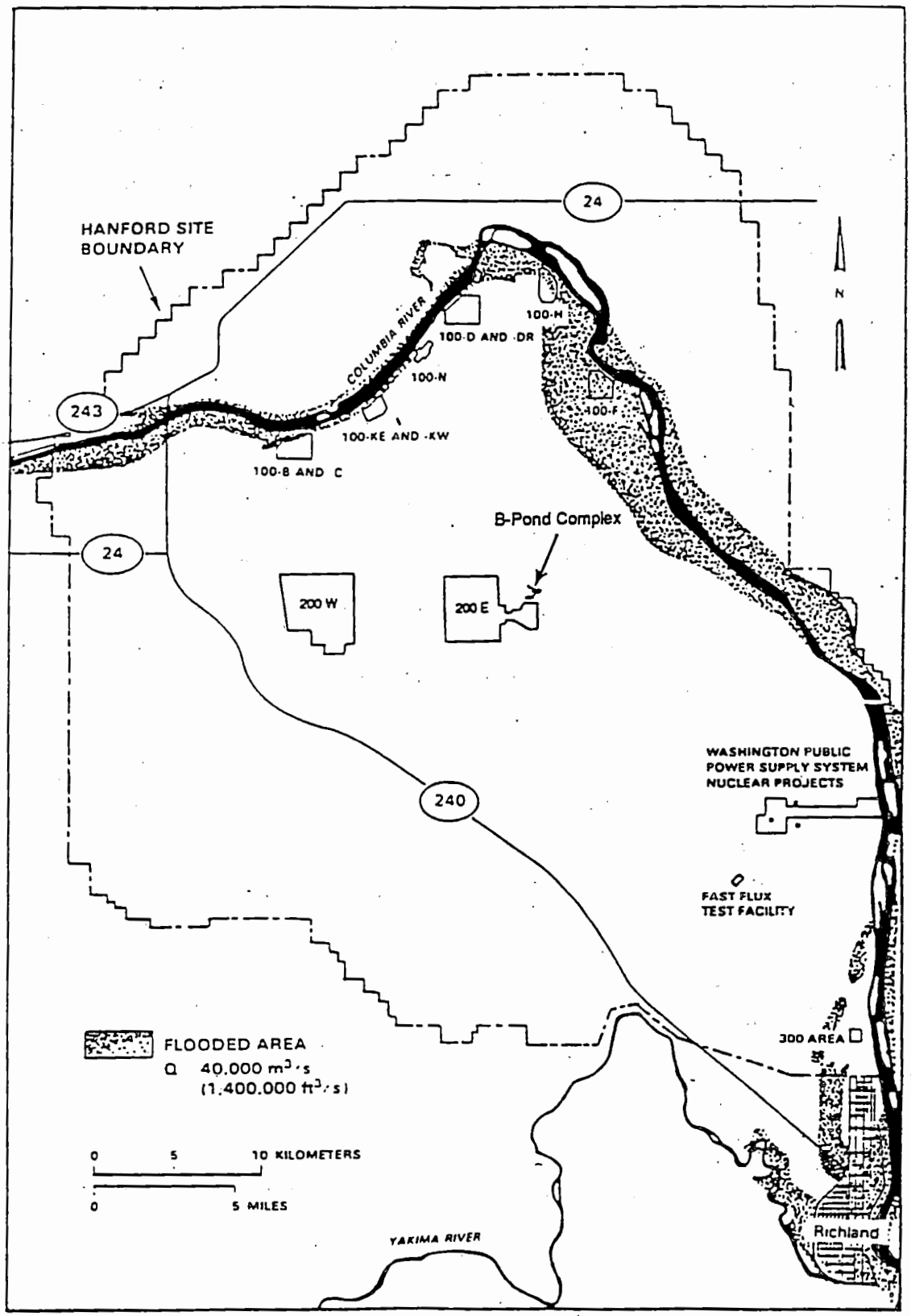


Figure 4-11. Flood Area for the Probable Maximum Flood (Cushing 1995).



It also was assumed that such a scenario as the 50% breach would occur only as the result of direct explosive detonation, not because of a natural event such as an earthquake. Even a 50% breach under these conditions would indicate an emergency situation where other overriding major concerns might be present.

The possibility of a landslide resulting in river blockage and flooding along the Columbia River also has been examined for an area bordering the east side of the river upstream from the City of Richland (Cushing 1995). The possible landslide area considered was the 75-m (250-ft) -high bluff (generally known as White Bluffs). Calculations were made for an 8 x 10^5 m^3 (1 x 10^6 yd^3) landslide volume with a concurrent flood flow of 17,000 m^3 (600,000 ft^3) per second (a 200-year flood) resulting in a flood wave crest elevation of 122 m (400 ft) above mean sea level. Areas inundated upstream from such a landslide event would be similar to those shown in Figure 4-11.

A flood risk analysis of Cold Creek was conducted in 1980 as part of the characterization of a geologic repository for high-level radioactive waste. Such design work is usually done to the criteria Standard Project Flood or Probable Maximum Flood rather than the worst case or 100-year flood scenario. Therefore, in lieu of 100- and 500-year floodplain studies, a probable maximum flood evaluation was made for a reference repository location directly west of the 200 East Area and encompassing the 200 West Area (Cushing 1995). Figure 4-12 shows the extent of this probable maximum flood.

4.2.1.2 Surface Water Quality. The Washington State Department of Ecology (Ecology) classifies the Columbia River as Class A (excellent) between Grand Coulee Dam and the mouth of the river near Astoria, Oregon (Cushing 1995). Class A waters are to be suitable for essentially all uses, including drinking water, recreation, and wildlife habitat. State and federal drinking water standards apply to the Columbia River, and are currently being met.

Pacific Northwest National Laboratory conducts routine monitoring of the Columbia River for both radiological and nonradiological water quality parameters. A yearly summary of results has been published since 1973 (PNL 1995a). Numerous other water quality studies have been conducted on the Columbia River relative to the impact of the Hanford Site during the past 37 years. Three outfalls currently are covered by National Pollutant Discharge Elimination System (NPDES) permits at the Hanford Site: at the 100-K and 100-N Areas, and at the 300 Area. These discharge locations are monitored for various measures of water quality, including nonradioactive and radioactive pollutants. The estimated dose from radionuclide releases is presented in the *Hanford Site Environmental Report for Calendar Year 1994* (PNL 1995a). In 1994, monitored liquid discharges resulted in a dose of 0.011 mrem to the downstream maximally exposed individuals (PNL 1995a).

Radiological monitoring shows low levels of radionuclides in samples of Columbia River water. Although radionuclides associated with Hanford operations continued to be identified in Columbia River water in 1994, concentrations remained low at all monitoring locations and were well below applicable standards (PNL 1995a). Tritium, iodine-129, and uranium concentrations downstream of the Hanford Site are found to be slightly higher than upstream, but were well below concentration guidelines established by DOE and U.S. Environmental Protection Agency (EPA) drinking water standards (Table 4-2). In 1994, the average annual strontium-90 concentrations were essentially the same at Priest Rapids Dam (upstream of the Hanford Site) and at the Richland Pumphouse (PNL 1995a).

Figure 4-12. Extent of the Probable Maximum Flood in the Cold Creek Area (Cushing 1995).

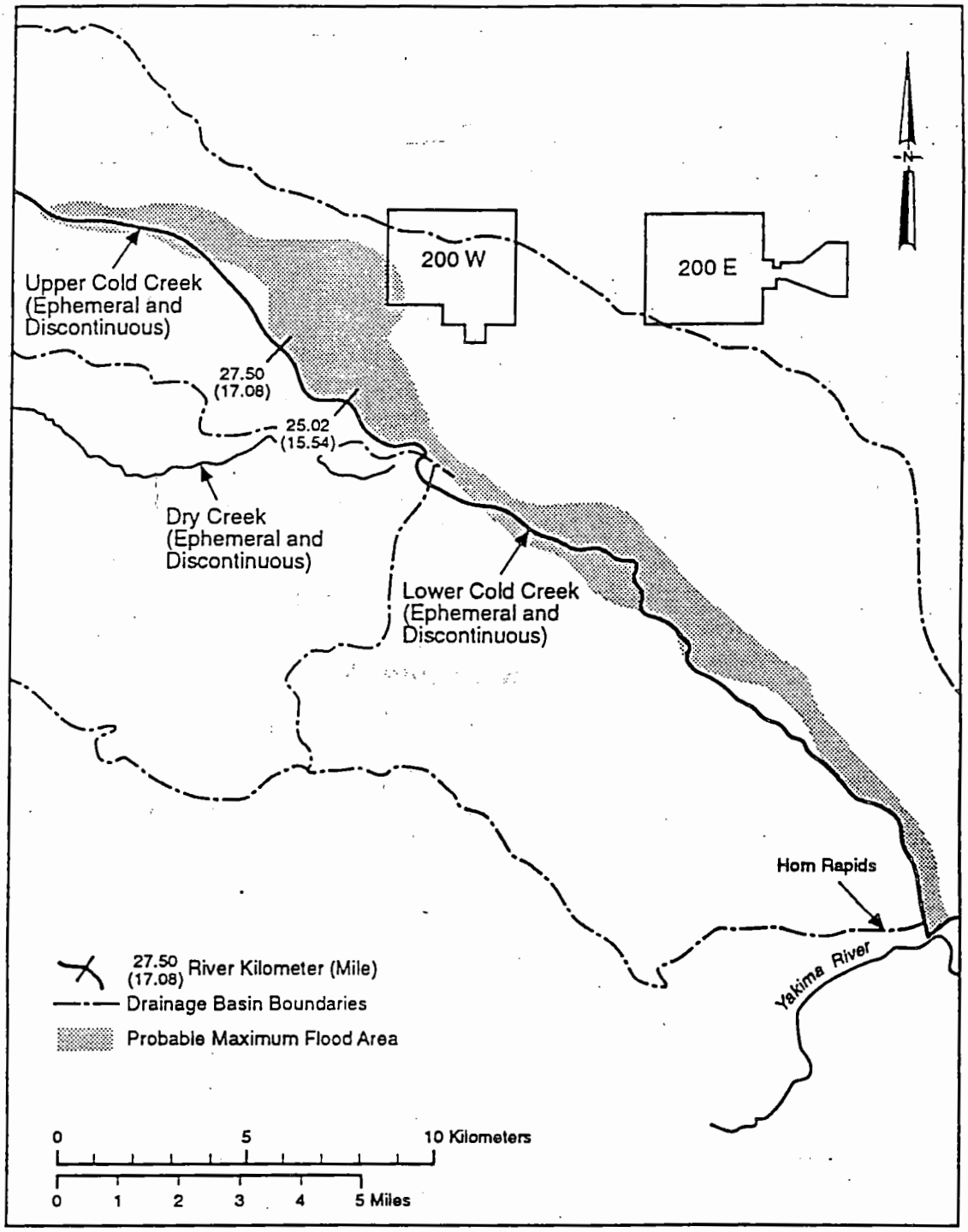


Table 4-2. Annual Average Concentrations of Radionuclides in Columbia River (PNL 1995a).

Radionuclides	Water concentrations (pCi/L)		
	Upstream Concentration (Priest Rapids Dam)	Downstream Concentration (Richland Pumphouse)	EPA Drinking Water Standard
H-3	38	87	20,000
Sr-90	0.09	0.09	8.0
U	0.42	0.49	20.0*
Tc-99	0.02	0.05	900
I-129	4.3×10^{-5}	7.7×10^{-5}	0.48

*Proposed.

For nonradiological water quality parameters measured in Columbia River water during 1994, metals and anions were generally similar upstream and downstream and in compliance with applicable primary drinking water standards. Volatile organic compounds (VOC) were generally less than regulatory standards (PNL 1995a).

4.2.2 Groundwater

The following sections describe the groundwater and hydrology of the Hanford Site. A generalized cross-section of the Hanford Site groundwater is presented in Figure 4-13. Water table elevations for the unconfined aquifer are presented in Figure 4-14.

4.2.2.1 Groundwater Hydrology. The multi-aquifer system within the Pasco Basin has been conceptualized as consisting of four geohydrologic units: (1) the Grande Ronde Basalt; (2) Wanapum Basalt; (3) Saddle Mountain Basalt; and (4) suprabasalt Hanford and Ringold formation sediments. Geohydrologic units older than the Grande Ronde Basalt probably are of minor importance to the regional hydrologic dynamics and system. Together, the Grande Ronde, Wanapum, and Saddle Mountain Basalts compose the Columbia River Basalt group.

The Grande Ronde Basalt is the most voluminous and widely spread formation within the Columbia River Basalt group, and has a thickness of at least 2,745 m (9,000 ft). The Grande Ronde Basalt geohydrologic unit is composed of the Grande Ronde Basalt and minor intercalated sediments equivalent to or part of the Ellensburg Formation (DOE 1988). More than 50 flows of Grande Ronde Basalt underlie the Pasco Basin, but little is known of the lower 2,200 to 2,500 m (7,216 to 8,200 ft) of this geohydrologic unit. This unit is a confined-to-semiconfined flow system that is recharged along the margins of the Columbia Plateau where the unit is at or close to the land surface, and by surface-water and groundwater inflow from lands adjoining the plateau. Vertical movement into and out of the unit is known to occur. Groundwater within the unit in the eastern Pasco Basin is believed to be derived from groundwater inflow from the east and northeast.

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Figure 4-13. Geologic Cross Section of the Hanford Site (PNL 1995b).

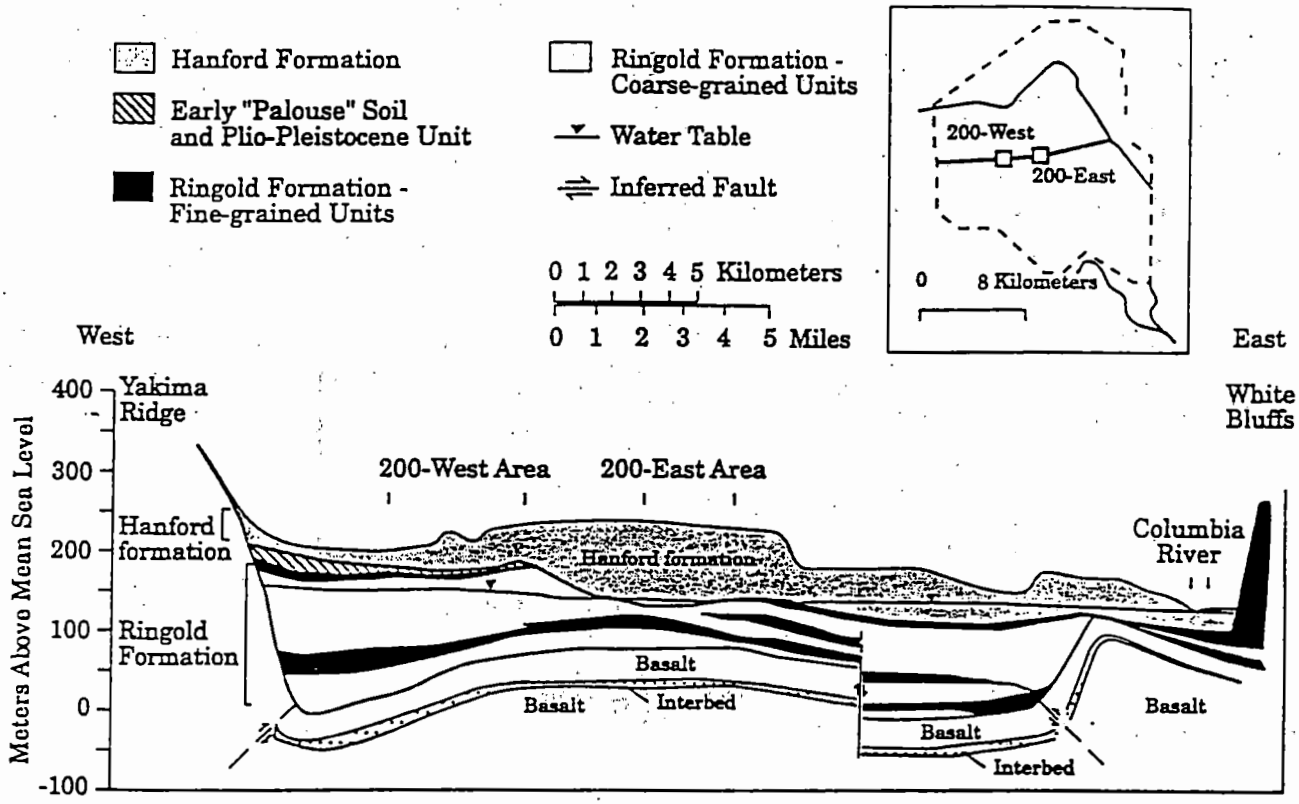
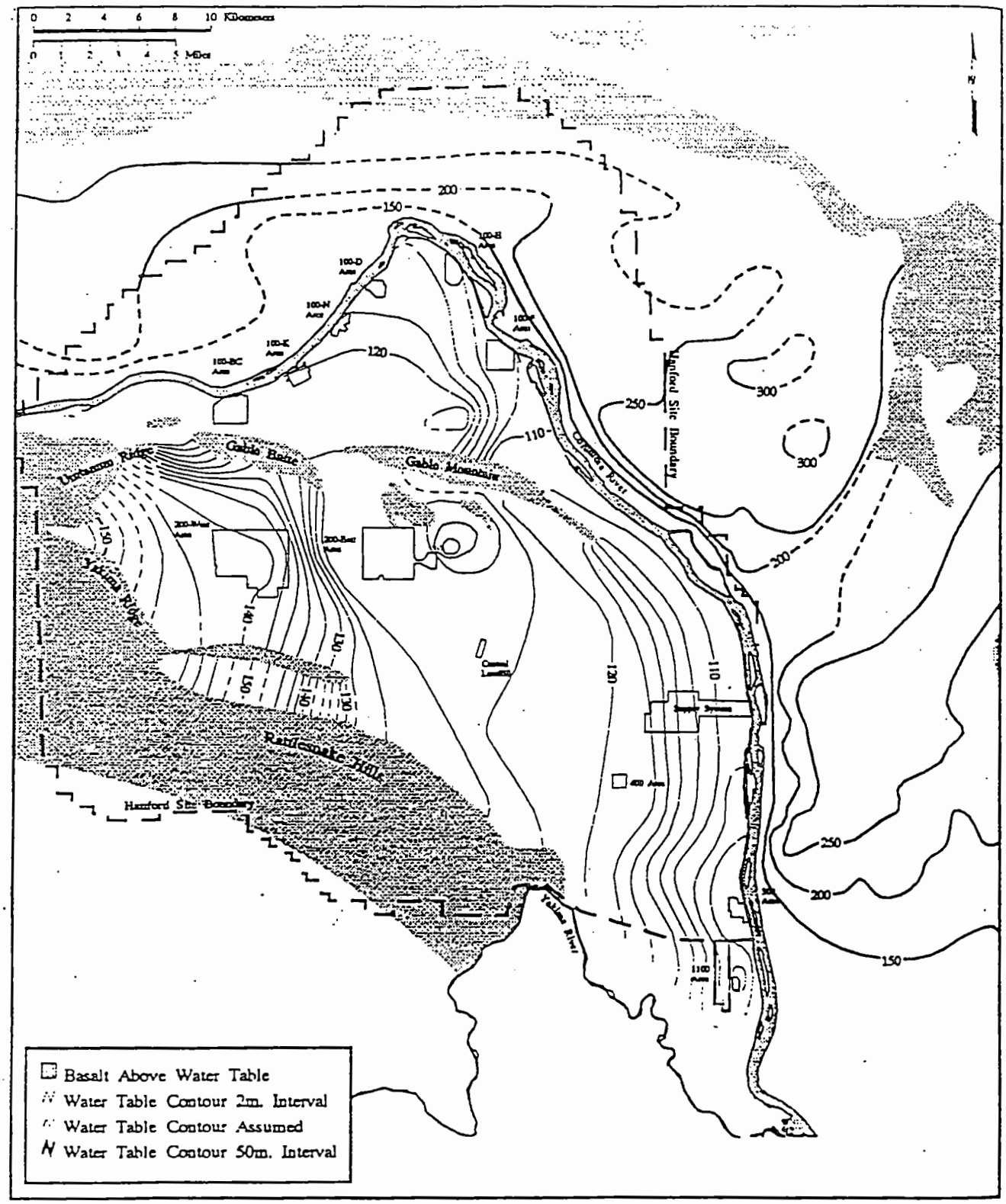


Figure 4-14. Water-Table Elevations for the Unconfined Aquifer at Hanford (Cushing 1995).



The Wanapum Basalt geohydrologic unit consists of basalt flows intercalated with minor and discontinuous sedimentary interbeds of the Ellensburg Formation or equivalent sediments. In the Pasco Basin, the Wanapum Basalt consists of three members, each consisting of multiple flows. The geohydrologic unit underlies the entire Pasco Basin and has a maximum thickness of 370 m (1,215 ft). Groundwater within the Wanapum Basalt geohydrologic unit is confined to semiconfined. Recharge is believed to occur from precipitation where the Wanapum Basalt is not overlain by great thicknesses of younger basalt, leakage from adjoining formations, and surface-water and groundwater inflow from lands adjoining the plateau. Local recharge is derived from irrigation. Within the Pasco Basin, recharge occurs along the anticlinal ridges to the north and west, with recharge in the eastern basin being from groundwater inflow from the east and northeast (DOE 1988). Interbasin transfer and vertical leakage are also believed to contribute to the recharge.

The Saddle Mountain Basalt geohydrologic unit is composed of the youngest formation of the Columbia River Basalt group and several thick sedimentary beds of the Ellensburg Formation or equivalent sediments that comprise up to 25% of the unit. Within the Pasco Basin, the Saddle Mountain Basalt contains seven members, each with one or more flows. This geohydrologic unit underlies most of the Pasco Basin, attaining a thickness of about 290 m (950 ft), but is absent along the northwest part of the basin and along some anticlinal ridges. Groundwater in the Saddle Mountain geohydrologic unit is confined to semiconfined, with recharge and discharge believed to be local (DOE 1988).

The rock materials that overlie the basalts in the structural and topographic basins within the Columbia Plateau generally consist of Miocene-Pliocene sediments, volcanics, Pleistocene sediments (including those from catastrophic flooding), and Holocene sediments consisting mainly of alluvium and eolian deposits. The suprabasalt geohydrologic unit (referred to as the Hanford/Ringold unit) consists principally of the Miocene-Pliocene Ringold Formation stream, lake, and alluvial materials, and the Pleistocene catastrophic flood deposits informally called the Hanford formation. Groundwater within the suprabasalt geohydrologic unit is generally unconfined, with recharge and discharge usually coincident with topographic highs and lows (DOE 1988). The Hanford/Ringold unit is essentially restricted to the Pasco Basin with principal recharge occurring along the periphery of the basin from precipitation and ephemeral streams.

Little if any natural recharge occurs within the Hanford Site, but artificial recharge occurs from liquid waste disposal activities (PNL 1995a). Recharge from irrigation occurs east and north of the Columbia River and in the synclinal valleys west of the Hanford Site. Upward leakage from lower aquifers into the unconfined aquifer is believed to occur in the northern and eastern sections of the Hanford Site. Groundwater discharge is primarily to the Columbia River.

Groundwater under the Hanford Site occurs under unconfined and confined conditions. The unconfined aquifer is contained within the glaciofluvial sands and gravels of the Hanford formation and within the Ringold Formation. It is dominated by the middle member of the Ringold Formation, consisting of sands and gravels with varying amounts of cementation. The bottom of the unconfined aquifer is the basalt surface or, in some areas, the clay zones of the Lower Ringold. A semiconfined aquifer occurs in areas where the coarse-grained Basal Ringold lies between the basalt and the fine-grained Lower Ringold. The confined aquifers consist of sedimentary interbeds and/or interflow zones that occur between dense basalt flows in the Columbia River Basalt group. The main water-bearing portions of the interflow zones occur within a network of interconnecting vesicles and fractures of the flow tops or flow bottoms.

4.2.2.2 Groundwater Recharge. Sources of natural recharge to the unconfined aquifer are rainfall and runoff from the higher bordering elevations, water infiltrating from small ephemeral streams, and river water along influent reaches of the Yakima and Columbia rivers. In order to define the movement of water in the vadose zone, the movement of precipitation through the unsaturated (vadose) zone has been studied at several locations on the Hanford Site. Conclusions from these studies are varied depending on the location studied. Some investigators conclude that no downward percolation of precipitation occurs on the Central Plateau where soil texture is varied and is layered with depth, and that all moisture penetrating the soil is removed by evaporation. Others have observed downward water movement below the root zone in tests conducted near the 300 Area, where soils are coarse textured and precipitation was above normal (DOE 1987).

From the recharge areas to the west, the groundwater flows downgradient to the discharge areas, primarily along the Columbia River. This general west-to-east flow pattern is interrupted locally by the groundwater mounds in the 200 East and 200 West Areas. From the 200 East and 200 West Areas, a component of groundwater also flows to the north, between Gable Mountain and Gable Butte. These flow directions represent current conditions; the aquifer is dynamic, and responds to changes in natural and artificial recharge.

Local recharge to the shallow basalts is believed to result from infiltration of precipitation and runoff along the margins of the Pasco Basin. Regional recharge of the deep basalts is thought to result from interbasin groundwater movement originating northeast and northwest of the Pasco Basin in areas where the Wanapum and Grande Ronde Basalts crop out extensively (DOE 1995). Groundwater discharge from the shallow basalt is probably to the overlying unconfined aquifer and the Columbia River. Presently, the discharge area(s) for the deep groundwaters is uncertain, but flow is believed to be generally southeastward with discharge speculated to be south of the Hanford Site (DOE 1995).

4.2.3 Groundwater of Hanford Site Geographic Areas

The following sections describe the groundwater in each of the four geographic areas of the Hanford Site.

4.2.3.1 Reactors on the River. A generalized hydrogeologic column for the Reactors on the River geographic area is shown on Figure 4-15. This representation was developed for the 100-N Area, but the basic units generally are found in the other areas as well. The major hydrostratigraphic units are the Rattlesnake Ridge interbed, Elephant Mountain Basalt Member, Ringold Formation, and Hanford formation (WHC 1991b). Two semiconfined water-bearing intervals are found in the generally unconfined Hanford and Ringold-dominated uppermost aquifer system. The aquifer in the basalts is a confined system.

The Rattlesnake Ridge interbed is the uppermost confined aquifer; it consists of tuffaceous siltstone and sandstone. Aquifers below the Rattlesnake Ridge interbed are considered less significant to environmental remediation issues because their generally upward hydraulic gradients prevent downward migration of contaminants. Potentiometric data are not available for the interbed in this area, but there is an upward hydraulic gradient between the Rattlesnake Ridge interbed and the uppermost aquifer system at other locations at the Hanford Site. The Elephant Mountain Basalt Member forms the confining layer above the Rattlesnake Ridge interbed. Both the Rattlesnake Ridge interbed aquifer and the Elephant Mountain Member confining layer are found throughout this area.

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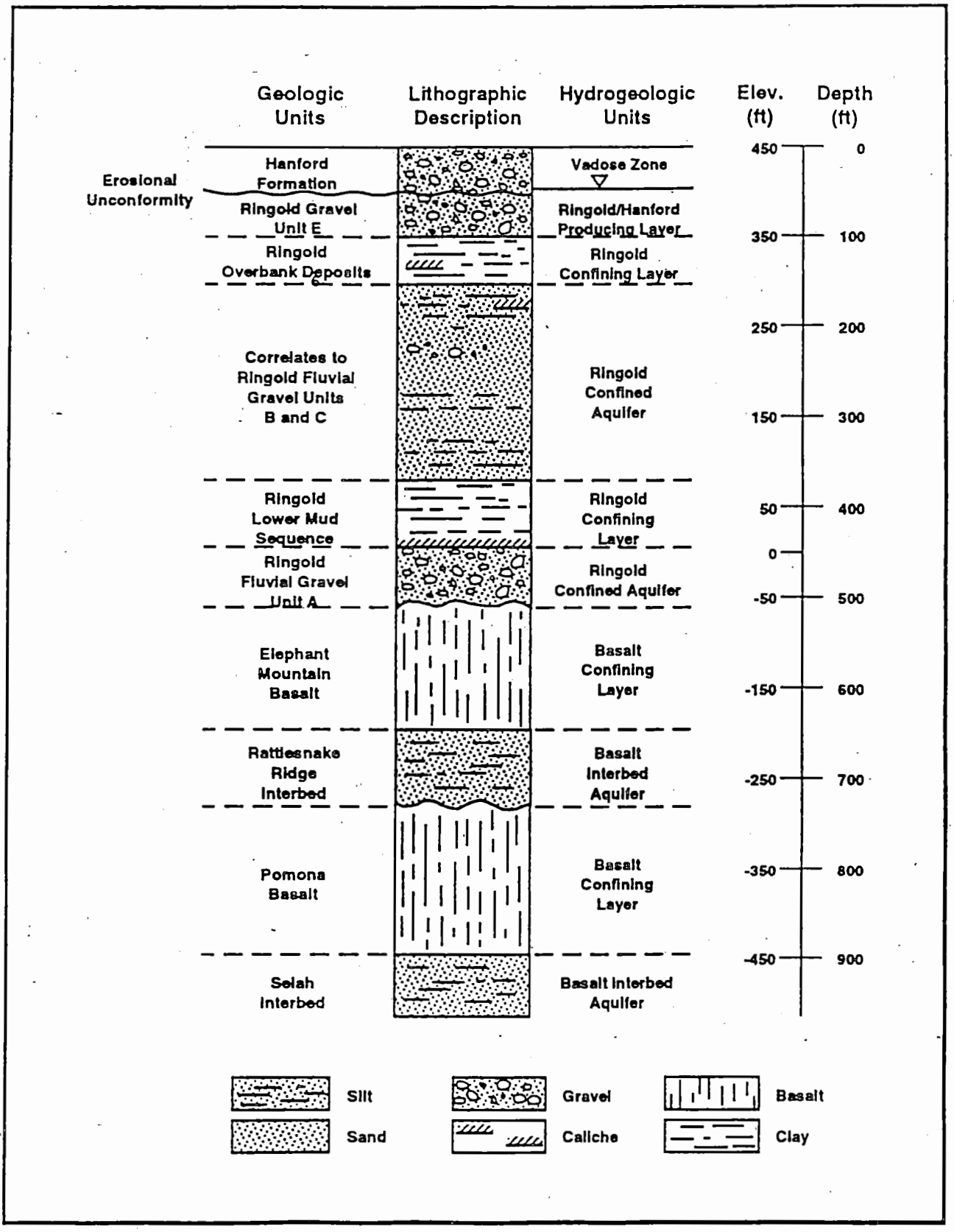
Figure 4-15. Generalized Stratigraphic and Hydrologic Column for the Reactors on the River Geographic Area (WHC 1991b).



The uppermost aquifer system consists of five hydrostratigraphic units (see Figure 4-15). The lowest unit in the uppermost aquifer system consists of Ringold fluvial gravel unit A, which lies unconformably on the Elephant Mountain Member. Unit A consists of interbedded sand and cobbles with some caliche layers. Unit A is not found at the 100-F, 100-H, or 100-D Areas. The confining layer above unit A consists of interbedded clay and silt assigned to the lower mud sequence of the Ringold Formation. These fine-grained sediments are continuous across this geographic area.

Layers of silty sand to sandy silt, equivalent to Ringold gravel units B and C, form the third hydrostratigraphic unit, a confined aquifer. This unit contains alternating lithologies that suggest the possibility of alternating producing and confining layers. The unit becomes coarser toward the southwest near the 100-K and 100-B/C Areas and finer toward the southeast in the vicinity of the 100-H and 100-F Areas. The fourth hydrostratigraphic unit is a confining interval that consists of interbedded overbank clay and silt with occasional sand layers.

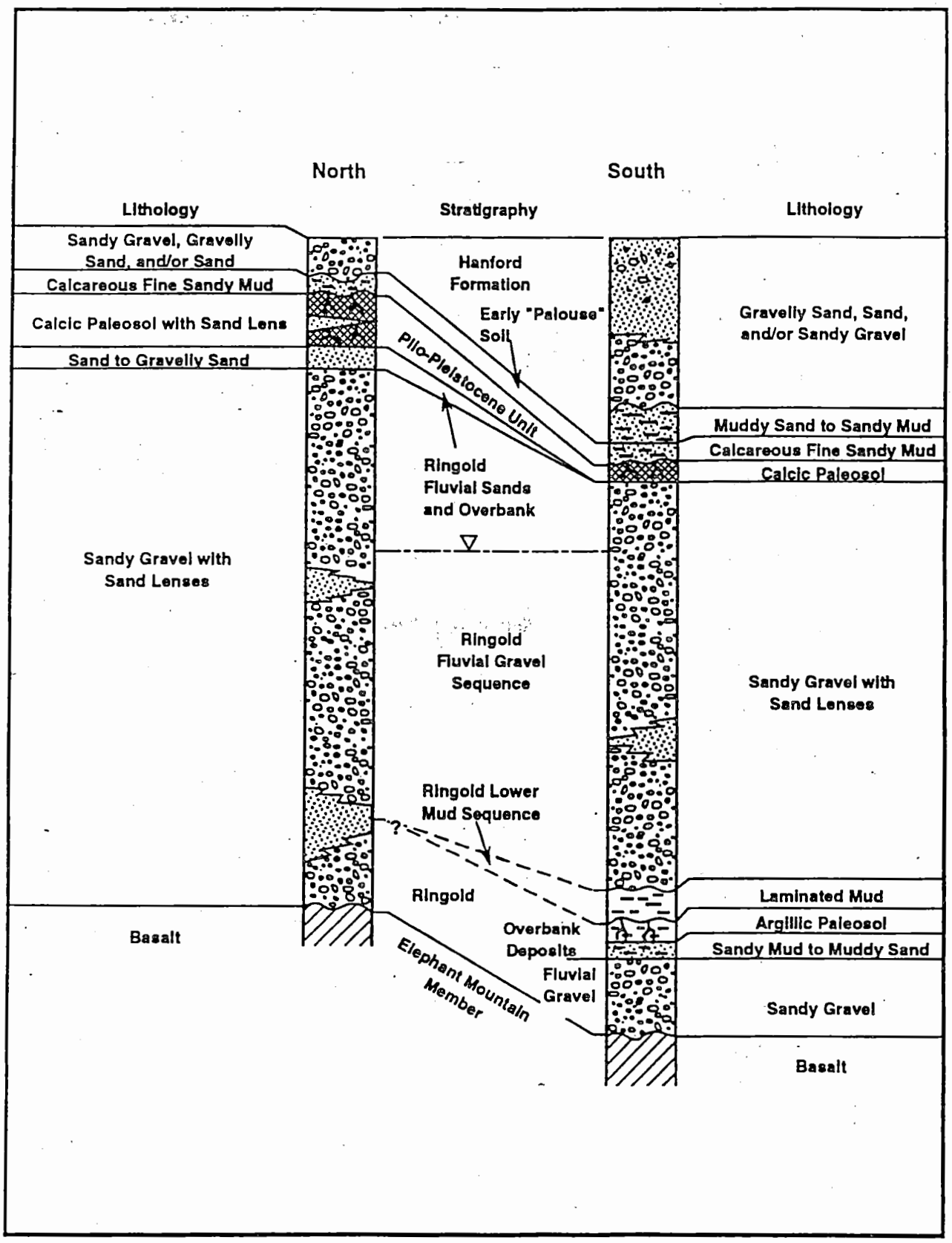
The uppermost hydrostratigraphic unit is unconfined, and occurs in the fluvial gravels of Ringold unit E and locally in the bottom few feet of the Hanford formation. In the vicinity of the 100-H and 100-F Areas, Ringold unit E is absent; the upper hydrostratigraphic unit consists entirely of Hanford gravels. Channels and other erosional features are cut into the top of the Ringold Formation. These channels are filled by higher-permeability Hanford deposits, and may act as preferred pathways for groundwater movement.

Flow direction within this area generally is toward the Columbia River. Groundwater gradients and flow directions were influenced in the past by groundwater mounds (resulting from discharge of reactor effluent to the subsurface). With the shutdown of the reactors, all groundwater mounds have now dissipated. During elevated river stages, however, the flow is away from the river.

4.2.3.2 Central Plateau. A generalized representation of the stratigraphic and hydrogeologic setting of the Central Plateau is shown on Figure 4-16. The major hydrostratigraphic units in the Central Plateau are the Rattlesnake Ridge interbed, Elephant Mountain Basalt Member, Ringold Formation, Plio-Pleistocene unit and Early Palouse soil, and the Hanford Formation (WHC 1991b). Aquifers below the Rattlesnake Ridge interbed are considered less significant to environmental remediation issues than those closer to ground surface.

The uppermost confined aquifer beneath most of the Central Plateau consists of the Rattlesnake Ridge interbed, the overlying flow bottom of the Elephant Mountain Member, and the underlying flow top of the Pomona Member. North of the 200 East Area, the Elephant Mountain Member has been removed locally by erosion, allowing hydraulic communication between the underlying Rattlesnake Ridge interbed aquifer and the overlying uppermost aquifer system (RHO 1984). Where such erosional windows occur, the Rattlesnake Ridge interbed is no longer confined and the uppermost confined aquifer is the Selah interbed. Several basalt flows have been removed by erosion in the Gable Gap area (north of the Central Plateau), allowing hydraulic communication between highly conductive sediments of the uppermost aquifer system and the sedimentary interbeds below the Selah interbed.

Figure 4-16. Generalized Stratigraphic and Hydrologic Column for the Central Plateau (WHC 1991b).



The uppermost aquifer system in the Central Plateau occurs primarily within the sediments of the Ringold Formation and Hanford formation. In the 200 West Area, the upper aquifer is contained within the Ringold Formation and displays unconfined to locally confined or semiconfined conditions. In the 200 East Area, the upper aquifer occurs in the Ringold Formation and Hanford formation. Depth to groundwater in the upper aquifer ranges from approximately 57.9 m (190 ft) beneath the former U Pond in the 200 West Area to 103.6 m (340 ft) west of the 200 East Area. The saturated thickness of the unconfined aquifer ranges from approximately 67.2 to 112.2 m (220 to 368 ft) in the 200 West Area and approximately 61 m (200 ft) in the southern 200 East Area to near 0 m (0 ft) in the northeastern 200 East Area where the aquifer thins out and terminates against the basalt located above the water table.

Ringold sediments in the uppermost aquifer system in the 200 East Area are dominated by fluvial gravels of unit E that overlie the basalts of the Elephant Mountain Member. Significant silt- and clay-dominated intervals are absent except in the southwestern part of the 200 East Area and east of B Pond where the lower mud sequence is found. Sandy gravels dominate the Hanford formation in the uppermost aquifer system in the 200 East Area.

The uppermost aquifer system in the 200 West Area occurs primarily within the Ringold Formation. The lower part of the upper aquifer system consists of unit A and generally is confined by fine-grained sediments of the lower mud sequence. The lower mud sequence is absent in the northern portion of the 200 West Area, and a single, undifferentiated gravel sequence consisting of unit A and the overlying deposits of unit E is found. In this area, it is not possible to hydraulically differentiate unit A from unit E. The confining zone overlying unit A thins and pinches out in the eastern section of the 200 West Area. The upper part of the uppermost aquifer system in the 200 West Area is contained mostly within the fluvial gravel of unit E.

Only the Hanford formation is continuous throughout the vadose zone in the Central Plateau. The upper unit of the Ringold Formation, the Plio-Pleistocene unit, and the Early Palouse soil only occur in the 200 West Area. As much as 42.7 m (140 ft) of Ringold strata belonging to unit E occur above the water table in the 200 West Area. However, in the northern half of the 200 East Area, post-Ringold erosion has removed unit E as well as the entire Ringold Formation. Where this occurs, as well as where groundwater mounds caused by sustained discharge of wastewater are found, the vadose zone occurs entirely within the Hanford formation.

The uppermost aquifer system beneath the Central Plateau receives artificial recharge from liquid disposal areas. The major sources of artificial recharge in the Central Plateau have been three waste ponds designated U Pond in the 200 West Area, B Pond (east of the 200 East Area), and Gable Mountain Pond (north of the 200 East Area). Wastewater disposed to these ponds has formed groundwater mounds and increased the water table elevation by approximately 20 m (65 ft). U Pond was deactivated in 1984, and Gable Mountain Pond was decommissioned and backfilled in 1987. With no further recharge, the groundwater mounds associated with these two ponds have begun to decline and will continue to do so over the coming years. The volume of liquid discharged to B Pond temporarily increased after the elimination of Gable Mountain Pond, but has now been reduced. As a result, the groundwater mound associated with B Pond is slowly receding.

4.2.3.3 All Other Areas. Because available hydrogeologic information for the All Other Areas geographic area is concentrated in the 1100 and 300 Areas, hydrologic system descriptions are provided for these two areas. Hydrologic systems within this area, which are adjacent to the Central Plateau and Reactors on the River geographic areas, are similar or transitional to the systems described previously for those two areas.

4.2.3.3.1 1100 Area. Hydrostratigraphic units in the 1100 Area consist of the Ice Harbor Member of the Saddle Mountains Basalt, lower confined zones in the Ringold Formation, and upper unconfined zones in the Ringold Formation and the Hanford formation (WHC 1991b) (see Figure 4-16).

The uppermost aquifer system occurs within both the Hanford and Ringold formations. The upper aquifer is divided into a semiconfined lower part and an unconfined upper part by a discontinuous site aquitard (Figure 4-17) consisting of overbank deposits of the Ringold Formation. One or more confined to semiconfined zones likely occur below this aquitard. The upper confined aquifer consists of fluvial gravels of Ringold units C and B. The silt aquitard is common throughout the 1100 Area, but it is unclear how laterally extensive the aquitard is outside the area.

The unconfined aquifer below the 1100 Area occurs predominantly within fluvial gravels of the Ringold Formation and coarse-grained deposits of the Hanford formation, and is considered to have continuity with the unconfined aquifer occurring elsewhere below the Hanford Site and east of the 1100 Area. The vadose zone consists predominantly of interbedded sands and gravels of the Hanford formation. The depth to the water table varies from 6.1 m (20 ft) west of the Horn Rapids Landfill to 15.2 m (50 ft) at the south end of the 1100 Area.

The Yakima River discharges directly to the unconfined aquifer along the Horn Rapids reach below Horn Rapids Dam (WHC 1991b). Groundwater recharge to the unconfined aquifer below the 1100 Area and vicinity results from groundwater inflow from the Yakima River. East of the 1100 Area, the City of Richland infiltration basin artificially recharges the unconfined aquifer.

This major source of recharge to the aquifer causes groundwater mounding that extends west of the infiltration basin. However, because the infiltration basin is recharged intermittently, the mound may dissipate between periods of recharge. Groundwater flow in the vicinity of the 1100 Area is east to southeast. Groundwater discharge from the unconfined aquifer is primarily into the Columbia River and to wells in the City of Richland's well field.

4.2.3.3.2 300 Area. The hydrostratigraphic units in the 300 Area, in ascending order, are the Levey interbed and Ice Harbor Member of the Saddle Mountains Basalt; the lower mud sequence and fluvial gravels of the Ringold units E, C, and B; coarse-grained deposits of the Hanford formation; and eolian sand (Figure 4-18). Unconfined and confined aquifers are present beneath the 300 Area. The uppermost aquifer is unconfined; the first underlying confined aquifer is contained in the flow top of the uppermost basalt and, locally in some parts of the 300 Area, the lowermost portion of the Ringold Formation.

The Levey interbed is the uppermost confined aquifer in the 300 Area. This aquifer consists of the flow bottom of the Ice Harbor Basalt, the flow top of the Elephant Mountain Basalt, and the Levey interbed. The overlying Ice Harbor Member acts as a confining unit to the Levey interbed aquifer, separating it from the overlying upper or suprabasalt aquifer.

Figure 4-17. Generalized Stratigraphic and Hydrologic Column for the 1100 Area (WHC 1991b).

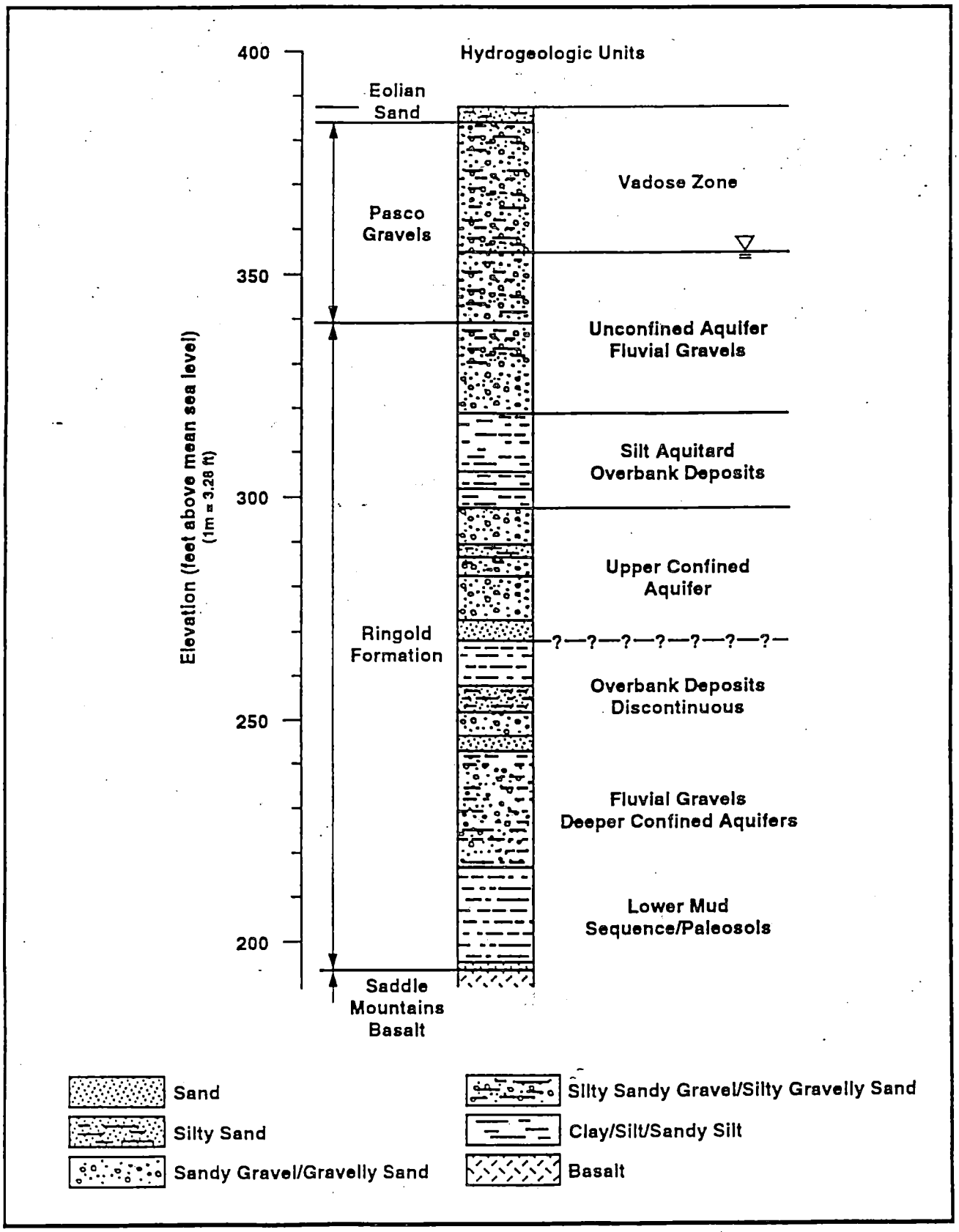
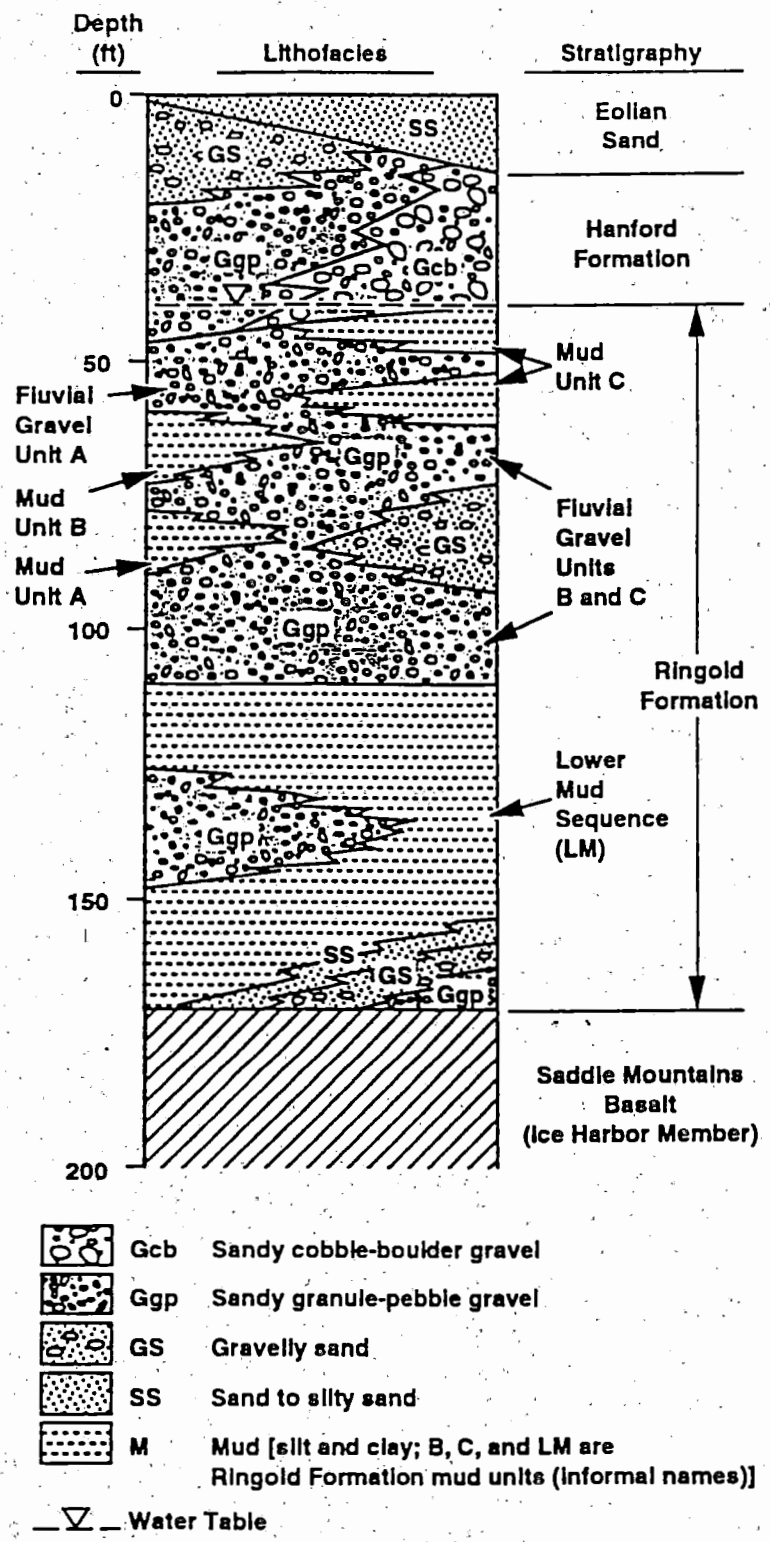


Figure 4-18. Generalized Stratigraphic and Hydrologic Column for the 300 Area (WHC 1991b).



The uppermost aquifer system in the 300 Area, as throughout most of the Hanford Site, is located in the Ringold Formation and the Hanford formation. The lower mud sequence of the Ringold Formation forms the base of the upper aquifer and acts as a local confining unit to discontinuous sand lenses located on top of the Ice Harbor Member. The lower mud sequence pinches out to the north of the 300 Area.

The main body of the upper aquifer occurs in the fluvial gravels of Ringold units E and possibly units C and B. These gravelly deposits are inferred to be laterally continuous in the area. The lower part of the unconfined aquifer in the fluvial gravel facies may be isolated hydraulically by discontinuous thin interbeds of silt and clay.

The water table in the 300 Area is at a depth of approximately 9.1 to 19 m (30 to 62 ft) below land surface, and is located near the contact between the Hanford formation and the Ringold Formation, but generally is found in the Ringold Formation (Cushing 1995). Depending on the location, the water table is present in both formations. The Hanford formation in the 300 Area consists of gravel with cobbles and boulders and only a small part of the lower half of the unit is usually saturated with water. The vadose zone in this area lies almost entirely within the gravels of the Hanford formation.

Groundwater flow across the 300 Area is generally to the southeast. However, in the southern part of the area there is a component of groundwater flow from the Yakima River southwest of the 300 Area. As a result, groundwater enters the 300 Area from the northwest, west, and southwest (WHC 1991b). In the past, the primary man-made influence on groundwater level and flow direction in the 300 Area was from process trenches. The large volumes of water formerly discharged to these trenches would percolate quickly to the groundwater and create small groundwater mounds. Discharge to the process trenches has been greatly reduced and the groundwater mounding beneath the trenches has now dissipated.

4.2.4 Groundwater Quality

Groundwater quality on the has been affected by activities related to the production of nuclear materials. Due to the arid climate, natural recharge of the groundwater on the Hanford Site is normally low. Artificial recharge has occurred in the past from the disposal of liquid waste associated with processing operations in the 100, 200, and 300 Areas (Reactors on the River, Central Plateau, and All Other Areas), which created mounds of water underlying discharge points. Large areas underlying the Hanford Site have elevated levels of both radiological and nonradiological constituents. The liquid effluents discharged into the ground have carried with them certain radionuclides and chemicals that move through the soil column at varying rates, eventually entering the groundwater and forming plumes of contamination.

4.2.4.1 Unconfined Aquifer. As part of the continuing environmental monitoring program at the Hanford Site, groundwater monitoring reports are published in the Hanford Site Environmental Report (PNL 1995a), which is issued each calendar year. The shallow, unconfined aquifer in the Pasco Basin and on the Hanford Site contains waters of a dilute (less than or approximately 350 milligrams per liter total dissolved solids) calcium bicarbonate chemical type. Other principal constituents include sulfate, silica, magnesium, and nitrate. Variability in chemical composition exists within the unconfined aquifer because of natural variation in the composition of the aquifer material; because of agricultural and irrigation practices north, east, and west of the Hanford Site; and, on the Hanford Site, because of liquid waste disposal.

Analyses of unconfined aquifer water samples taken by the U.S. Geological Survey in the Pasco Basin, but off the Hanford Site, were compared with samples taken by the Pacific Northwest National Laboratory and the U.S. Geological Survey on the Hanford Site for the years 1974 through 1979 (DOE 1995). In general, Hanford Site groundwater analyses showed higher levels of chemical constituents and temperatures than were reflected in the analyses of offsite samples.

Elevated levels of some constituents in Hanford Site groundwater result from releases of various liquid wastes from disposal facilities, primarily in the Reactors on the River (formerly the site of production reactor operations) and the Central Plateau (formerly the spent fuel reprocessing and defense materials production site) geographic areas. Mobile contaminants, such as tritium, iodine-129, and nitrate from the Central Plateau, are present in a groundwater plume that extends across the southeastern quadrant of the Hanford Site and enters the Columbia River along a broad front north of the 300 Area. Contaminants having lower mobility are confined generally to smaller localized plumes in the vicinity of the disposal facilities, and migrate more slowly toward the Columbia River (Cushing 1995). Some longer-lived radionuclides, such as strontium-90 and cesium-137 have reached the groundwater, primarily through liquid waste disposal cribs. Minor quantities of longer-lived radionuclides also have reached the water table through a failed groundwater monitoring well casing and through injection wells, a disposal practice that was discontinued at the Hanford Site in 1947 (DOE 1995).

Several radionuclides and nonradioactive contaminants were present in the groundwater at concentrations that exceeded the EPA's drinking water standards (PNL 1995a). These standards exist to protect public drinking water supplies. These standards are used for purposes of comparison, although it should be noted that, with one exception, groundwater beneath the site is not used for human consumption or food production. Groundwater utilized for drinking at the FFTF Visitor Center contains above-background concentrations of tritium and iodine-129 from the 200 East and 200 West Area plume; however, these levels are well below EPA drinking water standards. There is little opportunity for contaminated groundwater to migrate to locations where members of the public might utilize it directly for domestic purposes or irrigation. Groundwater in the unconfined aquifer is relatively isolated, and generally flows toward the north and east where it discharges to the Columbia River. Normal hydraulic gradients within the unconfined aquifer prevent southward migration of groundwater toward populated areas near the City of Richland. Recharge to the Columbia River from aquifers in Franklin County to the north and east prevents radionuclides in the Columbia River from migrating to groundwater across the river from the Hanford Site.

Groundwater monitoring at the Reactors on the River geographic area detected concentrations of chromium, nitrate, trichloroethylene, cobalt-60, strontium-90, tritium, and uranium that were above the existing or proposed EPA drinking water standards. Tritium concentrations exceeded both the EPA's drinking water standard and the DOE's Derived Concentration Guides at one sample well in each of the 100-N and 100-K Areas. In the 200 East and 200 West Area wells, chromium, nitrate, fluoride, carbon tetrachloride, chloroform, trichloroethylene, cesium-137, tritium, iodine-129, technetium-99, uranium, and plutonium were found in concentrations that exceeded EPA drinking water standards; tritium and strontium-90 exceeded both the EPA's drinking water standard and the DOE's Derived Concentration Guides in some locations. Only uranium exceeded the proposed EPA drinking water standards in the 300 Area wells, a result of liquid waste disposal at former fuel fabrication facilities (PNL 1995a).

The occurrence and consequences of leaks from waste storage tanks and of radioactive materials in soils have been described elsewhere (ERDA 1975). These occurrences have not resulted, and are not expected to result, in radiation exposure to the public (ERDA 1975; DOE 1987). Leakage from

the 105-KE fuel storage basin results in groundwater contamination with several radionuclides, as noted previously. The more mobile radionuclides reach the Columbia River through springs near the 100-K Area; concentrations of radionuclides in the springs were below EPA drinking water standards in 1993 (DOE 1995).

Radioactive and nonradioactive liquid effluents are discharged to the environment from facilities in the Central Plateau (DOE 1995). These effluents, in general, are discharged to the soil column. RL has committed to implement the Best Available Technology, and all known and reasonable methods of prevention, control, and treatment for several of the effluent streams, to permit the streams under the "State Waste Water Discharge Permit Program", *Washington Administrative Code* 173-216, by October of 1997. Under the provisions of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, remedial investigations/feasibility studies will be conducted to evaluate and implement remedial actions for groundwater operable units at the Hanford Site.

4.2.4.2 Confined Aquifer. The uppermost confined aquifer (Rattlesnake Ridge) was monitored to determine the extent of groundwater contamination resulting from interaction between the confined and unconfined aquifers. Groundwater samples from selected confined aquifer wells have been analyzed for a variety of radionuclides and hazardous chemicals. In most cases, no indication of contamination was observed. Detection of radionuclides in well 299-E33-12 (in the Central Plateau geographic area) is attributed to contamination by high-salt waste that migrated by density flow into the borehole when it was open to both the unconfined and the confined aquifer during drilling (PNL 1995a). The 1994 samples from well 299-E33-12 contained up to 770 pCi/L of tritium, similar to levels detected since 1991. The 1994 samples from this well also contain cobalt-60 at levels up to 36.4 pCi/L, nitrate at levels up to 46 mg/L, technetium-99 at levels up to 1,530 pCi/L, and cyanide at levels up to 39.5 μg/L. Although all of these are indicators of contamination, only nitrate and technetium-99 were detected at levels greater than the drinking water standards.

Elevated levels of tritium have been measured in groundwater from the Rattlesnake Ridge interbed in well 699-42-40C located adjacent to B Pond. This well contained a maximum of 7,050 pCi/L of tritium in 1994 samples, which were slightly lower levels than in 1993, and well below the drinking water standards.

Samples collected in 1994 from well 199-B3-2P in the 100-B Area, contained up to 20.9 pCi/L of strontium-90 and 504 pCi/L of tritium. This well is currently completed in the confined aquifer but was open to both the unconfined and confined aquifer between 1953 and 1970 so it is possible that the well provided a conduit downward for contamination in the unconfined aquifer. The current extent of contamination in the confined aquifer is unknown.

4.2.5 Water Use

Water use in the Pasco Basin is primarily from surface diversion, with groundwater diversions accounting for less than 10% of the use (DOE 1988). Industrial and agricultural usage represent about 32% and 50%, respectively, and municipal use about 9%. Until recently, the Hanford Site used about 81% of the water withdrawn for industrial purposes. However, because of the N Reactor shutdown, and considering other data (DOE 1988), these percentages now approximate 13% for industrial, 75% for agricultural, and 12% for municipal use, with the Hanford Site accounting for about 41% of the water withdrawn for industrial use.

Approximately 50% of the wells in the Pasco Basin are used for domestic purposes, and are generally shallow (less than 150 m [500 ft]). Agricultural wells, used for irrigation and stock supply, constitute the second-largest category of well use (about 24% for the Pasco Basin). Industrial users account for only about 3% of the wells (DOE 1995).

Most of the water used by the Hanford Site is withdrawn from the Columbia River. In the past, the principal users of groundwater within the Hanford Site were the FFTF, with a 1988 use of 142,000 m^3 (5.0 x 10^6 ft^3) from two wells in the unconfined aquifer, and the Pacific Northwest National Laboratory Observatory, with a water supply from a spring on the side of Rattlesnake Mountain.

Regional effects of water-use activities are apparent in some areas where the local water tables or potential levels have declined because of withdrawals from wells. In other areas, water levels in the shallow aquifers have risen because of artificial recharge mechanisms, such as excessive application of imported irrigation water or impoundment of streams. Wastewater ponds on the Hanford Site have artificially recharged the unconfined aquifer below the 200 East and 200 West Areas. The increase in water table elevations was most rapid from 1950 to 1960, and apparently nearly reached equilibrium between the unconfined aquifer and the recharge during 1970 to 1980, when only small increases in water table elevations occurred. Wastewater discharges from the 200 West Area were significantly reduced in 1984 (DOE 1988), with an accompanying decline in water table elevations.

4.3 Air Resources

This section addresses the general air resources at the Hanford Site and the surrounding region. Included in this section are discussions on climate and meteorology, ambient air quality, and atmospheric dispersion.

4.3.1 Climate and Meteorology

The Hanford Site is classified as mid-latitude semiarid or mid-latitude desert, depending on the climatological classification scheme used. Summers are warm and dry, with abundant sunshine. Large diurnal temperature variations result from intense solar heating during the day and radiational cooling at night. Daytime high temperatures in June, July, and August periodically exceed 38 °C (100 °F). Winters are cool with occasional precipitation. Outbreaks of cold air associated with modified Arctic air masses can reach the area and cause temperatures to drop below -18 °C (0 °F). Overcast skies and fog occur periodically (DOE 1995).

Topographic features have a significant impact on the climate of the Hanford Site. All air masses that reach the region undergo some modification during their passage over the complex topography of the Pacific Northwest. The climate of the region is strongly influenced by the Pacific Ocean and the Cascade Range to the west. The relatively low annual average rainfall of 16.1 cm (6.3 in.) at the Hanford Meteorological Station (HMS) is caused largely by the rain shadow created by the Cascade Range. These mountains limit much of the maritime influence of the Pacific Ocean, resulting in a more continental-type climate than would exist if the mountains were not present. Maritime influences are experienced in the region during the passage of frontal systems, and as a result of movement through gaps in the Cascade Range (such as the Columbia River Gorge).

The Rocky Mountains to the east and the north also influence the climate of the region. These mountains play a key role in protecting the region from the more severe winter storms, and the extremely low temperatures associated with the modified Arctic air masses that move southward through Canada. Local and regional topographical features, such as the Yakima Ridge and the Rattlesnake Hills, also impact meteorological conditions across the Hanford Site (DOE 1995). In particular, these features have a significant impact on wind directions, wind speeds, and precipitation levels.

Climatological data are available for the HMS, which is located between the 200 East and 200 West Areas. Data has been collected at this location since 1945 (Hoitink and Burk 1994). Data from the HMS are representative of the general climatic conditions for the region and describe the specific climate of the Central Plateau. Local variations in the topography of the Hanford Site may cause some aspects of the climate at portions of the Hanford Site to differ significantly from those of the HMS. For example, winds near the Columbia River are different than those at the HMS. Similarly, precipitation along the slopes of the Rattlesnake Hills differs from that at the HMS.

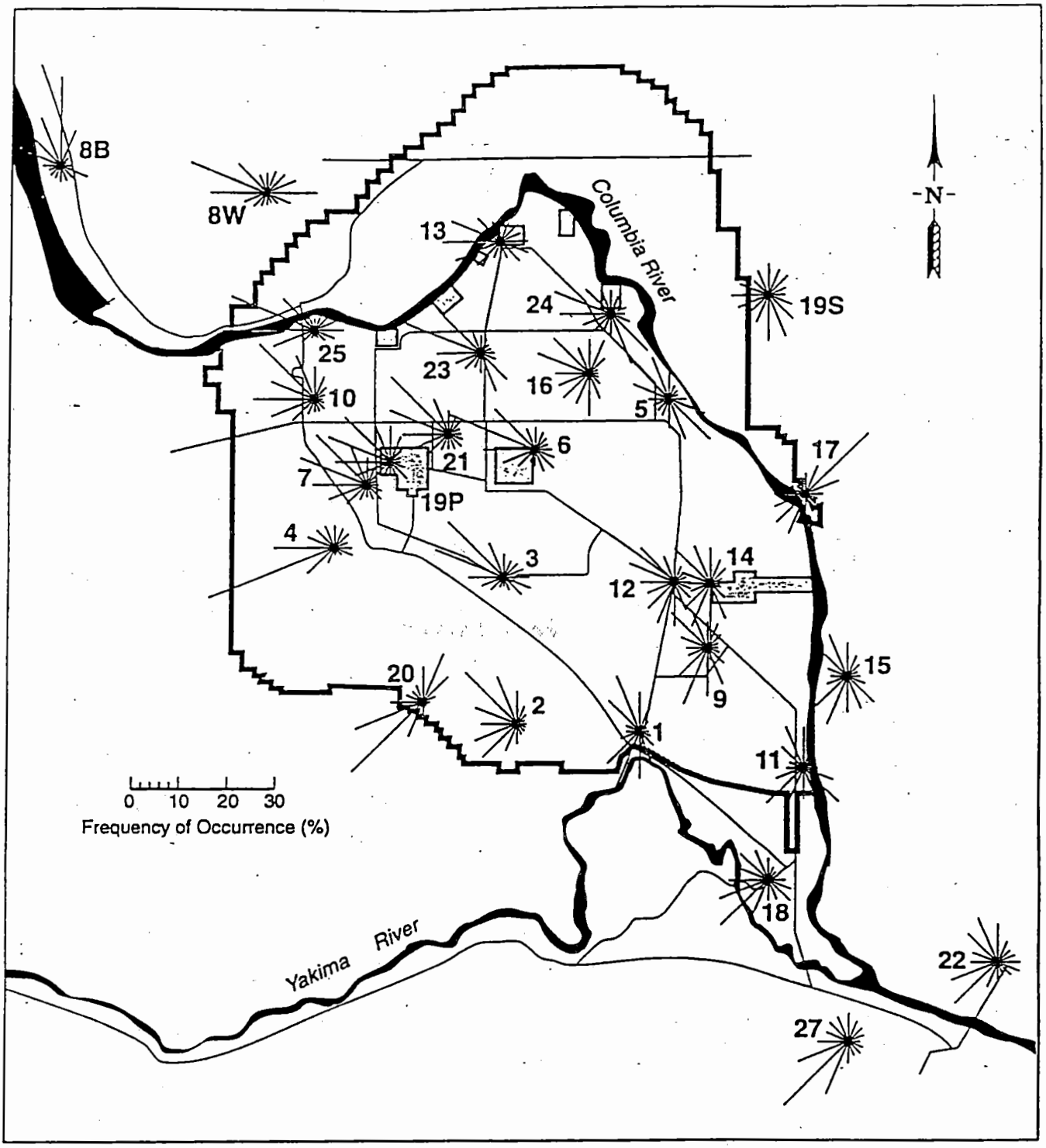
4.3.1.1 Wind. Prevailing wind directions on the Central Plateau are from the northwest during all months of the year. Secondary maxima occur for southwesterly winds. Summaries of wind direction indicate that winds from the northwest quadrant occur most often during the winter and summer. During the spring and fall, the frequency of southwesterly winds increases with a corresponding decrease in northwest flow. Winds blowing from other directions (for instance, the northeast) display minimal variation from month to month. Monthly average wind speeds are lowest during the winter months, averaging 10 to 11 km/hr (6 to 7 mi/hr), and highest during the summer, averaging 14 to 16 km/h (8 to 10 mi/hr). Summertime drainage winds generally are northwesterly, and can frequently gust to 50 km/hr (30 mi/hr) (Cushing 1995). A wind rose map for the Hanford Site is shown in Figure 4-19. The point of each rose represents the direction from which the winds come.

4.3.1.2 Temperature and Humidity. Nine separate temperature measurements are made at the 122-m (400-ft) tower at the HMS. Temperatures also are measured at the 2-m (6.5-ft) level on the twenty-four 9.1-m (30-ft) towers located on and around the Hanford Site. The three 61-m (200-ft) towers have temperature-measuring instrumentation at the 2-, 9.8-, and 60-m (6.5-, 33-, and 200-ft) levels. The temperature data from the 9.1- and 60-m (30- and 200-ft) towers are telemetered to the Hanford Meteorological Station.

Ranges of daily maximum and minimum temperatures vary from normal maxima of 2 °C (35 °F) in late December to 35 °C (95 °F) in late July (Hoitink and Burk 1994). On the average, 51 days during the summer months have maximum temperatures greater than or equal to 32 °C (90 °F), and 12 days have maxima greater than or equal to 38 °C (100 °F). From mid-November through early-March, minimum temperatures average less than or equal to 0 °C (32 °F), with the minima in late December and early January averaging -6 °C (-21 °F). During the winter, on average, four days have minimum temperatures less than or equal to -18 °C (0 °F); however, only about one winter in two experiences such temperatures. The record maximum temperature is 45 °C (113 °F), and the record minimum temperature is -31 °C (-23 °F). For the period 1946 through 1993, the average monthly temperatures ranged from a low of -0.9 °C (30 °F) in January to a high of 24.6 °C (76 °F) in July. During the winter, the highest monthly average temperature at the HMS was 6.9 °C (44 °F), and the record lowest was -11.1 °C (12 °F), both occurring during February. During the summer, the record highest monthly average temperature was 27.9 °C (82 °F) in July, and the record lowest was 17.2 °C (63 °F) in June.

9613470.0394

Figure 4-19. Wind Roses (at 10 m) for the Hanford Meteorological Monitoring Network, 1979 to 1994.



Relative humidity/dew point temperature measurements are made at the HMS and at the three 60-m (200-ft) tower locations. The annual average relative humidity at the HMS is 54%. It is highest during the winter months, averaging about 75%, and lowest during the summer, averaging about 35%. Wet bulb temperatures greater than 24 °C (75 °F) had not been observed at the HMS before 1975; however, on July 8, 9, and 10 of that year, seven hourly observations indicated wet bulb temperatures greater than or equal to 24 °C (75 °F). Fog reduces the visibility to 9.6 km (6 mi) during an average of 42 days each year and to less than 0.4 km (0.25 mi) during an average of 25 days per year (DOE 1995).

4.3.1.3 Precipitation. The average annual precipitation at the HMS is 16.1 cm (6.3 in). Most of the precipitation occurs during the winter with nearly half of the annual amount occurring in the months of November through February. Days with greater then 1.3 cm (0.5 in) precipitation. Rainfall intensities of at least 1.3 cm (0.5 in) per hour persisting for 1 hour has only a 10% probability of occurring in any given year. A rainfall intensity of at least 2.5 cm (1 in) per hour has only a 0.2% probability of occurring in any given year. Winter monthly average snowfall ranges from 0.8 cm (0.3 in) in March to 14.5 cm (6 in) in January. The seasonal record snowfall of 142 cm (56 in) occurred in the winter of 1993. During the months of December, January, and February, snowfall accounts for about 38% of all precipitation (Cushing 1995).

4.3.1.4 Severe Weather. A discussion of severe weather may include a variety of meteorological events, including, but not limited to, severe winds, dust and blowing dust, hail, fog, glaze, ash falls, extreme temperatures, temperature inversions, and blowing and drifting snow. The HMS's climatological summary and the National Severe Storms Forecast Center's database list only 24 separate tornado occurrences within 160 km (100 mi) of the Hanford Site from 1916 to 1994 (Cushing 1995). Only one of these tornadoes was observed within the boundaries of the Hanford Site (on its extreme western edge), and no damage resulted. The estimated probability of a tornado striking a point at Hanford is 9.6×10^{-6} per year (Cushing 1995). Because tornadoes are infrequent and generally small in the Pacific Northwest (and hurricanes do not reach this area), risks from severe winds are generally associated with thunderstorms or the passage of strong cold fronts. The greatest peak wind gust recorded at 15 m (50 ft) above ground level at the HMS was 36 m/s (80 mi/hr). Extrapolations based on 35 years of observations indicate a return period of about 200 years for a peak gust in excess of 40 m/s (90 mi/hr) at 15 m (50 ft) above ground level.

4.3.1.5 Atmospheric Stability. Atmospheric dispersion is a function of wind speed, duration and direction of wind, atmospheric stability, and mixing depth. Dispersion conditions are generally good if winds are moderate to strong, if the atmosphere is of neutral or unstable stratification, and if there is a deep mixing layer. Good dispersion conditions associated with neutral and unstable stratification exist about 57% of the time during the summer. Less favorable dispersion conditions may occur when the wind speed is light and the mixing layer is shallow. These conditions are most common during the winter when moderately to extremely stable stratification exists about 66% of the time. Less favorable conditions also occur periodically for surface and low-level releases in all seasons from about sunset to about an hour after sunrise as a result of ground-based temperature inversions and shallow mixing layers. Mixing-layer thicknesses have been estimated at the HMS using remote sensors (Cushing 1995).

Occasionally there are extended periods of poor dispersion conditions associated with stagnant air in stationary high-pressure systems that occur primarily during the winter months. The probability of an inversion period extending more than 12 hours varies from a low of about 10% in May and June to a high of about 64% in September and October (Cushing 1995). These probabilities decrease rapidly for durations of greater than 12 hours.

4.3.2 Air Quality

4.3.2.1 Nonradiological Air Quality. National ambient air quality standards (NAAQS) have been set by the EPA as mandated in the *Clean Air Act of 1970*. Ambient air is that portion of the atmosphere, external to buildings, to which the general public has access. For DOE facilities, this is interpreted to mean the site boundary or other publicly accessible locations (e.g., highways on the site). The standards define levels of air quality that are necessary, with an adequate margin of safety, to protect the public health and welfare. Standards exist for sulfur oxides (measured as sulfur dioxide), nitrogen dioxide, carbon monoxide total suspended particles (TSP), particles with an aerodynamic diameter less than or equal to 10 micrometers (PM_{10}), lead, and ozone. The standards specify the maximum pollutant concentrations and frequencies of occurrence that are allowed for specific averaging periods (that is, the concentration of carbon monoxide when averaged over 1 hour is allowed to exceed 40 milligrams per cubic meter only once per year). The averaging periods vary from 1 hour to 1 year, depending on the pollutant.

In addition to ambient air quality standards, the EPA has established standards for the Prevention of Significant Deterioration (PSD) of air quality. The PSD standards differ from the NAAQS in that the NAAQS provide maximum allowable concentrations of pollutants, while PSDs provide maximum allowable increases in concentrations of pollutants for areas already in compliance with NAAQS. PSD standards are expressed as allowable increments in atmospheric concentrations of specific pollutants (nitrogen dioxide, sulfur dioxide, and PM_{10}) (40 CFR 52). Different PSD standards exist for Class I areas (where degradation of ambient air quality is to be severely restricted), and Class II areas (where moderate degradation of air quality is allowed). The PSD standards are presented in Table 4-3. The Hanford Site operates under a PSD permit issued by the EPA in 1980. This permit provides specific limits for emissions of nitrogen oxide from the PUREX and the UO_3 Plants.

State and local governments have the authority to impose standards for ambient air quality that are more stringent than the national standards. Washington State has established more stringent standards for sulfur dioxide and TSP. In addition, Washington has established standards for VOCs, arsenic, fluoride, total suspended particulates, and other pollutants that are not covered by national standards. The state standards for carbon monoxide, nitrogen dioxide, ozone, PM^{10}, and lead are identical to the national standards. Table 4-4 summarizes the relevant air quality standards (federal and supplemental state standards).

4.3.2.1.1 Background Air Quality. The closest Class I areas to the Hanford Site are Mount Rainier National Park, located approximately 160 km (100 mi) west of the Hanford Site; Goat Rocks Wilderness Area, located approximately 145 km (90 mi) west of the Hanford Site; Mount Adams Wilderness Area, located approximately 150 km (95 mi) southwest of the Hanford Site; and Alpine Lakes Wilderness Area, located approximately 175 km (110 mi) northwest of the Hanford Site.

Air quality in the Hanford region is well within the state and federal standards for criteria pollutants, except that short-term particulate concentrations occasionally exceed the 24-hour PM_{10} standard. Concentrations of toxic chemicals, as listed in 40 CFR 60.1, are not available for the Hanford Site. Because the highest concentrations of airborne particulate material are generally a result of natural events, the area has not been designated nonattainment[3] with respect to the PM_{10}

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[3]An attainment area is an area where measured concentrations of a pollutant are below the primary and secondary NAAQS.

Table 4-3. Maximum Allowable Increases for Prevention of Significant Deterioration of Air Quality (40 CFR 52).

Pollutant	Averaging Time	Class I	Class II
Particulate matter* (PM_{10})	Annual	4	17
	24 hours	8	30
Sulfur dioxide	Annual	2	20
	24 hours	5	91
	3 hours	25	512
Nitrogen dioxide	Annual	2.5	25

*Particulate matter is defined as suspended particulates with an aerodynamic diameter less than 10 micrometers.

Table 4-4. National and Washington State Ambient Air Quality Standards.[a]

Pollutant	National Primary	National Secondary	Washington State
Total Suspended Particulates			
Annual geometric mean	NS	NS	60 $\mu g/m^3$
24-hour average	NS	NS	150 $\mu g/m^3$
PM-10 (fine particulates)			
Annual arithmetic mean	50 $\mu g/m^3$	50 $\mu g/m^3$	50 $\mu g/m^3$
24-hour average	150 $\mu g/m^3$	150 $\mu g/m^3$	150 $\mu g/m^3$
Sulfur Dioxide			
Annual average	0.03 ppm	NS	0.02 ppm
24-hour average	0.14 ppm	NS	0.10 ppm
3-hour average	NS	0.50 ppm	NS
1-hour average	NS	NS	0.40 ppm[b]
Carbon Monoxide			
8-hour average	9 ppm	9 ppm	9 ppm
1-hour average	35 ppm	35 ppm	35 ppm
Ozone			
1-hour average	0.12 ppm	0.12 ppm	0.12 ppm
Nitrogen Dioxide			
Annual average	0.05 ppm	0.05 ppm	0.05 ppm
Lead			
Quarterly average	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$

[a]Annual standards are never to be exceeded; short-term standards are not to be exceeded more than once per year unless otherwise noted (Ecology 1994).

[b]0.25 ppm not to be exceeded more than twice in any 7 consecutive days; not to be exceeded more than 1 day per calendar year.

NS = No standard.
ppm = Parts per million.
$\mu g/m^3$ = Micrograms per cubic meter.

standard. However, the local Benton County Clean Air Authority is currently completing discussions with the EPA and Ecology regarding plans to conduct additional evaluations of potential sources and mitigation measures, if any, that might be implemented to reduce the short-term particulate loading.

4.3.2.1.2 Source Emissions. Emission inventories for permitted pollution sources in Benton County are routinely compiled by the Benton County Clean Air Authority. The annual emission rates for stationary sources within the Hanford Site boundaries were reported to Ecology by the DOE (Table 4-5).

4.3.2.1.3 Onsite Nonradiological Air Quality Monitoring. Monitoring of nitrogen oxides was discontinued after 1990, mostly because of the end of operations at the PUREX Plant. Monitoring of TSP was discontinued in early 1988 when the Basalt Waste Isolation Project, for which those measurements were required, ended.

Seventeen air samples for polychlorinated biphenyls (PCB) analysis were collected during 1993. Nine samples of PCBs were above the detection limit, with results ranging from 0.25 to 3.9 ng/m^3. The other eight results were below the detection limit of 50 ng/sample component, which yields air concentrations of <=0.03 to 0.1 ng/m^3. The EPA specifies a general detection limit of 1 ng/m^3.

Table 4-5. Emission Rates for Stationary Emission Sources Within the Hanford Site for 1993 (Cushing 1995).

Source	Operation (h/yr)	TSP (t/yr)	PM_{10} (t/yr)	SO_2 (t/yr)	NO_x (t/yr)	VOC (t/yr)	CO (t/yr)
300 Area Res. Dis. #2 Boiler	4,368	5	4	65	13	0	1
300 Area Boiler #3	0	0	0	0	0	0	0
300 Area Boiler #4	0	0	0	0	0	0	0
300 Area Boiler #5	0	0	0	0	0	0	0
300 Area Boiler #6	4,368	3	3	48	10	0	1
200 E Boiler	8,760	8	2	232	174	1	64
200 W Boiler	8,760	2	0	213	160	1	58
200 E, 200 W Fugitive Coal	8,760	107	54	0	0	0	0
200 E Fugitive Emissions	8,760	1	0	0	0	0	0
Fugitive Coal Pile 300 Area	8,760	4	2	0	0	0	0
Temp. Boiler Res. Dis., 300 Area	8,760	15	13	215	43	0	4

CO = carbon monoxide.
NO^x = oxides of nitrogen.
PM^{10} = fine particulates.
SO^2 = sulfur dioxide.
t/yr = tons per year.
TSP = total suspended particulates.
VOC = volatile organic compounds.

However, some of the results below the general detection limit (1 ng/m^3) exceeded the required sensitivity, and thus were included as though they were above the detection limit. This is why the range on the nine detectable samples was 0.25 to 3.9 ng/m^3 (Cushing 1995). PCBs were well below the National Institute of Occupational Safety and Health (Cushing 1995) occupational limit of 1,000 ng/m^3 (10-hour time-weighted average). No regulatory limits for PCBs in ambient air have been established (Cushing 1995).

Fourteen air samples were collected for VOC analysis in 1993. These samples were analyzed for benzene, alkylbenzenes, halogenated alkanes, and alkenes. All of the VOC concentrations measured were well within the maximum allowable concentrations of air contaminants as established in 29 CFR 1910 (Cushing 1995).

4.3.2.1.4 Offsite Nonradiological Air Quality Monitoring. During the past 10 years, carbon monoxide, sulfur dioxide, and nitrogen dioxide have been monitored periodically in communities and commercial areas southeast of Hanford. These urban measurements are typically used to estimate the maximum background pollutant concentrations for the Hanford Site because of a lack of specific onsite monitoring. Because these measurements were made in the vicinity of local sources of pollution, they will overestimate maximum background concentrations for the Hanford Site or at the Hanford Site boundaries.

The only offsite monitoring near the Hanford Site in 1993, for PM_{10}, was conducted by Ecology (Cushing 1995). PM_{10} was monitored at one location in Benton County, at Columbia Center in Kennewick. During 1993, the 24-hour PM_{10} standard established by the State of Washington, 150 μg/m^3, was exceeded twice at the Columbia Center monitoring location; the maximum 24-hour concentration at Columbia Center was 1166 μg/m^3 (the suspected cause was windblown dust); the other occurrence >150 μg/m^3 was 155 μg/m^3. The site did not exceed the annual primary standard, 50 μg/m^3, during 1993. The arithmetic mean for 1993 was 32 μg/m^3 at Columbia Center.

Particulate concentrations can reach relatively high levels in eastern Washington State because of exceptional natural events (i.e., dust storms, volcanic eruptions, and large brushfires) that occur in the region. Washington State ambient air quality standards have not considered "rural fugitive dust" from exceptional natural events when estimating the maximum background concentrations of particulates in the area east of the Cascade Mountain crest. In the past, the EPA has exempted the rural fugitive dust component of background concentrations when considering permit applications and enforcement of air quality standards. However, the EPA is now investigating the prospect of designating parts of Benton, Franklin, and Walla Walla counties as a nonattainment area for PM_{10}. Windblown dust has been identified as a particularly large problem in this area. Ecology has been working with the EPA and the Benton County Clean Air Authority under a Memorandum of Agreement (MOA) to characterize and document the sources of PM_{10} emissions and develop appropriate control techniques in the absence of formally designating the area nonattainment. At this time, the parties are characterizing the sources of PM_{10} emissions and working through other items in the MOA. A final decision on this issue will be made by the EPA, when the final results of the PM_{10} characterization analysis are received.

4.3.3 Radiological Air Quality

Radionuclide emissions to the atmosphere from the Hanford Site have been steadily decreasing over the last few years as Hanford Site operations have changed emphasis from the historical mission of nuclear materials production and processing to energy and waste management research. During

1994, all operations at the Hanford Site released approximately 17 Ci of radionuclides to the atmosphere, most of which consisted of tritium and noble gases (PNL 1995a). These releases resulted in a dose to the maximally exposed offsite resident of less than 0.012 mrem (PNL 1995a), which is substantially less than the current EPA standard of 10 mrem per year for DOE facilities.

Ambient air monitoring for radionuclides consisted of sampling at 39 onsite and offsite locations during 1994. Total concentrations of beta-emitting radionuclides at the Hanford Site perimeter were indistinguishable from those at distant locations that are unaffected by Hanford emissions. Air concentrations of total alpha are slightly elevated at the Hanford Site perimeter; concentrations in nearby communities were within the range of historical values (PNL 1995a). Concentrations of two specific radionuclides (tritium and iodine-129) were elevated relative to background; however, their contribution to the total airborne activity was small.

4.4 Ecological Resources

The Hanford Site is a relatively large, undisturbed area of shrub-steppe habitat that contains numerous plant and animal species adapted to the region's semiarid environment. The site consists of mostly undeveloped land, with widely spaced clusters of industrial buildings located along the western shoreline of the Columbia River, and at several locations in the interior of the Hanford Site. The industrial buildings are interconnected by roads, railroads, and electrical transmission lines. The major facilities and activities occupy about 6% of the total available land area, and their impact on the surrounding ecosystems is minimal. Most of the Hanford Site has not experienced tillage or livestock grazing since the early 1940s. The Columbia River flows through the Hanford Site, and although the river flow is not directly impeded by dams within the Hanford Site, the historical daily and seasonal water fluctuations have been changed by dams upstream and downstream of the Hanford Site (DOE 1995). The Columbia River and other water bodies on the Hanford Site provide habitat for aquatic organisms. The Columbia River is accessible for public recreational use and commercial navigation.

4.4.1 Vegetation

The Hanford Site has been botanically characterized as a shrub-steppe. The region is characterized by bunchgrasses and sagebrushes, often referred to as high desert, northern desert shrub, or desert scrub (Franklin and Dyrness 1973). Because of the Hanford Site's arid climate, the productivity of both plants and animals is relatively low compared with other natural communities. In the early 1800s, the dominant plant in the area was big sagebrush with an understory of perennial bunchgrasses, especially Sandberg's bluegrass and bluebunch wheatgrass. With the advent of settlement that brought livestock grazing and crop raising, the natural vegetation mosaic was opened to a persistent invasion by alien annuals, especially cheatgrass. Today cheatgrass is the dominant plant on fields that were cultivated 50 years ago. Cheatgrass also is well established on rangelands at elevations less than 244 m (800 ft) (DOE 1995). Wildfires in the area are common; the most recent extensive fire in 1984 significantly altered the shrub component of the vegetation. The dryland areas of the Hanford Site were treeless in the years before land settlement; however, for several decades before 1943, trees were planted and irrigated on most of the farms to provide windbreaks and shade. When the farms were abandoned in 1943, some of the trees died but others have persisted, presumably because their roots are deep enough to contact groundwater. Today these trees serve as

nesting platforms for several species of birds, (i.e., hawks, owls, ravens, magpies, and great blue herons), and as night roosts for wintering bald eagles (DOE 1995). The vegetation mosaic of the Hanford Site currently consists of twelve major kinds of plant communities (Figure 4-20).

The State of Washington has designated large and small blocks of shrub-steppe as priority habitat, because it possesses unique or significant value to many species. The state makes this classification determination based on the quality of the following attributes: comparatively high fish and wildlife density; comparatively high fish and wildlife species diversity; important fish and wildlife breeding habitat; important fish and wildlife seasonal ranges; important fish and wildlife movement corridors; limited availability; high vulnerability to habitat alteration; and unique or dependent species.

Almost 600 species of plants have been identified on the Hanford Site (Cushing 1995). The dominant plants are big sagebrush, rabbitbrush, cheatgrass, and Sandberg's bluegrass, with cheatgrass providing half of the total plant cover. Cheatgrass and Russian thistle, annuals introduced to the United States from Eurasia in the late 1800s, invade areas where the ground surface has been disturbed. Mosses and lichens appear abundantly on the soil surface; lichens commonly grow on the shrub stems. The important desert shrubs, big sagebrush and bitterbrush, are widely spaced and usually provide less than 20% canopy cover. The important understory plants are grasses, especially cheatgrass, Sandberg's bluegrass, Indian ricegrass, June grass, and needle-and-thread grass.

As compared to other semiarid regions in North America, primary productivity is relatively low, and the number of vascular plant species also is low. This situation is attributed to the low annual precipitation (16 cm [approximately 6 in.]), the low water-holding capacity of the rooting substrate (sand), and the droughty summers and occasionally very cold winters.

Sagebrush and bitterbrush are easily killed by summer wildfires, but the grasses and other herbs are relatively resistant and usually recover in the first growing season after burning. Fire usually opens the community to wind erosion. The severity of erosion depends on the severity and areal extent of the fire. Hot fires incinerate entire shrubs and damage grass crowns. Less intensive fires leave dead stems standing, and recovery of herbs is prompt. The most recent and extensive wildfire occurred in the summer of 1984.

Bitterbrush shrubs provide browse for a resident herd of mule deer. Bitterbrush shrubs are slow to recolonize burned areas because invasion is by seeds. Bitterbrush does not sprout even when fire damage is relatively light.

Certain passerine birds (i.e., sage sparrow, sage thrasher, and loggerhead shrike) rely on sagebrush or bitterbrush for nesting. These birds are not expected to nest in places devoid of shrubs. Jackrabbits also appear to avoid burned areas without shrubs. Birds that nest on the ground in areas without shrubs include longbilled curlews, horned larks, Western meadowlarks, and burrowing owls.

The following sections briefly discuss the vegetation that occurs in the Columbia River, Reactors on the River, Central Plateau, and All Other Areas geographic areas.

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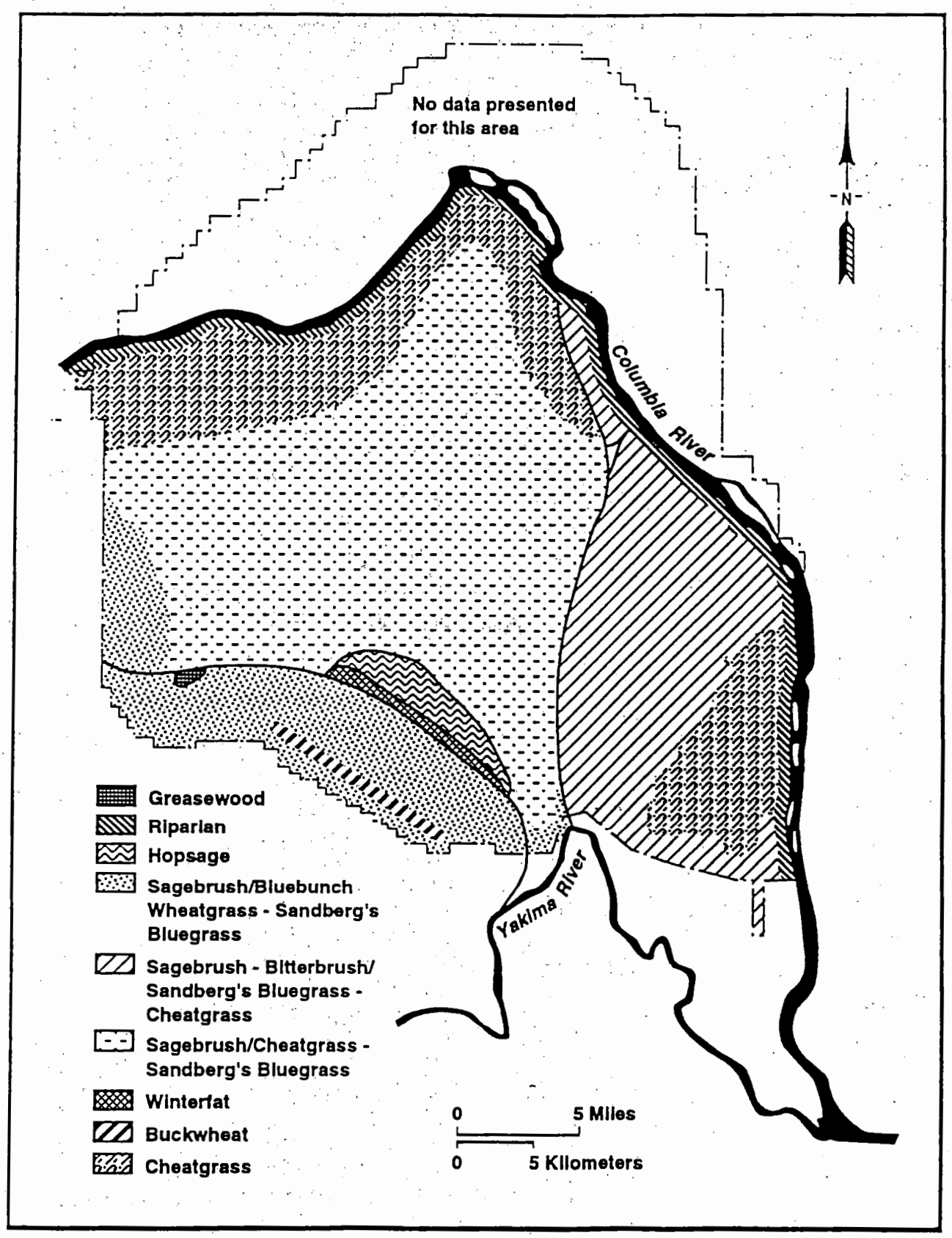
Figure 4-20. Distribution of Vegetation Types on the Hanford Site (Cushing 1995).



4.4.1.1 Columbia River Vegetation. The two major vegetation types occurring along the Hanford Reach of the Columbia River are riparian and upland (NPS 1994). Riparian habitats are found along the shoreline, slack water and slough areas, and islands in the river. Riparian vegetation at these locations includes both woody and herbaceous species maintained by the high water table immediately adjacent to the river. Common plant species occurring in the riparian zone include black cottonwood, mulberry, willow, dogbane, and a variety of grasses and forbs (Cushing 1992). Sensitive habitats within the riparian zone include cobbled shoreline occurring as a narrow band along the Hanford Reach. Plant species occurring in these areas include perennial summer-blooming forbs adapted to seasonal changes in river water levels (NPS 1994). Upland habitats along the Hanford Reach are composed of shrub-steppe vegetation similar to that found in the Reactors on the River and the Central Plateau geographic areas.

4.4.1.2 Reactors on the River Vegetation. The dominant vegetation type in this geographic area of the Hanford Site is cheatgrass associated with tumble mustard. Some of the cheatgrass-tumble mustard vegetation in the 100 Areas occurs on former agricultural lands abandoned since 1943. Other vegetation occurring in the 100 Areas includes riparian plant communities along the Columbia River and scattered groves of nonnative trees. Ecological investigations within the 100-B/C-5 and 100-HR-3 operable units identified the following tree species in the vicinity of the Columbia River: white mulberry, black locust, Siberian elm, apricot, juniper, and willow (WHC 1992d).

4.4.1.3 Central Plateau Vegetation. More than 100 species of plants have been identified on the Central Plateau (Cushing 1992). Common species include sagebrush, rabbitbrush, cheatgrass, and Sandberg's bluegrass. The dominant vegetation type consists of big sagebrush with an understory of cheatgrass and Sandberg's bluegrass (Cushing 1995). Cheatgrass provides approximately 50% of total plant cover. Cheatgrass also is common where native plant communities have been disturbed by wildfire or past construction activities.

Three vegetation subtypes occurring in the vicinity of the 200 West Area of the Central Plateau are sagebrush/Sandberg's bluegrass, sagebrush/needle-and-thread grass, and spiny hopsage/Sandberg's bluegrass. Past wildfires in the Central Plateau have opened up some areas, creating a mosaic of shrub and grass-dominated areas. Grass species include both native and introduced species. Sandberg's bluegrass and cheatgrass are the most common grass species.

Other vegetation includes wetland species associated with man-made ditches and ponds on the Central Plateau and introduced perennial grass planted to revegetate disturbed areas. Wetland species, such as cattail and reeds, and trees, such as willow, cottonwood, and Russian olive, are established around some of these ponds (Cushing 1995). However, several of the ponds have been decommissioned, resulting in the elimination of wetland habitat as the supply of industrial water feeding the ponds was terminated.

Introduced perennial grass (i.e., Siberian wheatgrass) has been used extensively in the Central Plateau to revegetate and stabilize waste burial grounds against wind and water erosion. Siberian wheatgrass has proven to be drought tolerant and better adapted to sandy soils than other cultivars used in the Central Plateau revegetation (WHC 1993).

4.4.1.4 All Other Areas Vegetation. The All Other Areas geographic areas contains developed sections of the Hanford Site, including the 300, 400, and 1100 Areas, and large tracts of undeveloped land. Special topographic features include Gable Butte and Gable Mountain north of the Central Plateau and sand dunes in the southeast portion of the area. The dominant plant communities are cheatgrass, sagebrush-bitterbrush/Sandberg's bluegrass, sagebrush/cheatgrass-Sandberg's bluegrass,

and riparian plant communities (WHC 1992e). Depending on location, many of the terrestrial plants occurring in this area are the same as those found in the adjacent Columbia River, Reactors on the River, and Central Plateau geographic areas.

Big sagebrush, bitterbrush, rabbitbrush, cheatgrass, and Sandberg's bluegrass are common species in the 300 Area and the 400 Area (Cushing 1995). Common plants growing in riparian areas along the Columbia River include reed canarygrass, common witchgrass, large barnyard grass, summer-blooming forbs, sandbar willow, poplar, white mulberry, and Russian olive (NPS 1994). Vegetation occurring on scree slopes, outcrops, and scarps on Gable Butte and Gable Mountain is limited to scattered individuals or groups of plants. Plant species include squaw currant, bluebunch wheatgrass, rock buckwheat, and thyme buckwheat. Rigid sagebrush occurs at the Hanford Site only on Gable Mountain and Umtanum Ridge (PNL 1993b).

4.4.2 Wildlife

Major habitat types occurring on the Hanford Site include basalt outcrops, scarps and screes, riparian and riverine areas, shrub-steppe, sand dunes and blowouts, and abandoned fields (PNL 1993b).

4.4.2.1 Mammals. Approximately 40 species of mammals have been identified on the Hanford Site (Cushing 1995). The largest vertebrate predator inhabiting the Hanford Site is the coyote, which ranges all across the Hanford Site. Coyotes have been a major cause of destruction of Canada goose nests on Columbia River islands, especially islands upstream from the abandoned Hanford townsite. Bobcats and badgers also inhabit the Hanford Site in low numbers.

Black-tailed jackrabbits are common on the Hanford Site, mostly associated with mature stands of sagebrush. Cottontail rabbits also are common but appear to be more closely associated with the buildings, debris piles, and equipment laydown areas associated with the onsite laboratory and industrial facilities.

Townsend's ground squirrels occur in colonies of various sizes scattered across the Hanford Site but marmots are scarce. The most abundant mammal inhabiting the site is the Great Basin pocket mouse. It occurs all across the Columbia River plain and on the slopes of the surrounding ridges. Other small mammals include the deer mouse, harvest mouse, grasshopper mouse, montane vole, vagrant shrew, and Merriam's shrew.

The Hanford Site has seven species of bats that are known to be or are potential inhabitants, most of which may be present year-round. The pallid bat frequents deserted buildings and is thought to be the most abundant of the various species. Other species include the hoary bat, silver-haired bat, California brown bat, little brown bat, Yuma brown bat, and Pacific western big-eared bat.

A herd of Rocky Mountain elk is present on the ALE Reserve. It is believed these animals migrated to the reserve from the Cascade Mountains in the early 1970s. This herd grew from approximately 8 animals in 1975 to approximately 300 animals in 1994 (Cushing 1995). Elk frequently move off the ALE Reserve to private lands located to the north and west, particularly during late spring, summer, and early fall. However, while the elk are on the Hanford Site, they restrict their activities to the ALE Reserve. Lack of water and the high level of human activity presumably inhibit the elk from using other areas of the Hanford Site. Despite the arid climate and their unusual habitat, these elk appear to be very healthy; antler and body size for given age classes

are among the highest recorded for this species (DOE 1995). In addition, reproductive output also is among the highest recorded for this species. Elk remain on the ALE Reserve because of the protection it provides from human disturbance.

Mule deer are found throughout the Hanford Site, although areas of highest concentrations are on the ALE Reserve and along the Columbia River. Deer populations on the Hanford Site appear to be relatively stable. Islands in the Hanford Reach are used extensively as fawning sites by the deer (DOE 1995) and thus are a very important habitat for this species. Hanford Site deer frequently move offsite, and are killed by hunters on adjacent public and private lands (DOE 1995).

4.4.2.2 Birds. In general, bird species on the Hanford Site include a variety of raptors, songbirds, and species associated with riparian, riverine, and upland habitats. Approximately 238 species of birds, including migrants and accidental species, have been observed at or near Hanford (WHC 1992f). Of these, 36 are common species and 40 occur as accidental species.

Twenty-six species of raptors have been sighted on the Hanford Site, 11 of which are known to nest on the Hanford Site (PNL 1981). These include the great horned owl, long-eared owl, short-eared owl, barn owl, burrowing owl, northern harrier, ferruginous hawk, Swainson's hawk, red-tailed hawk, prairie falcon, and American kestrel. In 1994, 41 nests of Swainson's and ferruginous hawks were located across the Hanford Site.

Raptors that may occur onsite year-round on the Hanford Site are the northern harrier, red-tailed hawk, golden eagle, prairie falcon, American kestrel, barn owl, great horned owl, long-eared owl, and burrowing owl (Fitzner and Gray 1991). Raptors use a variety of habitats for nesting and foraging at the Hanford Site. Depending on raptor size and species, prey may include small mammals, birds, reptiles such as snakes, and insects.

A variety of passerine species is known to occur in the shrub-steppe vegetation type on the Hanford Site. These include the loggerhead shrike, sage sparrow, western meadowlark, grasshopper sparrow, horned lark, and sage thrasher. The western meadowlark, sage sparrow, and horned lark are the most abundant shrub-steppe passerine bird species that breed on the Hanford Site (Rickard and Poole 1989). The western meadowlark and horned lark nest on the ground in the open, while shrub-steppe species like the sage sparrow, sage thrasher, and loggerhead shrike require sagebrush or bitterbrush for nesting habitat.

Common upland game bird species include the chukar, California quail, and ring-necked pheasant. Sage grouse and gray partridge are less common and rarely seen. Sage grouse populations have declined since the early 1800's because of the conversion of shrub-steppe habitat. Surveys conducted by the Washington Fish and Wildlife Service and the Pacific Northwest National Laboratory during 1993 did not reveal the presence of sage grouse on the ALE Reserve (Cushing 1995).

4.4.2.3 Reptiles and Amphibians. Twelve species of reptiles and amphibians are known to occur on the Hanford Site (Cushing 1995). The occurrence of these species is infrequent when compared with similar fauna of the southwestern United States. The side-blotched lizard is the most abundant reptile and can be found throughout the Hanford Site. Short-horned and sagebrush lizards are also common in selected habitats. The most common snakes are the gopher snake, the yellow-bellied racer, and the Pacific rattlesnake, all found throughout the Hanford Site. Striped whipsnakes and desert night snakes are rarely found, but some sightings have been recorded for the site. Toads and frogs are found near the permanent water bodies and along the Columbia River.

4.4.2.4 Insects. Approximately 600 species of terrestrial and aquatic insects have been found on the Hanford Site (Cushing 1995). Grasshoppers and darkling beetles are among the more conspicuous groups and, together with other species, are important in the food web of the local birds and mammals. Most species of darkling beetles occur throughout the spring to fall period, although some species are present only during two or three months in the fall (PNL 1977). Grasshoppers are evident during the late spring to fall. Both beetles and grasshoppers are subject to wide annual variations in abundance.

4.4.3 Wildlife Use by Geographic Area

4.4.3.1 Columbia River. Terrestrial wildlife species use both shoreline riparian and shrub-steppe habitats occurring along the Columbia River and on the islands occurring in the Hanford Reach. Wildlife reported to use the Hanford Reach include 184 species of birds, 36 species of mammals, 9 species of reptiles, and 4 species of amphibians (NPS 1994). The Canada goose uses islands along the Hanford Reach extensively for nesting. Studies on the nesting habits of geese that use the Hanford Site have been ongoing since 1953. These studies indicate a general decline over the years in numbers of nests on islands in the Hanford Reach because of heavy predation by coyotes (Cushing 1995). Mule deer use the islands and other riparian areas for fawning habitat. Wildlife occurring on shoreline habitat includes 46 species that use willow communities and 49 that use grass areas (NPS 1994). Wildlife species using riparian habitats along the Columbia River include a variety of waterfowl, shorebirds, passerine birds, and mammals.

4.4.3.2 Reactors on the River. Terrestrial wildlife species found in the Reactors on the River geographic area (100 Areas) generally are the same ones found across the Hanford Site (Cushing 1992). The largest vertebrate predator is the coyote, which can be found anywhere on the Hanford Site. Coyotes occurring along the Columbia River reportedly feed on carp and small mammals such as the Great Basin pocket mouse, northern pocket gopher, Nuttall's cottontail, and black-tailed jack rabbit (Fitzner and Gray 1991). Mule deer may occur almost anywhere on the Hanford Site but prefer habitats along the Columbia River where riparian areas provide abundant food and cover. Mule deer forage on mulberry, Russian olive, cottonwood trees, and shrubs such as willow (WHC 1992g).

Wildlife likely to occur in riparian habitat in the 100 Areas adjacent to the Columbia River include a variety of birds, mammals, reptiles, and amphibians (Fitzner and Gray 1991). The three known species of amphibians at the Hanford Site use riparian habitat along permanent water bodies and the Columbia River. Medium-size mammals using riparian habitat are the muskrat, raccoon, beaver, weasel, skunk, otter, and porcupine; small mammals include the vagrant shrew and montane meadow mouse. Upland birds likely to occur in habitats in the 100 Areas along the Columbia River are the California quail and ring-necked pheasant (Cushing 1992). Trees along the river, including those found in the 100 Areas, provide habitat for several species of birds. These include the great blue heron, which has colonial nest sites (rookeries) near the White Bluffs ferry landing, and the bald eagle, which uses selected trees for perching and night roosts during the winter (Cushing 1995).

4.4.3.3 Central Plateau. Terrestrial wildlife species common to the Hanford Site also can be found in the Central Plateau (Cushing 1992). A characterization study of small mammals occurring in the 200 East and 200 West Areas near the B-C Cribs resulted in five species being trapped: Great Basin pocket mouse, deer mouse, northern grasshopper mouse, sagebrush vole, and western harvest mouse (PNL 1977). Data from these studies indicate that the Great Basin pocket mouse represents more than 90% of the mammals caught. Medium and large-size mammals that may occur in the Central

Plateau include rabbits, coyotes, badgers, and mule deer (PNL 1977). Mammals potentially using riparian areas associated with ponds and ditches in the 200 East and 200 West Areas include muskrats, porcupines, and raccoons.

Of the 238 species of birds observed on the Hanford Site, many common species such as the western meadowlark and sage sparrow are likely to occur on the Central Plateau where suitable habitats exist. Thirty-seven species of terrestrial birds were recorded during surveys conducted in the 200 East and 200 West Areas of the Hanford Site in 1986 (Schuller et al. 1993). Bird studies associated with wastewater ponds in the Central Plateau reveal that a large number of species, particularly waterfowl, use these ponds during migration (PNL 1977).

4.4.3.4 All Other Areas. Wildlife species occurring in this geographic area are similar to those found elsewhere on the Hanford Site. The 300 Area, for example, closely resembles the 100 Areas in terms of terrestrial ecology because of its proximity to the Columbia River. Unique habitats can be found on Gable Butte and Gable Mountain situated north of the Central Plateau. These unique habitats include basalt outcrops, scarps, and scree slopes. Birds likely to occur in these habitats are the prairie falcon, rock wren, poorwill, and chukar; small mammals include the yellow-bellied marmot and wood rat; reptiles include rattlesnakes, gopher snakes, and horned lizards (PNL 1993b).

4.4.4 Aquatic Species and Habitat

There are two types of natural aquatic habitats on the Hanford Site: one is the Columbia River, which flows along the northern and eastern edges of the Hanford Site, and the other is provided by the small spring-streams and seeps located mainly in the Rattlesnake Hills. Several artificial water bodies, both ponds and ditches, have been formed as a result of wastewater disposal practices associated with the operation of the reactors and separation facilities. These bodies of water are temporary and will vanish with cessation of activities, but while present, the ponds form established aquatic ecosystems (except West Pond) complete with representative flora and fauna (DOE 1995). West Pond is created by a rise in the water table in the 200 East and 200 West Areas and is not fed by surface flow; thus, it is alkaline and has low species diversity.

Forty-four species of fish representing 13 families are known to occur in the Hanford Reach. Since 1977, one additional fish, the brown bullhead (*Ictalurus nebulosus*), has been collected from the Hanford Reach (Cushing 1995). Of these species, chinook salmon, sockeye salmon, coho salmon, and steelhead trout use the river as a migration route to upstream spawning areas. Other fish of importance to sport fishermen are whitefish, sturgeon, smallmouth bass, catfish, walleye, and perch. Large populations of rough fish also are present, including carp, shiners, suckers, and squawfish (Cushing 1995).

The Hanford Reach represents the only remaining significant mainstream Columbia River spawning habitat for stocks of upriver bright fall chinook salmon (PNL 1990a). Fall chinook salmon are known to spawn throughout the Hanford Reach. Since 1948, an annual census of salmon spawning on the Hanford Reach indicates that over 60% of fall chinook spawning occurs at Vernita Bar and the Locke Island area near White Bluffs (PNL 1993b). The numbers of fall chinook spawning sites (redds) in the Hanford Reach increased between the late 1940s and the 1980s. In 1988, the Hanford Reach served as the spawning area for 50 to 60% of the total fall chinook salmon runs in the Columbia River (Cushing 1995).

Aquatic plants in the Hanford Reach include water milfoil, waterweed, pondweed, Columbia yellowcress, watercress, and duckweed (Cushing 1995). Aquatic plants generally are more prevalent where currents are less swift (i.e., in slack water areas like sloughs) (WHC 1992g). Aquatic plants are important to resident fish because they provide food, cover, and spawning areas for a variety of species. Water milfoil, an aggressive introduced aquatic plant, is becoming a nuisance in the Columbia River because of its rapid growth and lack of natural control.

Other aquatic species found in the Hanford Reach include a variety of microflora, zooplankton, and benthic invertebrates. Microflora include both sessile types (periphyton) and free-floating types (phytoplankton). Microflora species include diatoms, golden or yellow-brown algae, green algae, blue-green algae, red algae, and dinoflagellates. Dominant zooplankton taxa include *Bosmina*, *Diaptomus*, and *Cyclops*. Benthic invertebrate taxa occurring in the Hanford Reach include insect larvae such as caddisflies, midge flies, and black flies; snails; freshwater sponges; limpets; and crayfish (Cushing 1995).

The small spring streams, such as Rattlesnake and Snively springs, contain diverse biotic communities and are extremely productive (DOE 1995). Dense blooms of watercress occur and are not lost until one of the major flash floods occurs. The aquatic insect production is fairly high as compared to that in mountain streams (DOE 1995). The macrobenthic biota varies from site to site, and is related to the proximity of colonizing insects and other factors.

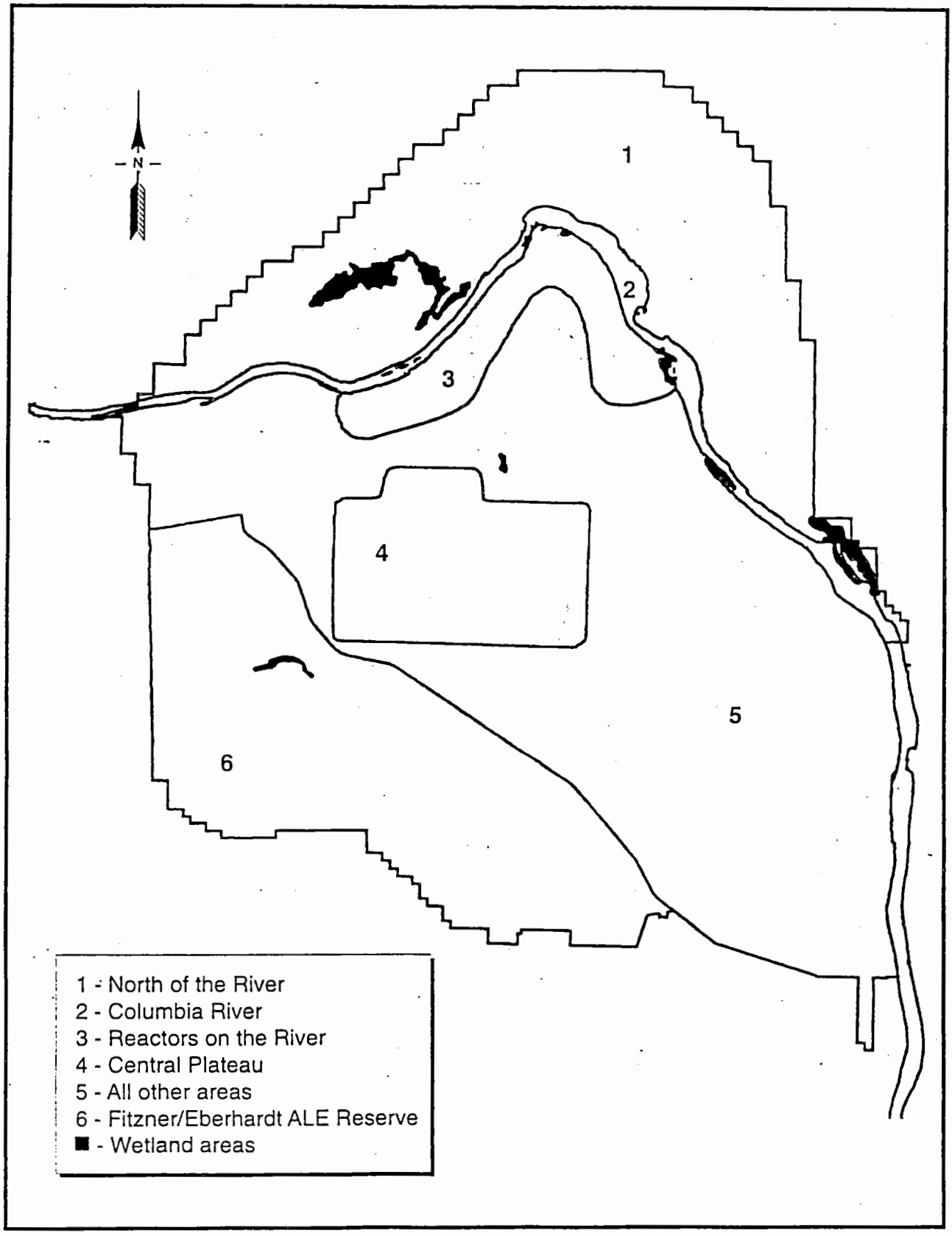
4.4.5 Wetland Habitat

Wetlands include those transitional lands occurring between terrestrial and aquatic ecosystems (Figure 4-21) where the water table usually is close to the surface or where shallow water covers the surface (Cowardin et al. 1979). The primary jurisdictional wetlands found on the Hanford Site occur along the Hanford Reach, and include the riparian and riverine habitats located along the river shoreline. Riparian habitat includes the uplands immediately adjacent to the Hanford Reach or its backwater sloughs and supports vegetation typical of a high water table (NPS 1994). Common riparian species found along the Hanford Reach include a variety of woody and herbaceous plant species.

Other wetland habitats found on the Hanford Site are associated with man-made ponds and ditches occurring on the Hanford Site. Included are the B Pond Complex located near the 200 East Area, and a small cooling and wastewater pond at the FFTF in the 400 Area. The B Pond complex was constructed in 1945 to receive cooling water from facilities in that area. Since that time, effluent flow to the B Pond has largely halted. Only one lobe of the pond is currently receiving cooling water; the rest of the B Pond Complex is slowly reverting to a shrub-steppe ecosystem.

West Lake, a shallow, highly saline and alkaline pond located southwest of Gable Mountain, fluctuates in size with changes in the water table (PNL 1991b) and is currently less than 5 acres (conversion) in size. Unlike other ponds on the Hanford Site, West Lake does not receive direct effluent discharges from Hanford Site facilities (PNL 1993a). Wetland vegetation found at West Lake is limited to scattered patches of emergent macrophytes such as cattails and bulrushes.

Figure 4-21. Wetlands on the Hanford Site (Cushing 1995).



4.4.6 Species of Concern on the Hanford Site

Species of concern on the Hanford Site include federally-listed threatened and endangered species, federal candidate species, state threatened or endangered species, state candidate species, and state monitor species. No plants or mammals on the Federal List of Endangered and Threatened Wildlife and Plants (50 CFR 17) are known to occur on the Hanford Site. There are, however, three species of birds that are federally listed, and several species of plants and animals that are under consideration for formal listing by the Federal Government and Washington State. Candidate species occurring on the Hanford Site are currently treated as though they are threatened and endangered, based on guidance provided by the USFWS. Species of concern occurring on the Hanford Site are listed in Tables 4-6 and 4-7; the tables also include definitions of each category of species of concern found on the Hanford Site.

4.4.6.1 Columbia River Species of Concern. No federally listed threatened or endangered plant species occur on the Hanford Reach. State endangered plant species occurring along the Hanford Reach include the Columbia yellowcress (also federal candidate Category 2). Preferred habitat for Columbia yellowcress is shoreline areas with gently sloping, cobbly, or sandy substrate (PNL 1993b). Wetland species that have been found along the shoreline and on islands of the Hanford Reach between the Vernita Bridge and the 300 Area include the southern mudwort, dense sedge, and shining flatsedge (WHC 1992h), all of which are state-sensitive species.

Wildlife species of concern that may occur along the Hanford Reach include several species of birds associated with riparian and aquatic habitat (PNL 1993b). Federally listed threatened and endangered birds include the Aleutian Canada goose, peregrine falcon, and bald eagle. The Aleutian Canada goose and the peregrine falcon are rare migrants or accidental species on the Hanford Site (PNL 1993b). Federal candidate Category 2 species include the black tern and trumpeter swan. Both of these species have been reported, but seldom observed, on the Hanford Site (Cushing 1995). Other bird species of concern (see Table 4-7) occurring along the Hanford Reach include the Arctic Tern, black-crowned night heron, black-necked stilt, Caspian tern, Clark's grebe, common loon, Forster's tern, great blue heron, great egret, horned grebe, osprey, red-necked grebe, western grebe, and sandhill crane (PNL 1993b). Bird species of concern occurring along the Hanford Reach that are considered relatively common include the American white pelican, bald eagle, Caspian tern, common loon, Forster's tern, great blue heron, and sandhill crane, while other species discussed are rare migrants or accidental species on the Hanford Site (Fitzner and Gray 1991).

4.4.6.2 Reactors on the River Species of Concern. A state-endangered and federal candidate plant species, the northern wormwood may occur in the 100 Areas but has not yet been found. State sensitive plant species that are known to occur in the 100 Areas are Piper's daisy, southern mudwort, false pimpernel, dense sedge, and shining flatsedge (WHC 1992h). Columbia yellowcress, southern mudwort, false pimpernel, dense sedge, and shining flatsedge occur in wetland areas, while northern wormwood and Piper's daisy are upland species.

Table 4-6. Plant Species of Concern Occurring on the Hanford Site (Cushing 1995).

Common Name	Scientific Name	Federal Status	State Status
Columbia milk-vetch	*Astragalus columbianus*	C1	T
Columbia yellowcress	*Rorippa columbiae*	C2	E
Hoover's desert parsley	*Lomatium tuberosum*	C2	T
Northern wormwood	*Artemisia campestris borealis* var. *wormskioldii*	C1	E
Bristly cryptantha	*Cryptantha interrupta*		M2
Columbia River mugwort	*Artemisia lindleyana*		M3
Crouching milkvetch	*Astragalus succumbens*		M3
Dense sedge	*Carex densa*		S
Desert evening primrose	*Oenothera cespitosa*		S
False pimpernel	*Lindernia anagallidea*		S
Fuzzy-beard tongue penstemon	*Penstemon eriantherus*		M3
Gray cryptantha	*Cryptantha leucophaea*		S
Medic milkvetch	*Astragalus speirocarpus*		M3
Palouse thistle	*Cirsium brevifolium*		M3
Piper's daisy	*Erigeron piperianus*		S
Robinson's onion	*Allium robinsonii*		M3
Rosy balsamroot	*Balsamorhiza rosea*		M3
Shining flatsedge	*Cyperus rivularis*		S
Smooth cliffbrake	*Pellaea glabella*		M3
Southern mudwort	*Limosella acaulis*		S
Squill onion	*Allium scillioides*		M3
Stalked-pod milkvetch	*Astragalus sclerocarpus*		M3
Thompson's sandwort	*Arenaria franklinii* v. *thompsonii*		M2
Tooth-sepal dodder	*Cuscuta denticulata*		M1
The following species may inhabit the Hanford Site, but have not been recently collected, and the known collections are questionable in terms of location and/or identification.			
Coyote tobacco	*Nicotiana attenuata*		S
Few-flowered blue-eyed Mary	*Collinsia sparsiflora*		S
Palouse milkvetch	*Astragalus arrectus*		S

C1 = Taxa for which the U.S. Fish and Wildlife Service has enough substantial information on biological vulnerability to support proposals to list them as endangered or threatened species. Listing is anticipated but has temporarily been precluded by other listing activity.

C2 = Taxa for which current information indicates that proposing to list as endangered or threatened is possibly appropriate, but for which conclusive data on biological vulnerability are not available to support listing. The U.S. Fish and Wildlife Service will not propose listing unless additional supporting information becomes available.

E = Endangered. A species native to Washington State that is seriously threatened with extinction throughout all or a significant portion of its range within the state. Endangered specie are designated legally in WAC 232-12-014.

M1 = Monitor group 1. Taxa for which there are insufficient data to support listing as threatened, endangered, or sensitive.

M2 = Monitor group 2, i.e., taxa with unresolved taxonomic questions.

M3 = Monitor group 3, i.e., taxa that are more abundant and/or less threatened than previously assumed.

S = Sensitive, i.e., taxa vulnerable or declining, and could become endangered or threatened without active management or removal of threats.

T = Threatened. A species native to Washington State likely to become endangered within the foreseeable future throughout significant portions of its range within the state without cooperative management or the removal of threats. Threatened species are designated legally in WAC 232-12-011.

Table 4-7. Wildlife Species of Concern Occurring on the Hanford Site (Cushing 1995). (2 sheets)

Common Name	Scientific Name	Federal Status	State Status
Molluscs			
Columbia pebble snail	*Fluminicola* (= *Lithoglyphus*) columbiana	C2	C
Shortfaced lanx	*Fisherola* (= *Lanx*) *nuttalli*	C3	C
Birds			
Aleutian Canada goose[b]	*Branta canadensis leucopareia*	T	E
American white pelican	*Pelecanus erythrorhychos*		E
Bald eagle	*Haliaeetus leucocephalus*	T	T
Ferruginous hawk	*Buteo regalis*		T
Peregrine falcon[b]	*Falco peregrinus*	E	E
Sandhill crane[b]	*Grus canadensis*		E
Black tern[b]	*Chlidonius niger*	C2	
Burrowing owl	*Athene cunicularia*		C
Common loon	*Gavia immer*		C
Ferruginous hawk	*Buteo regalis*	C2	
Flammulated owl[b]	*Otus flammeolus*		C
Golden eagle	*Aquila chrysaetos*		C
Lewis' woodpecker[b]	*Melanerpes lewis*		C
Loggerhead shrike	*Lanius ludovicianus*	C2	C
Long-billed curlew	*Numenius americanus*	C3	
Northern goshawk[b]	*Accipter gentilis*	C2	C
Sage sparrow	*Amphispiza belli*		C
Sage thrasher	*Oreoscoptes montanus*		C
Swainson's hawk	*Buteo swainsoni*		C
Trumpeter swan[b]	*Cygnus columbianus*	C2	
Western bluebird[b]	*Sialia mexicana*		C
Western sage grouse[b]	*Centrocercus urophasianus phaios*	C2	C
Insects			
Columbia River tiger beetle[c]	*Cicindela colubica*		C
Oregon silverspot butterfly[a]	*Speyerna zerone*	T	T
Reptiles			
Striped whipsnake	*Masticophis taeniatus*		C

Table 4-7. Wildlife Species of Concern Occurring on the Hanford Site (Cushing 1995). (2 sheets)

Common Name	Scientific Name	Federal Status	State Status
Mammals			
Merriam's shrew	*Sorex merriami*		C
Pacific western big-eared bat[c]	*Plecotus townsendii townsendii*	C2	C
Pygmy rabbit[a]	*Brachylagus idahoensis*	C2	E

C = Candidate. A wildlife species native to Washington State that the Department of Wildlife will review for possible listing as endangered, threatened, or sensitive.

C1 = Taxa for which the U.S. Fish and Wildlife Service has enough substantial information on biological vulnerability to support proposals to list them as endangered or threatened species. Listing is anticipated but has temporarily been precluded by other listing activity.

C2 = Taxa for which current information indicates that proposing to list as endangered or threatened is possibly appropriate, but for which conclusive data on biological vulnerability are not available to support listing. The U.S. Fish and Wildlife Service will not propose listing unless additional supporting information becomes available.

C3 = Taxa that were once considered for listing as endangered or threatened (i.e., in categories 1 or 2) but are no longer current candidates for listing. Such taxa are further subdivided into three categories that indicate why they were removed from consideration.

E = Endangered. A species that is seriously threatened with extinction throughout all or a significant portion of its range. Endangered specie are designated legally in WAC 232-12-014.

T = Threatened. A species that is likely to become endangered within the foreseeable future throughout significant portions of its range without cooperative management or the removal of threats. Threatened species are designated legally in WAC 232-12-011.

[a]Likely not currently occurring on the Hanford Site.

[b]Reported, but seldom observed, on the Hanford Site.

[c]Probable, but not observed, on the Hanford Site.

The bald eagle, a federal and Washington State threatened species, is the only federally listed wildlife species known to regularly use the 100 Areas. Bald eagles use groves of trees including black locust, white poplar, and Siberian elm near the White Bluffs peninsula along the Hanford Reach for perching and night roosts (PNL 1993b). Daytime perching areas used by bald eagles are trees along the Hanford Reach from the Hanford townsite upstream to Vernita Bridge (PNL 1991a). Other sensitive bird species occurring in the 100 Areas include the great blue heron and long-billed curlew. Great blue herons (a state monitor species) nest in trees along the Hanford Reach. During 1993, three great blue heron rookeries were located on the Hanford Site within the Hanford Reach (Cushing 1995). Long-billed curlews (a state monitor species) also nest in the 100 Areas near the 100-D, 100-F, and 100-H Areas (WHC 1992i).

Sensitive mammals using the 100 Areas include the pallid bat (a Washington state monitor species). Colonial nesting by this species occurs in old buildings near the 100-F Area (WHC 1992i). The Pacific western big-eared bat, a federal candidate Category 2 species, could potentially use reactor buildings in the 100 Areas for roosting, but its presence has not been confirmed (PNL 1991a).

4.4.6.3 Central Plateau Species of Concern. No federal or state listed threatened or endangered plant or animal species occur in the Central Plateau. Piper's daisy (a state sensitive species) has been found at B Pond near the 200 East Area, and may occur in sagebrush-steppe habitat elsewhere on the Hanford Site (WHC 1992e). Dwarf evening primrose (a state sensitive species) has been found on mechanically disturbed areas near the Wye Barricade (Cushing 1995).

Wildlife species of concern occurring in the 200 East and 200 West Areas include the loggerhead shrike (a federal and state candidate species) and sage sparrow (a state candidate species). Both species nest in undisturbed sagebrush habitat in the Central Plateau (PNL 1993b). Other bird species of concern that may occur in shrub-steppe habitat in the Central Plateau are the burrowing owl (a state candidate species), ferruginous hawk (a state threatened and federal candidate Category 2 species), golden eagle (a state candidate species), long-billed curlew (a state monitor species), and Swainson's hawk (a state candidate species). Reptile species of concern using the Central Plateau include the striped whipsnake (state candidate species), and the desert night snake (state monitor species) (PNL 1977).

4.4.6.4 All Other Areas Species of Concern. Plant species of concern include three federal candidate Category 2 species: the Columbia milk-vetch, Columbia yellowcress, and Hoover's desert-parsley. Columbia yellowcress also is a state endangered species while Columbia milk-vetch and Hoover's desert-parsley also are listed as state threatened plants. State sensitive plants in this area include dense sedge, gray cryptantha, Piper's daisy, and dwarf evening-primrose. Columbia yellowcress and dense sedge are known to occur in wetland habitats along the Columbia River while the other species of concern are found on upland habitats (WHC 1992h).

Wildlife species of concern occurring in this area include the ferruginous hawk, Swainson's hawk, and loggerhead shrike (PNL 1993b). Sensitive wildlife species include the long-billed curlew, burrowing owl, sage sparrow, sage thrasher, grasshopper sparrow, and golden eagle. All of these species except the golden eagle nest on the Hanford Site (Fitzner and Gray 1991).

4.4.7 Biodiversity

Biodiversity has been defined as the diversity of ecosystems, species, and genes, and the variety and variability of life (CEQ 1993). Major components of biodiversity are plant and animal species, microorganisms, ecosystems and ecological processes, and the interrelationships between and among these components. Biodiversity also is a qualitative measure of the richness and abundance of ecosystems and species in a given area (NPS 1994).

Factors contributing to biodiversity on the Hanford Site include one of the largest undisturbed tracts of native shrub-steppe habitat left in Washington State and the Hanford Reach, which is the last free-flowing nontidal stretch of the Columbia River in the United States (Cushing 1995). Other factors include topographic features such as Rattlesnake Mountain, Gable Butte, and Gable Mountain; a variety of soil textures ranging from sand to silty and sandy loam; and the lack of human use and development over much of the Hanford Site. Specialized terrestrial habitats contributing to the biodiversity of the Hanford Site include areas of sagebrush-steppe, basalt outcrops, scarps (cliffs), scree slopes, and sand dunes. Aquatic components of biodiversity are mainly associated with the Columbia River and include aquatic habitat, wetland and riparian areas, and riverine habitat along Hanford Reach shoreline and islands in the Columbia River. Ecologically important plant and animal species on Hanford include species of concern; commercial and recreational wildlife species such as anadromous fish, mule deer, and upland game birds; and plant species used as a source of food, medicine, fiber, and dye by native peoples of the Columbia Basin (WHC 1992d).

In 1992, the DOE and The Nature Conservancy entered into a memorandum of understanding that called for a cooperative and coordinated inventory of plants, animals, and ecologically significant areas at the Hanford Site. In 1994, the DOE awarded The Nature Conservancy a grant to conduct a partial inventory of the Hanford Site on the ALE Reserve and the North Slope, which occurred from

March 1994 to March 1995. Findings from the 1994 biodiversity inventory show that the Hanford Site supports a rich mosaic of relatively unaltered and increasingly uncommon native habitats, the quality and extent of which are unequaled within the Columbia Basin (TNC 1995). Significant numbers of plant, bird, and insect species, many of which are rare or in decline in Washington, were found to be associated with or dependent on these habitats. The Hanford Site serves as a genetic bank for both the common and unusual plants and animals that comprise the shrub-steppe ecosystem. This initial inventory can provide only a rough indication of the quality of biodiversity that is to be found on the main part of the Hanford Site, which is more extensively disturbed than the ALE Reserve or the North Slope. Further inventories of plant communities, rare plants, birds, and insects would broaden the scope of the first inventory effort. It is hoped that additional inventories can be performed of the main part of the Hanford Site and include studies of small mammals, reptiles and amphibians, and nonvascular plants.

The Hanford Site has not been farmed or grazed by livestock for over 50 years, allowing the Hanford Site to serve as a refuge for various plant and animal species (Cushing 1995). However, the invasion and spread of nonnative plant species into previously disturbed areas such as abandoned farmland represent a potential threat to biodiversity through displacement of native species, simplification of plant communities, and fragmentation of habitat. Introduced plant species account for approximately 21% of the vascular plants found on the Hanford Site and include species such as cheatgrass, Russian thistle, and most of the tree species found on the Hanford Site (WHC 1992e). Most of the disturbed areas on Hanford, including abandoned farmland and areas burned by wildfire, are dominated by pure stands of cheatgrass where the native shrub component has been modified severely or replaced altogether (Cushing 1992).

Human activities may have profound effects on the biodiversity of an ecosystem or community. Among other factors, these human activities include habitat modification or destruction and habitat fragmentation. Destruction or modification of a habitat can occur when undisturbed areas are harvested or converted to other uses, such as agriculture or industrial facilities. Habitat fragmentation occurs when disturbed areas break up a large community into smaller isolated undisturbed areas. When fragmentation occurs, biodiversity is impacted because the smaller undisturbed areas may not be capable of supporting the same number of species. The edges of the undisturbed area also may be strongly affected by proximity to the disturbed area, further reducing the size of the area that is truly undisturbed. Furthermore, the disturbed areas may serve as migration barriers for some species, effectively blocking recolonization of areas where small localized extinctions have occurred. Areas such as the Hanford Site serve to preserve regional biodiversity by providing refuges for species that have been eliminated by human activities in the surrounding countryside.

4.5 Cultural Resources

The Hanford Site is known to be rich in cultural resources. It contains numerous, well-preserved archaeological sites representing both the prehistoric and historical periods and is still thought of as a homeland by many Native American people. Management of Hanford's cultural resources follows the *Hanford Cultural Resources Management Plan* (PNL 1989) and is conducted by the Hanford Cultural Resources Laboratory of Pacific Northwest National Laboratory. The Plan contains contingency guidelines for handling the discovery of previously unknown cultural resources encountered during construction activities.

Cultural resources are defined as any prehistoric or historic district, site, building, structure, or object considered to be important to a culture, subculture, or community for scientific, traditional, religious or any other reason. These are usually divided into three major categories: prehistoric and historic archaeological resources, architectural resources, and traditional cultural resources. Significant cultural resources are those that are eligible or potentially eligible to the National Register of Historic Places (National Register).

Consultation is required to identify the traditional cultural properties that are important to maintaining the cultural heritage of Native American Tribes. Under the Treaties of 1855, lands ultimately occupied by the Hanford Site were ceded to the United States by the Confederated Tribes and Bands of the Yakama Indian Nation, and Confederated Tribes of the Umatilla Indian Reservation. Under the treaties, the Native American Tribes retained the rights to perform certain activities on ceded lands, including the rights to hunt, fish, gather foods and medicines, and pasture livestock on open and unclaimed lands. The Nez Perce Tribe's treaty with the U.S. Government retained their rights to fish at all usual and accustomed places, including the Hanford Reach. The Wanapum, although they never signed a treaty, claim similar rights on the Hanford Site.

The methodology for identifying, evaluating, and mitigating impacts to cultural resources is defined by federal laws and regulations including the *National Historic Preservation Act of 1966*, the *Archaeological Resources Protection Act of 1979*, the *Native American Graves Protection and Repatriation Act of 1990* and the *American Indian Religious Freedom Act of 1978*. A project affects a significant resource when it alters the property's characteristics, including relevant features of its environment or use, that qualify it as significant according to the National Register criteria. These effects may include those listed in 36 CFR 800.9. Impacts to traditional Native American properties can be determined only through consultation with the affected Native American groups.

Currently, 645 cultural resource sites and isolated finds are recorded in the files of the Hanford Cultural Resources Laboratory (Cushing 1995). Forty-eight archaeological sites and one building are included on the National Register. National Register nominations have been prepared for several archaeological districts and sites considered to be eligible for listing on the National Register.

4.5.1 Prehistoric Archaeological Resources

People have inhabited the Middle Columbia River region since the end of the glacial period. More than 10,000 years of prehistoric human activity in this largely arid environment have left extensive archaeological deposits along the river shores (Cushing 1995). Well-watered areas inland from the river show evidence of concentrated human activity, and recent surveys indicate extensive, although dispersed, use of arid lowlands for hunting. Graves are common in various settings, and spirit quest monuments can still be found on high, rocky summits of the mountains and buttes (Cushing 1995). Throughout most of the region, hydroelectric development, agricultural activities, and domestic and industrial construction have destroyed or covered the majority of these deposits. Amateur artifact collectors have had an immeasurable impact on what remains. Within the Hanford Site, from which the public is restricted, archaeological deposits found in the Hanford Reach and on adjacent plateaus and mountains have been spared some of the disturbances that have befallen other sites. The Hanford Site is thus a de facto reserve of archaeological information of the kind and quality that has been lost elsewhere in the region.

Currently 283 prehistoric archaeological sites have been found on the Hanford Site, 17 of which contain historic components. Of 48 sites included on the National Register, two are single sites,

Hanford Island Site (45BN121) and Paris Site (45GR317), and the remainder are located in seven archaeological districts (Table 4-8). In addition, four other historic properties have been nominated, or are planned to be nominated to the National Register (Table 4-9). Archaeological sites include remains of numerous pithouse villages, various types of open campsites, and graves along the river banks, spirit quest monuments (rock cairns), hunting camps, game drive complexes, and quarries in mountains and rocky bluffs, hunting/kill sites in lowland stabilized dunes, and small temporary camps near perennial sources of water located away from the river (Cushing 1995).

Many recorded sites were found during four archaeological reconnaissance projects conducted between 1926 and 1968. Systematic archaeological surveys conducted from the middle 1980s through 1993 are responsible for the remainder. Little excavation has been conducted at any of the sites, and the Mid-Columbia Archaeological Society has done most of that work. They have conducted minor test excavations at several sites on the river banks and islands and a larger scale test at site 45BN157 (Cushing 1995). The University of Idaho also excavated a portion of site 45BN179 (Rice 1980) and collaborated with the Mid-Columbia Archaeological Society on its other work. Test excavations have been conducted by the Hanford Cultural Resources Laboratory at several sites, results support assessments of significance for those sites. Most of the archaeological survey and reconnaissance activity has concentrated on islands and on a strip of land less than 400 m (1,310 ft) wide on either side of the river, but this is changing because of a Hanford Cultural Resources Laboratory effort to inventory a 10% sample of the site. The 100 Areas were surveyed in 1991 through 1993, revealing a large number of new archaeological sites (DOE 1995). To date only about 6% of the Hanford Site has been surveyed. Cultural resource reviews are conducted when projects are proposed in areas that have not been previously reviewed. About 100 to 120 reviews were conducted annually through 1991; this figure rose to more than 500 reviews during 1994 (Cushing 1995).

4.5.2 Native American Cultural Resources

In prehistoric and early historic times, the Hanford Reach was heavily populated by Native Americans of various tribal affiliations. The Wanapum people and the Chamnapum band of the Yakama tribe dwelt along the Columbia River from south of Richland upstream to Vantage (DOE 1995). Some of their descendants still live nearby at Priest Rapids, and others have been incorporated into the Yakama and Umatilla reservations. Palus people, who lived on the lower Snake River, joined the Wanapum and Chamnapum to fish the Hanford Reach, and some inhabited the river's east bank (DOE 1995). Walla Walla and Umatilla people also made periodic visits to fish in the area. These people retain traditional secular and religious ties to the region, and many, young and old alike, have knowledge of the ceremonies and lifeways of their aboriginal culture. The Washani, or Seven Drums religion, which has ancient roots and had its start on what is now the Hanford Site, is still practiced by many people on the Yakama, Umatilla, Warm Springs, and Nez Perce reservations. Native plant and animal foods, some of which can be found on the Hanford Site, are used in the ceremonies performed by sect members (Cushing 1995).

During public scoping of this EIS, tribal members emphatically expressed their interest in renewing their use of these resources in accordance with the Treaties of 1855. The DOE is assisting them in this effort. Certain landmarks, such as Rattlesnake Mountain, Gable Mountain, Gable Butte, and various sites along the Columbia River, are sacred to them. Native American people also consider numerous burial sites along the Columbia River to be sacred (Cushing 1992). Given the secular and nonsecular ties and beliefs that Native Americans ascribe to this portion of the Columbia

Table 4-8. Archaeological Districts (with their archaeological sites) and Historic Properties on the Hanford Site Listed on the National Register of Historic Places.

District/Property Name	Site(s) Included
Wooded Island A.D.	45BN107 through 45BN112, 45BN168
Savage Island A.D.	45BN116 through 45BN119, 45FR257 through 45FR262
Hanford Island Site	45BN121
Hanford North A.D.	45BN124 through 45BN134, 45BN178
Locke Island A.D.	45BN137 through 45BN140, 45BN176, 45GR302 through 45GR305
Ryegrass A.D.	45BN149 through 45BN157
Paris Site	45GR317
Rattlesnake Springs A.D.	45BN170, 45BN171
Snively Canyon A.D.	45BN172, 45BN173
100-B Reactor	NA

A.D. = archaeological district (this table).
NA = not applicable.

Table 4-9. Historic Properties on the Hanford Site Nominated, or Prepared for Nomination, to the National Register of Historic Places.

Property Name[a]	Site(s) Included
Coyote Rapids A.D.[b,c]	45BN152, 45GR312 through 45GR314
Gable Mountain/Gable Butte Archaeological Site[a,b,c]	45BN348 through 45BN363, 45BN402 through 45BN410
Hanford South A.D.[c,d]	45BN026 through 45BN036; 45BN040 through 45BN045; 45BN101 through 45BNN112; 45BN162 through 45BN168; 45BN191, 45BN192; 45FR019 through 45FR025; 45FR251 through 45FR253, and 45FR308
Wahluke A.D.[b,c]	45BN141 through 45BN148; 45GR306A, 45GR306B, 45GR307C

[a]Nomination forms have been prepared.
[b]Nominated; rejected because of lack of documentation; renomination is pending.
[c]Archaeological District is listed on the Washington State Register of Historic Places.
[d]Nominated; rejected because of technical issues and unresolved questions involving ownership of lands included in the nomination.
A.D. = archaeological district (this table).

River Basin, the entire Hanford Site could be considered to be of traditional cultural significance under National Park Service *Guidelines for Evaluating and Documenting Traditional Cultural Properties* (Parker and King 1990). This designation would make the property potentially eligible for listing on the National Register.

The Hanford Site possesses attributes of traditional cultural significance for Native Americans. These attributes relate to locations on the Hanford Site in the following ways.

- A Native American group associates the location(s) with traditional beliefs about its origin, its cultural history, or the nature of the world.

- Native American religious practitioners historically have gone, and are known or believed to continue to go, to the location(s) to perform ceremonial activities in accordance with traditional cultural rules.

- A community traditionally has carried out economic, artistic, or other cultural practices important in maintaining its historical identity (Parker and King 1990).

The Hanford Site holds particular spiritual significance in traditional Native American history because the Washani Religion had its origins here.

4.5.3 Historic Resources

The first Euro-Americans who came to this region were Lewis and Clark, who traveled along the Columbia and Snake rivers during their 1803-1806 exploration of the Louisiana Territory. They were followed by fur trappers, military units, and miners who also passed through on their way to more productive lands upriver and downstream and across the Columbia Basin. It was not until the 1860s that merchants set up stores, a freight depot, and the White Bluffs Ferry on the Hanford Reach. Chinese miners began to work the gravel bars for gold. Cattle ranches opened in the 1880s and farmers soon followed. Several small, thriving towns, including Hanford, White Bluffs, and Ringold, grew up along the riverbanks in the early 20th Century. Other ferries were established at Wahluke and Richmond. The towns and nearly all other structures were razed after the U.S. Government acquired the land for the Hanford Nuclear Reservation in the early 1940s (DOE 1995; Cushing 1995).

A total of 201 historic archaeological sites have been recorded by the Hanford Cultural Resources Laboratory on the Hanford Site (Figure 4-22). Properties from the pre-Hanford Site era include semi-subterranean structures near McGee Ranch; the Hanford Irrigation and Power Company's pumping plant at Coyote Rapids; the Hanford Irrigation Ditch; the old Hanford Townsite, pumping plant, and high school; Wahluke Ferry; the White Bluffs Townsite and bank; the Richmond Ferry; Arrowsmith Townsite; a cabin at East White Bluffs ferry landing; the White Bluffs road; the Chicago, Milwaukee, St. Paul, and Pacific Railroad (Priest Rapids-Hanford Line) and associated whistle stops; and Bruggeman's fruit warehouse (Cushing 1995). Archaeological sites, including the East White Bluffs townsite and associated ferry landings and an assortment of trash scatters, homesteads, corrals, and dumps, have been recorded by the Hanford Cultural Resources Laboratory since 1987. Ertec Northwest, Inc. was responsible for minor test excavations at some of the historic sites, including the Hanford townsite locality. In addition to the recorded sites, numerous unrecorded

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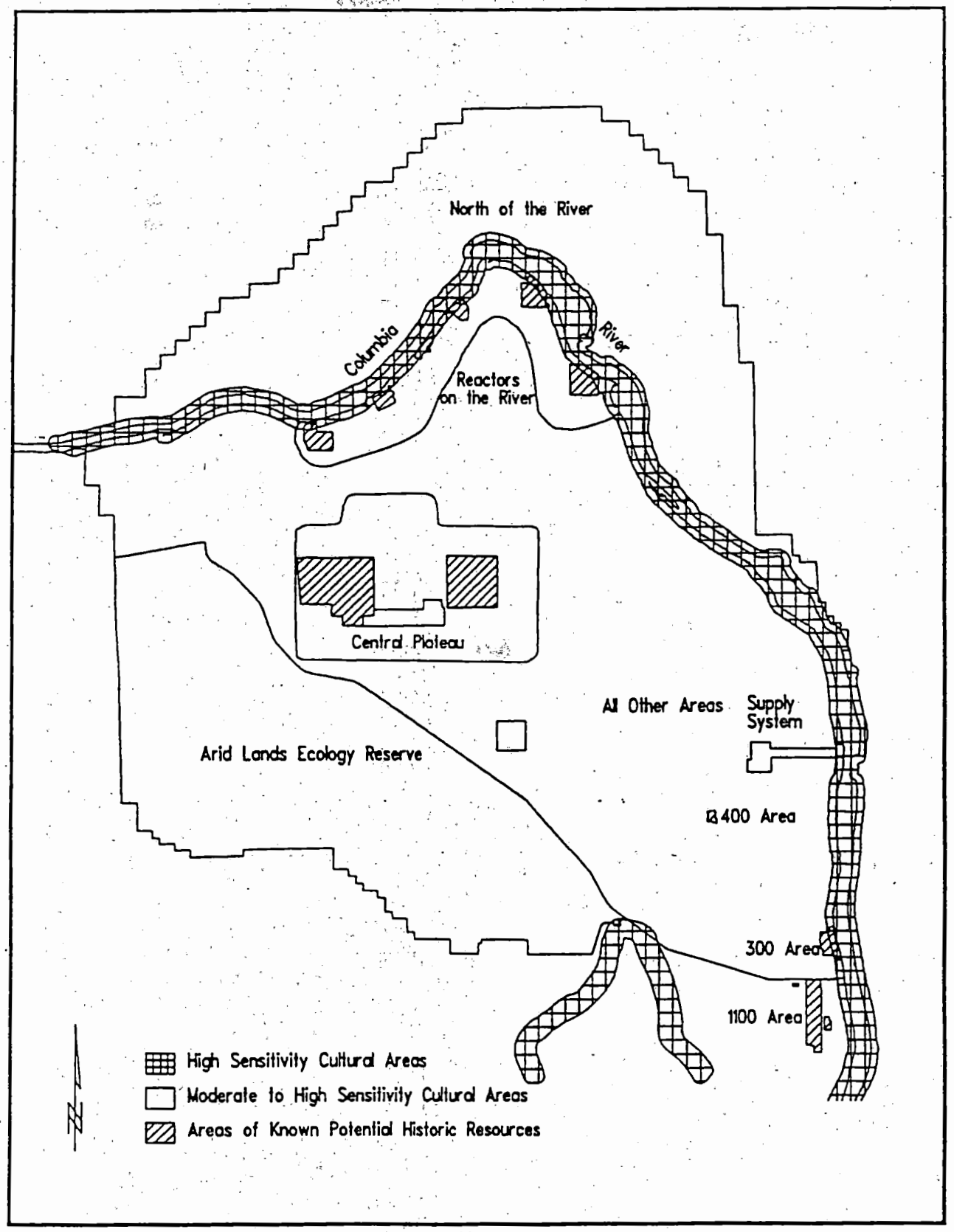
Figure 4-22. Locations of Major Historic Areas on the Hanford Site.



site areas of gold mine tailings along the river bank and the remains of homesteads, farm fields, ranches, and abandoned Army installations are scattered over the entire Hanford Site. Of these historic sites, one is included in the National Register as an historic site, and 56 are listed as archeological sites.

More recent historic locations are the defense reactors and associated materials processing facilities that now dominate the Hanford Site. The first reactors (B, D, and F) were constructed in 1943 as part of the Manhattan Project. Plutonium for the first atomic explosion and the bomb that destroyed Nagasaki to end World War II was produced in the B Reactor. Additional reactors and processing facilities were constructed after World War II during the Cold War. All reactor containment buildings still stand, although many ancillary structures have been removed. The B Reactor has been listed on the National Register. About 45 buildings have been evaluated for National Register eligibility by the State Historic Preservation Office. As individual buildings are scheduled for major remodeling or demolition, they are evaluated on an as-needed basis. Long-range plans for sitewide building evaluations include the use of prepared historic contexts for the Manhattan Project and Cold War eras to assist with National Register eligibility determinations (Cushing 1995).

The following section briefly discusses cultural resources for each of the geographical areas of the Hanford Site.

4.5.4 Columbia River and Reactors on the River Cultural Resources

For the purpose of this discussion, the cultural resources present in the Reactors on the River and the Columbia River geographic areas are considered together. This allows a discussion of sensitive cultural resources, but does not provide information sufficient to allow the discovery and/or adverse impact of these resources by unauthorized personnel. Much of the following information has been obtained from Cushing (1995).

Intensive field surveys were completed in the 100 Areas from 1991 to 1993. Much of the surface area within and near the 100 Area fencelines has been disturbed by the industrial activities that have taken place during the past 50 years. Numerous prehistoric and historic archaeological sites have been encountered, and many are potentially eligible for the National Register. A complete inventory of historic period 100 Area buildings and structures will be completed during fiscal years 1995 and 1996, and a National Register evaluation for each will be finalized during 1996. To date, approximately 23 buildings and structures have been inventoried in the 100 Areas.

100-B/C Area. Three sites can be identified from area literature (Cushing 1995); all lie partially within the 100-B/C Area. The remains of Haven Station, a small stop on the old Priest Rapids-Hanford railroad, is located to the west of the reactor compound. A fourth archaeological site and the remains of the small community of Haven lie on the opposite bank of the Columbia River. Many sites related to hunting and religious activities are located at the west end of Gable Butte, due south of the 100 B/C Area. These sites are part of the proposed Gable Mountain/Gable Butte Cultural District nomination.

Two sites located in the general area near 100 B/C have been investigated. Test excavations conducted in 1991 at one hunting site revealed large quantities of deer and mountain sheep bone and projectile points dating from 500 to 1,500 years old. A second archaeological site is considered to be eligible for listing on the National Register, in part, because it may contain new information about the Frenchman Springs and Cayuse Phases of prehistory.

B Reactor was the first full-scale plutonium production reactor and is designated as a National Historic Mechanical Engineering Landmark. It is also listed on the National Register, was recently named as a National Civil Engineering Landmark, and was given the Nuclear Historic Landmark Award. Several buildings from the Manhattan Project and early Cold War eras remain standing within the reactor compound, including 183-C and 190-C, which have been determined to be ineligible for the National Register. The other buildings will be inventoried in 1995 and evaluated for National Register eligibility in 1996.

100-D Area. Sixty-six known archaeological sites lie within 2 km (1.2 mi) of the 100-D/DR Reactor Compound, three on the northern bank and sixty-three on the southern bank. Two sites located north of the reactor compound are within the Wahluke Archaeological District. Ten sites located south of the reactor compound may be potentially eligible for the National Register because of their association with a traditional cultural property. Most of the remaining sites represent early Euroamerican settlement activities. The former community of Wahluke, which was at the landing of a ferry of the same name, is also situated on the river's north bank.

All of the buildings and structures in this area were built during the Manhattan Project and Cold War eras. The 185/189 buildings and adjoining facilities, all part of the 190-D complex, have been determined eligible for the National Register and have been the subject of documentation to mitigate their proposed demolition. The complex has since been demolished. The other buildings/structures in this area will be inventoried in 1995 and evaluated for National Register eligibility in 1996.

100-F Area. The 100-F Area is situated on a segment of the Columbia River that contains many cultural sites. Camps and villages of the Wanapum people extended from the old Hanford Townsite upstream to the former White Bluffs Townsite. Among those were the villages of *Wakwaltkh*, *Tohoke*, and *Tacht* and the sites of *Wyone* and *Y'yownow*, which were fishing and fish processing locations, respectively. *Tacht* (the name for White Bluffs) was one of the village sites used by the Wanapum, and was occupied until 1943 when the Band relocated to Priest Rapids.

Four prehistoric archaeological sites, including one dating to 4,000 to 9,000 years old, were found in the 100-F Area during 1991 surveys. Two of these sites are considered to be ineligible for the National Register; two have not been evaluated. During 1991 surveys, four historic sites consisting of household debris were found inside the 100-F Area.

There are six other prehistoric archaeological sites within 2 km (1.2 mi) of this area. They are all identified as open camps, except for one, which contains housepits. Sites of particular importance include a cemetery, a site included in the Hanford North Archaeological District and listed on the National Register, and another site which appears to contain artifact deposits dating to at least 6,000 years before present.

The principal historic site in the vicinity is the East White Bluffs ferry landing and former townsite, which has been considered for nomination to the National Register. It is located on the east bank of the Columbia River. The site was the upriver terminus of shipping during the early- and mid-19th Century. It was at this point that supplies for trappers, traders, and miners were off-loaded, and commodities from the interior were transferred from pack trains and wagons to river boats. The first store and ferry of the mid-Columbia region were located there. A log cabin, thought by some to have been a blacksmith shop in the mid-19th Century, still stands there. The structure has been recorded according to standards of the Historic American Buildings Survey. The only remaining

structure associated with the White Bluffs Townsite (near the railroad) is the White Bluffs Bank. A revised historic property inventory form for the bank will be completed in 1995. Two Manhattan Project buildings, 108-F and 105-F, remain in the 100-F Area. Both will be inventoried and evaluated during 1995 and 1996.

100-H Area. There are 10 recorded archaeological sites within 2 km (1.2 mi) of the area. These include two historic Wanapum cemeteries, six camps (one with an associated cemetery), and three housepit villages. The largest village contains more than 100 housepits and numerous storage caches. It appears to have been occupied from 2,500 years ago to historic times. All these sites are included in the Locke Island Archaeological District. Locke Island itself was known to the Wanapum Indians an *K'watch*. The historic village of *Tacht* was located 1 km (0.6 mi) south of the reactor facility. Several living members of the Wanapum, Palus, and Yakama tribes recall residing there. Surveys conducted in 1992 by the Hanford Cultural Resources Library showed that this site had been destroyed by soil borrowing, probably in the 1940s or 1950s.

Fourteen historic sites in the vicinity were recorded during 1992 and 1993 and include 20th Century farmsteads, household dumps, and military encampments. None have yet been evaluated for eligibility to the National Register.

Only three buildings associated with the Cold War era remain in this area. These buildings will be inventoried in 1995 and evaluated in 1996.

100-K Area. Events took place at this locality that were of great significance to Native American people in the interior Northwest. It was here, in the mid-19th Century, that Smohalla, Prophet of the Wanapum people, held the first *Washat*, the dance ceremony that has become central to the Washani or Seven Drums religion. As a result of Smohalla's personal abilities, the religion spread to many neighboring tribes and is now practiced in some form by members of the Colville, Nez Perce, Umatilla, Wanapum, Warm Springs, and Yakama tribes. The site of this historic event was the south bank of the Columbia River near *Moon*, or Water Swirl Place, which also is known as Coyote Rapids.

An archaeological survey of the 100-K Area in 1991 revealed five previously unrecorded archaeological sites. Two sites date to the Cascade Phase (9,000 to 4,000 years ago). A large fish processing camp, represented by fire-broken rock mingled with river gravel, extends downstream from Coyote Rapids. These areas have yet to be evaluated. More importantly, a recent (one or two centuries old) group of pithouses with associated long house and sweat lodge were identified and may have been the site of Smohalla's first *Washat* dance. Three other sites, which compose the Coyote Rapids Archaeological District, are on the opposite bank of the river. This district was nominated to the National Register, but the nomination was rejected in 1976 because of insufficient information. The Ryegrass Archaeological District extends north and east of the 100-K Reactor Compound. Three archaeological sites are included; all are listed on the National Register. Two other sites have been determined by the SHPO to be eligible for listing on the National Register.

Historic sites containing the remains of farms litter the nearby area; four historic sites and three isolated finds have been recorded as of 1994. Two important linear features, the Hanford Irrigation Ditch and the former Priest Rapids-Hanford railroad, also are present in the 100-K Area. Remnants of the Allard community and the Allard Pumphouse at Coyote Rapids are located west of the K Reactor compound. Site forms for these historic resources will be completed in 1995.

100-N Area. Within 2 km (1.2 mi) of the 100-N Area perimeter are fourteen archaeological sites. Four of these sites are either listed, or considered eligible for listing, on the National Register. Three sites, which include two pithouse villages and one cemetery, comprise the Ryegrass Archaeological District.

Mr. D.G. Rice conducted test excavations at one site in 1973 (Cushing 1995). During that excavation, which consisted of excavating two trenches and two smaller pits, Rice found evidence of habitation during four periods of prehistory. The earliest undated occupation of the site occurred during the Vantage Phase of the local chronology, which dates to before 4,500 years before present (BP). Small amounts of material, also undated, were attributable to the Frenchman Springs Phase (4,500 to 2,500 BP). Above that were dense artifact deposits and remains of pithouses dating after 1,862 BP, which Rice attributed to the Cayuse Phase (2,000 BP to historic times). Capping the sequence of deposits was debris left by Wanapum people during their historic occupation of the sites. No excavations have been conducted in other sites within the Ryegrass Archaeological District.

Extant knowledge about the archaeology of the 100-N Area is based largely on reconnaissance-level archaeological surveys conducted during the late 1960s to late 1970s (Cushing 1995), which do not purport to produce complete inventories of the areas covered. Intensive surveys of surrounding areas were conducted during 1991. The Hanford Generating Plant vicinity also has been surveyed intensively for archaeological resources.

Three areas near the 100-N Area are known to be of importance to tribal members. The knobs and kettles surrounding the area may have been called *Moolimooli*, which means Little Stacked Hills. Coyote Rapids, which is a short distance upstream, was called *Moon*, or Water Swirl Place. Gable Mountain (called *Nookshai* or Otter) and Gable Butte, which lie to the south of the river, are sacred mountains where youths would go on overnight vigils seeking guardian spirits. No sites of religious importance are known to exist within the 100-N compound but may exist nearby.

The most common evidence of historic activities now found near the 100-N Area consists of gold mine tailings on riverbanks and historic archaeological sites where farmsteads once stood. The significance of most 100-N buildings and structures, their role in the Cold War, and their potential eligibility for listing on the National Register have not yet been determined. All of the buildings will be inventoried and evaluated in 1995.

4.5.5 Central Plateau Cultural Resources

An archaeological survey conducted of all undeveloped portions of the 200 East Area and a 50% random sample conducted of undeveloped portions of the 200 West Area have indicated no findings of archaeological sites (PNL 1990b). However, three small sites are known to exist within 2 km (1.2 mi) of the 200 East Area and 200 West Area boundaries (DOE 1995). The only evaluated historic site is the old White Bluffs freight road that crosses diagonally through the 200 West Area. The road, which was originally a Native American trail, has been in continuous use as a transportation route since prehistory. It has played a role in Euro-American immigration, regional development, agriculture, and the recent Hanford Site operations. As such, the property has been determined to be eligible for the National Register, although the segment that passes through the 200 West Area is considered to be a noncontributing element. A 100-m (328-ft) easement has been created to protect the road from uncontrolled disturbance. Approximately 20 buildings have been evaluated for National Register eligibility. The remaining buildings associated with the Manhattan Project and Cold War eras have not been inventoried (Cushing 1995).

4.5.6 All Other Areas Cultural Resources

This area represents the largest portion of land on the Hanford Site, comprising 627 km^2 (242 mi^2) (Cushing 1995). It includes developed operations in the 300, 400, and 1100 Areas, and the predominantly undeveloped tracts of land in the 600 Area.

4.5.6.1 300 Area. Most of the 300 Area has been highly disturbed by industrial activities. Archaeological surveys of the 300 Area have included inspection of a narrow strip along the riverbanks, the right-of-way for a proposed toll bridge just south of the area boundary, and several DOE project-driven surveys. Five archaeological sites are located partially within the 300 Area. There are 21 sites within 2 km (1.2 mi) of the 300 Area perimeter. Although the areas have been only minimally surveyed, historic site have been documented and additional historic site may be expected to be found in this area. One site has been tested for subsurface deposits and is recognized as eligible for listing on the National Register. Several sites in this area are in the Hanford South Archaeological District, which is listed on the State Register.

All of the buildings in the 300 Area were constructed in the Manhattan Project and Cold War eras. These facilities will be evaluated for eligibility for listing on the National Register in the next few years.

A traditional food resource gathering area important to the historic Wanapum people is situated near the 300 Area. *Sekema*, a favorite place for taking salmon that had already spawned, was located 10 km (6 mi) north of Richland (Cushing 1995), placing it 2 to 3 km (1.2 to 1.8 mi) north of the 300 Area perimeter. However, because the geographic descriptions are only approximate, it is possible that *Sekema* corresponds to any or all of the previously recorded archaeological sites in or around the 300 Area.

4.5.6.2 400 Area. Most of the 400 Area has been subjected to intensive development-related construction activities. Archaeologists surveying the site in 1978 were able to find only 12 ha (30 ac) that were undisturbed. No cultural resources were found in that small area and no sites have been recorded or are known to exist within 2 km (1.2 mi) of the 400 Area (Cushing 1995).

4.5.6.3 600 Area. The 600 Area contains diverse cultural resource sites and traditional cultural properties, representing a full range of human activity across the Hanford Site. Project-driven surveys have been conducted throughout the area, but much of the 600 Area remains unsurveyed.

Five anti-aircraft artillery sites have been determined eligible for the National Register. Because of the proposed remediation of these sites, mitigation to reduce the adverse effects will be carried out in 1995 and 1996. The Central Shops Complex, in the 600 Area, was determined ineligible for the National Register in 1995 (Cushing 1995).

4.5.6.4 1100 Area. Historic cultural resources have been identified in or near the 1100 Area. These include remnants of homesteads and agricultural structures predating the establishment of the Hanford Site. These historic sites will be evaluated for National Register eligibility before the start of any project that might adversely effect them.

4.6 Socioeconomic Environment

Activity on the Hanford Site plays a dominant role in the socioeconomics of the Tri-Cities (Richland, Pasco, and Kennewick) and other parts of Benton and Franklin counties. The Tri-Cities serves as a market center for a much broader area of eastern Washington, including Adams, Columbia, Grant, Walla Walla, and Yakima counties. The Tri-Cities also serves parts of northeastern Oregon, including Morrow, Umatilla, and Wallowa counties. Socioeconomic impacts of changes at Hanford are mostly confined to the immediate Tri-Cities community and Benton and Franklin counties (Yakima County to a lesser extent) (PNL 1984 and PNL 1987). However, because of the significance of the wider agricultural region and surrounding communities in the Tri-Cities' economic base, this section briefly discusses the wider region as well. Additionally, the impact of the proposed actions might be altered by changes in socioeconomic resources in the surrounding counties of Adams, Columbia, Grant, Walla Walla, and Yakima in Washington state; and Morrow, Umatilla, and Wallowa counties in Oregon (Figure 4-23). This section describes the population, economic activity, housing, and public services and public finance of each county and the Tri-Cities. Because Benton and Franklin counties are expected to be most impacted from changes in Hanford Site activities, the information presented in this section concentrates on those counties, with less attention paid to the other areas.

Table 4-10 summarizes the regional (Benton and Franklin counties) nonagricultural jobs from 1993 to 1994. Hanford Site employment projections were provided by the DOE; an average workforce of 15,600 employees will be required for the foreseeable future. A down-turn in Hanford Site employment is anticipated, the extent of this down-turn is unknown at this time.

4.6.1 Demographics

Estimates for 1994 placed population totals for Benton and Franklin counties at 127,000 and 42,899, respectively (Cushing 1995). When compared to the 1990 census data in which Benton County had 112,560 residents and Franklin County's population totaled 37,473, the current population totals reflect the continued growth occurring in these two counties.

Within each county, the 1994 estimates distributed the Tri-Cities population as follows: Richland 35,430; Pasco 22,170; and Kennewick 46,960. The combined populations of Benton City, Prosser, and West Richland totaled 11,985 in 1994. The unincorporated population of Benton County was 32,610. In Franklin County, incorporated areas other than Pasco have a total population of 3,155. The unincorporated population of Franklin County was 17,575 (Cushing 1995).

The 1994 estimates of racial categories by the Office of Financial Management (Cushing 1995) indicate that in Benton and Franklin counties, Asians represent a lower proportion and individuals of Hispanic origin represent a higher proportion of the racial distribution than those in the State of Washington. Countywide, Benton and Franklin counties exhibit varying racial distributions (Cushing 1995).

Figure 4-23. Areas of Washington and Oregon Where Socioeconomic Resources May Be Affected (DOE 1995).

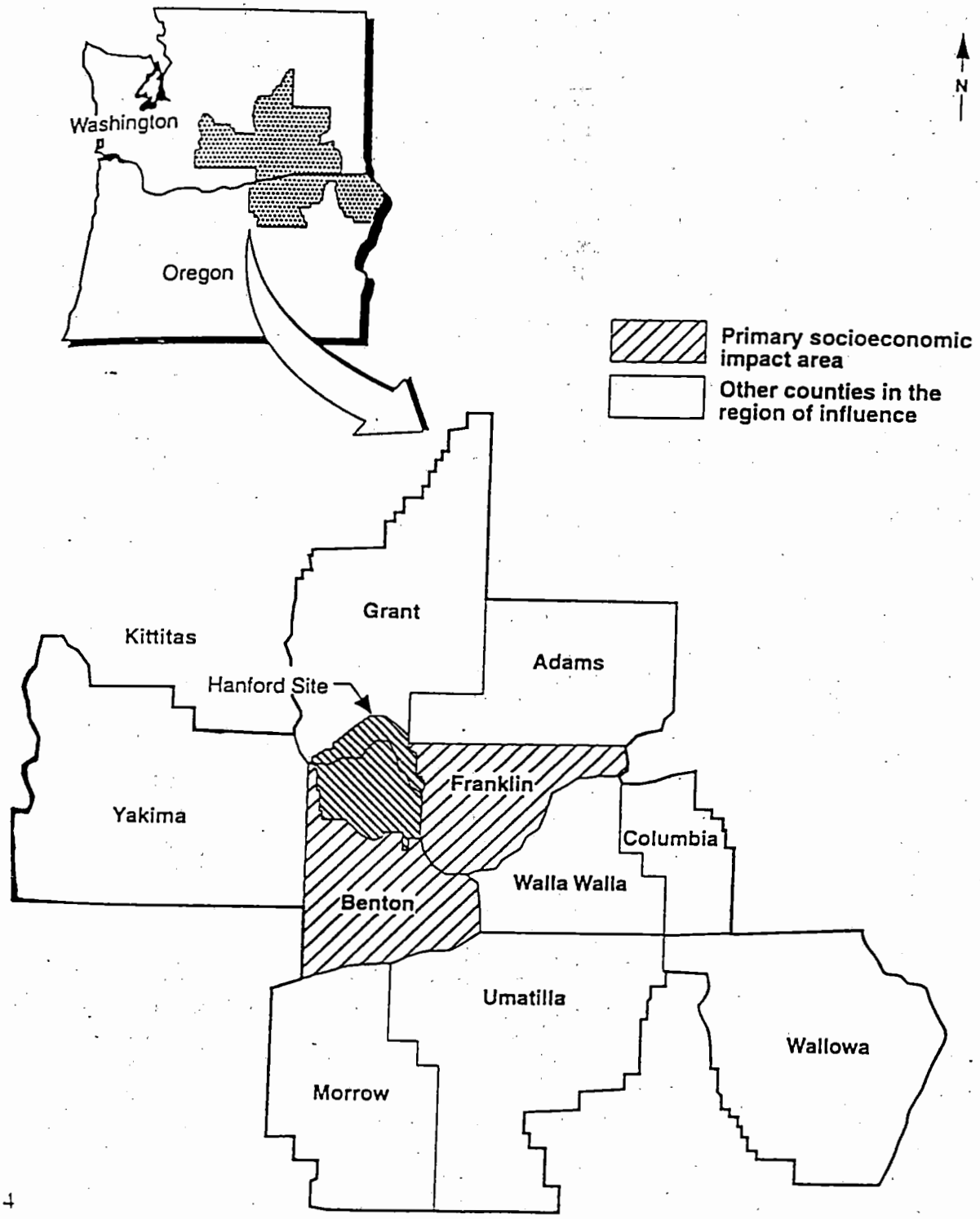


Table 4-10. Nonagricultural Workers in Benton and Franklin Counties, 1993 and 1994.

Industry	1994 Annual Average	1993 Annual Average	% Change 1993-1994
Nonagricultural wage laborers	72,300	69,500	4
Manufacturing	5,500	5,000	3
Construction[a]	4,000	4,400	-9
Public utilities	2,200	2,100	5
Wholesale and retail trade	15,000	14,100	6
Finance, insurance, and real estate	2,200	1,900	16
Services and mining[a]	30,300	28,800	5
Government	13,300	12,900	3

[a]During 1994, employees of one Hanford contractor were reclassified from construction to services, making actual changes in employment in these sectors difficult to determine.

Benton and Franklin counties accounted for 3.2% of Washington State's population (Cushing 1995). In 1994, the population demographics of Benton and Franklin counties are quite similar to those found within the State of Washington. 55% of the population of Benton and Franklin counties is under the age of 35, compared to 52% for the State of Washington. Within the State of Washington, 30- to 39-year olds constitute the largest age group (17.6%) compared to 16.8% found within Benton and Franklin counties. In general, the population of Benton and Franklin counties is somewhat younger than that of Washington State. The 0- to 14-year old age group accounts for 27.1% of the total bicounty population as compared to 22.7% for Washington State. In 1994, the 65-year old and older age group constituted 9.8% of the population of Benton and Franklin counties compared to 11.6% for the State of Washington.

4.6.2 Economics

This subsection summarizes pertinent economic activity within the region of interest, including information on the general economy, employment, income, and impact of the Hanford Site. Historically, the primary industries within the region have been related to agriculture; a multitude of crops encompassing many fruits, vegetables, and grains, are grown each year.

4.6.2.1 Employment in the Tri-Cities. Three major sectors have been the principal driving forces of the economy in the Tri-Cities since the early 1970s: (1) the DOE and its Hanford Site contractors, (2) Washington Public Power Supply System (WPPSS) in its construction and operation of nuclear power plants; and (3) agriculture, including a substantial food-processing industry. With the

exception of a minor amount of agricultural commodities sold to local area consumers, the goods and services produced by these sectors are exported from the Tri-Cities. In addition to direct employment and payrolls, these major sectors also support a sizable number of jobs in the local economy through their procurement of equipment, supplies, and business services.

1. *The DOE and its Hanford Contractors.* Hanford continued to dominate the local employment picture with almost one-quarter of the total nonagricultural jobs in Benton and Franklin counties in 1994 (18,388 of 72,300) (Cushing 1995). Hanford's payroll has a widespread impact on the Tri-Cities economy and state economy in addition to providing direct employment.

2. *WPPSS.* Although activity related to nuclear power plant construction ceased with the completion of the WNP-2 reactor in 1983, the WPPSS continues to be a major employer in the Tri-Cities area. Headquarters personnel based in Richland oversee the operation of one generating facility and perform a variety of functions related to two mothballed nuclear plants and one standby generating facility. In 1994, the WPPSS employment was more than 1,700 workers. WPPSS activities generated a payroll of approximately $83.6 million in the Tri-Cities during the year. Decommissioning of the two mothballed power plants (WNP-1 and WNP-4) is expected to begin in 1995. This decommissioning is expected to reduce the number of employees necessary to maintain these facilities (Cushing 1995)

3. *Agriculture.* In 1993, agricultural activities in Benton and Franklin counties were responsible for approximately 9,482 jobs, or 12% of the area's total employment. According to the U.S. Department of Commerce's Regional Economic Information System, about 2,330 people were classified as farm proprietors in 1992. Farm proprietors' income from this same source was estimated at $82.9 million in the same year (Cushing 1995).

In 1994, seasonal farm workers in Benton, Franklin, and Walla Walla counties averaged 6,307, ranging from 1,600 workers during the winter pruning season to 17,260 workers at the peak of harvest. An estimated average 4,640 seasonal workers were classified as local (ranging from 1,250 to 9,220); an average of 423 were classified as intrastate (ranging from 0 to 2,211); and an average of 1,245 were classified as interstate (ranging from 0 to 5,830). Most intrastate workers resided elsewhere in Benton, Franklin, Walla Walla, and Yakima counties, although the peak harvest season saw an influx of workers from around Eastern and Central Washington. The weighted seasonal wage for 1994 ranged from $5.18 per hour to $5.80 per hour, with an average of $5.44 per hour (Cushing 1995).

The area's farms and ranches generate a sizable number of jobs in supporting activities, such as agricultural services (for example, application of pesticides and fertilizers or irrigation system development) and sales of farm supplies and equipment. Although formally classified as a manufacturing activity, food processing is a natural extension of the farm sector. More than 20 food processors in Benton and Franklin counties produce such items as potato products, canned fruits and vegetables, wine, and animal feed.

In addition to those three major employment sectors, three other components are readily identified as contributors to the economic base of the Tri-Cities economy. The first component, categorized as other major employers, includes five employers: (1) Siemens Nuclear Power Corporation in north Richland, (2) Sandvik Special Metals in Kennewick, (3) Boise-Cascade in Wallula, (4) Burlington Northern Railroad in Pasco, and (5) Iowa Beef Processors in Wallula. These employers employed approximately 3,500 in Benton and Franklin Counties in 1994 (Cushing 1995).

4.6.2.1.1 Tourism. The Tri-Cities Visitors and Convention Bureau reported approximately 320 conventions were held in the Tri-Cities in 1994, with 52,428 attending visitors who spent an estimated $17.3 million. The number of conventions and visitors is up 40% from levels reported in 1993, while the dollar volume generated by visitors is up nearly 47%.

A study by the Washington State Tourism Development Division estimated that overall tourism expenditures in the Tri-Cities were roughly $143.5 million in 1993 and that travel-generated employment in Benton and Franklin counties was about 2300 with an estimated $25.2 million in payroll.

4.6.2.1.2 Retirees. Although the Benton and Franklin counties have a relatively young population (approximately 55% under the age of 35), 16,406 people over the age of 65 resided in Benton and Franklin counties in 1994. The portion of the total population 65 years and older in Benton and Franklin counties accounts for 9.8% of the total population, slightly below that of the State of Washington (11.6%). This segment of the population supports the local economy on the basis of income received from government transfer payments and pensions, private pension benefits, and prior individual savings.

Although information on private pensions and savings is not available, data are available regarding the magnitude of government transfer payments. The U.S. Department of Commerce's Regional Economic Information System has estimated transfer payments by various programs at the county level. A summary of estimated major government pension benefits received by the residents of Benton and Franklin counties in 1991 is shown in Table 4-11. About two-thirds of the Social Security payments go to retired workers; the remainder are for disability and other payments. The historical importance of government activity in the Tri-Cities area is reflected in the relative magnitude of the government employee pension benefits as compared to total payments (Cushing 1995).

4.6.2.2 Income Sources. Total personal income is comprised of all forms of income received by the populace, including wages, dividends, and other revenues. Per capita income is roughly equivalent to total personal income divided by the number of people residing in the area. Median household income is the point at which half of the households have an income greater than the median and half have less. The source for total personal income and per capita income was the U.S. Department of Commerce's Regional Economic Information System, while median income figures for Washington State were provided by the Office of Financial Management (Cushing 1995).

Table 4-11. Government Retirement Payments in Benton and Franklin Counties in 1991 ($ million).

Source	Benton County	Franklin County	Total
Social Security (including survivors and disability)	129.5	34.8	164.3
Railroad retirement	3.2	4.1	7.3
Federal civilian retirement	11.5	2.8	14.3
Veterans pension and military retirement	17.1	3.6	20.7
State and local employee retirement	24.3	4.8	29.1
Total	185.6	50.1	235.7

In 1992, the total personal income for Benton County was $2,422 million, Franklin County was $633 million, and the State of Washington was $109.5 billion. Per capita income in 1992 for Benton County was $20,122, Franklin County was $15,620, and Washington State was $21,289. Median income in 1992 for Benton County was estimated to be $40,288, Franklin County was estimated $28,317, and the State of Washington was estimated at $36,648 (Cushing 1995).

4.6.2.3 Hanford Employment. In 1994, Hanford employment accounted directly for 25% of total nonagricultural employment in Benton and Franklin counties and slightly more than 0.8% of all statewide nonagricultural jobs. In 1994, the Hanford Site total wage payroll was $740 million, and accounted for an estimated 45% of the payroll dollars earned in the area (Cushing 1995).

Previous studies have revealed that each Hanford job supports about 1.2 additional jobs in the local service sector of Benton and Franklin counties (about 2.2 total jobs) and about 1.5 additional jobs in the state's service sector (about 2.5 total jobs). Similarly, each dollar of Hanford income supports about 2.1 dollars of total local incomes and about 2.4 dollars of total statewide incomes. Based on these multipliers, Hanford directly or indirectly accounts for more than 40% of all jobs in Benton and Franklin counties (Cushing 1995).

Based on employee residence records as of December 1993, 93% of the direct employment of Hanford is comprised of residents of Benton and Franklin counties. Approximately 81% of the employment is comprised of residents who reside in one of the Tri-Cities. More than 42% of the employment is comprised of Richland residents, 30% of Kennewick residents, and 9% of Pasco residents. West Richland, Benton City, Prosser, and other areas in Benton and Franklin counties account for 12% of total employment. Table 4-12 contains the estimated percent of Hanford employees residing in each of the counties within the region of influence. The information available did not include the residences of DOE employees nor those of ICF Kaiser Hanford Company. It was assumed that the distribution of these employees would be similar to the distribution of the other Hanford contractors.

Table 4-12. Hanford Employee Residences by County.

County	Percent of Employees in Residence (%)
Adams	0.18
Benton	84.16
Columbia	0.01
Franklin	9.07
Grant	0.25
Walla Walla	0.21
Yakima	5.08
Morrow	0.01
Umatilla	0.01

The DOE and Hanford Site contractors spent nearly $298 million, or 45.6% of total procurements of $653 million, initially through Washington firms in 1993. About 18% of Hanford orders were filled by Tri-Cities firms.

The DOE and Hanford Site contractors paid a total of $10.9 million in state taxes on operations and purchases in fiscal year 1988 (the most recent year available). Estimates show that Hanford employees paid $27.0 million in state sales tax, use taxes, and other taxes and fees in fiscal year 1988. In addition, Hanford paid $0.9 million to local government in Benton, Franklin, and Yakima counties in local taxes and fees (DOE 1995).

4.6.3 Emergency Services

Police protection in Benton and Franklin counties is provided by Benton and Franklin counties' sheriff departments, local municipal police departments, and the Washington State Patrol Division headquartered in Kennewick. Table 4-13 shows the number of commissioned officers and patrol cars in each department in February 1995. The Kennewick, Richland, and Pasco municipal departments maintain the largest staffs of commissioned officers with 66, 44, and 43, respectively.

Table 4-14 indicates the number of firefighting personnel, both paid and unpaid, on the staffs of fire districts in the area.

Table 4-13. Police Personnel in the Tri-Cities for 1995 (Cushing 1995).

Area	Commissioned Officers	Reserve Officers	Patrol Cars
Kennewick Municipal	66	22	18
Pasco Municipal	43	26	13
Richland Municipal	44	23	18
West Richland Municipal	9	8	9
Benton County Sheriff	43	20	50
Franklin County Sheriff	21	15	21

Table 4-14. Fire Protection in the Tri-Cities for 1995 (Cushing 1995).

Station	Fire Fighting Personnel	Volunteers	Total	Service Area
Kennewick	57	0	57	City of Kennewick
Pasco	30	0	30	City of Pasco
Richland	56	0	56	City of Richland
BCRFD 1	5	100	105	Kennewick Area
BCRFD 2	0	30	30	Benton City
BCRFD 4	4	30	34	West Richland

BCRFD = Benton County Rural Fire Department.

The Hanford Fire Department, with 155 firefighters, is trained to dispose of hazardous waste and to fight chemical fires. During the 24-hour duty period, the 1100 Area has 5 firefighters; 300 Area has 7; 200 East and 200 West Areas have 7; the 100 Areas have 6; and the 400 Area, which includes the Supply System, has 6. To perform their responsibilities, each station has access to a Hazardous Material Response Vehicle that is equipped with chemical fire-extinguishing equipment, an attack truck that carries foam and Purple-K dry chemical, a mobile air truck that provides air for gas masks, and a transport tanker that supplies water to six brushfire trucks. The Hanford Fire Department owns five ambulances and maintains contact with local hospitals. The Hanford Fire Department is currently involved in discussions with DOE, the City of Richland, and Westinghouse Hanford Company regarding the possibility of contracting with the City of Richland for Hanford's fire protection services (Cushing 1995).

4.6.4 Health Care

The Tri-Cities have three major hospitals and five minor emergency centers. All three hospitals offer general medical services and include a 24-hour emergency room, basic surgical services, intensive care, and neonatal care.

Kadlec Medical Center, located in Richland, has 144 beds and functioned at 45.3% capacity in 1994. Their 5,628 annual admissions represent more than 38% of the Tri-Cities market. Non-Medicare/Medicaid patients accounted for 55%, or 3,101 of their annual admissions in 1994. An average stay of 3.92 days per admission was reported for 1994.

Kennewick General Hospital maintains a 45.7% occupancy rate of its 70 beds with 4,731 annual admissions in 1994. Non-Medicare/Medicaid patients in 1994 represented 35% of its total admissions. An average stay of 3.2 days per admission was reported in 1994.

Our Lady of Lourdes Hospital operates a 132-bed Health Center, located in Pasco, providing acute, subacute, skilled nursing and rehabilitation, and alcohol and chemical dependency services. Our Lady of Lourdes also operates the Carondolet Psychiatric Care Center, a 32-bed psychiatric hospital located in Richland. They also provide a significant amount of outpatient and home health services. For their fiscal year ending June 30, 1994, Our Lady of Lourdes had a total of 4,449 admissions of which 32.8% were non-Medicare/Medicaid admissions. Lourdes had an average acute care length of stay of 3.1 days (Cushing 1995).

4.6.5 Housing

In 1994, 95% of all housing (of 41,562 total units) in the Tri-Cities was occupied. Single-unit housing, which represents nearly 59% of the total units, has a 98% occupancy rate throughout the Tri-Cities. Multiple-unit housing, defined as housing with two or more units, has an occupancy rate of 95%, a 4% increase since 1990. Pasco has the lowest occupancy rate, 93%, in all categories of housing; followed by Kennewick with 96%, and Richland with 97%. Representing 11% of the housing unit types, mobile homes have the lowest occupancy rate, 90%. Table 4-15 shows a detailed listing of total units and occupancy rate by type in the Tri-Cities.

Table 4-15. Total Units and Occupancy Rates, Estimates 1994 (Cushing 1995).

City	All Units	Rate (%)	Single Units	Rate (%)	Multiple Units	Rate (%)	Manufactured Homes	Rate (%)
Richland	14,828	97	10,355	98	3,827	96	646	88
Pasco	8,035	93	3,802	97	2,933	93	1,300	86
Kennewick	18,699	96	10,179	98	5,961	97	2,559	97
Total for Tri-Cities	41,562	95	24,336	98	12,721	95	4,505	90

4.6.6 Human Services

The Tri-Cities offers a broad range of social services. State human service offices in the Tri-Cities include the Job Services office of the Employment Security Department; Food Stamp offices; the Division of Developmental Disabilities; Financial and Medical Assistance; the Child Protective Service; emergency medical service; a senior companion program; and vocational rehabilitation.

The Tri-Cities also are served by a large number of private agencies and voluntary human services organizations. The United Way, an umbrella fund-raising organization, incorporates 24 participating agencies offering more than 48 programs. These member agencies had a cumulative budget total of $21.1 million in 1994. In addition, there were 407 organizations that received funds as part of the United Way-Franklin County donor designation program (Cushing 1995).

4.6.7 Educational Services

Primary and secondary education are served by the Richland, Pasco, Kennewick, and Kiona-Benton School Districts. The combined 1994 spring enrollment for all districts was approximately 31,970 students, an increase of 7.4% from the 1993 total of 29,777 students. The 1994 total includes approximately 8,665 from the Richland School District, 8,739 students from the Pasco School District, about 13,012 students from the Kennewick School District, and 1,550 from Kiona-Benton. In 1994, Richland was operating near capacity, Pasco was at capacity for primary education but had room for approximately 200 to 250 more students at the secondary level; Kennewick was at capacity at the primary level and over capacity at the secondary level; and Kiona-Benton was operating above capacity at all levels. The Kennewick School District is working on alleviating some of the overcrowded conditions by constructing a new high school, one new middle school, and two new elementary schools (Cushing 1995).

Post-secondary education in the Tri-Cities area is provided by a junior college, Columbia Basin College (CBC), and the Tri-Cities branch campus of Washington State University (WSU-TC). WSU-TC offers a variety of upper-division, undergraduate, and graduate degree programs. The 1994 fall enrollment was approximately 6,839 at CBC and 1300 at WSU-TC. Many of the programs offered by these two institutions are geared towards the vocational and technical needs of the area. Currently, 23 associate degree programs are available at CBC, and WSU-TC offers 10 undergraduate and 15 graduate programs (Cushing 1995).

4.6.8 Transportation

The Tri-Cities serve as a regional transportation and distribution center with major air, land, and river connections. The Tri-Cities have direct rail service, provided by Burlington Northern and Union Pacific, that connects the area to more than 35 states. The Washington Central Railroad serves Eastern Washington as well. Union Pacific operates the largest fleet of refrigerated rail cars in the United States and is essential to food processors, which ship frozen food from this area. Passenger rail service is provided by Amtrak, which has a station in Pasco.

Docking facilities at the Ports of Benton, Kennewick, and Pasco are important aspects of this region's infrastructure. These facilities are located on the 525-km- (325.5-mi-) long commercial waterway, which includes the Snake and Columbia rivers, that extends from the Ports of Lewiston-Clarkston in Idaho to the deep-water ports of Portland, Oregon, and Vancouver, Washington. The average shipping time from the Tri-Cities to these deep-water ports by barge is 36 hours (Cushing 1995).

Daily air passenger and freight services connect the area with most major cities through the Tri-Cities Airport, located in Pasco. The airport is currently served by one national and two commuter-regional airlines. There are two runways: a main and minor crosswind. The main runway is equipped for precision instrumentation landings and takeoffs. Each runway can accommodate landings and takeoffs by medium-range commercial aircraft, such as the Boeing 727-200 and Douglas DC-9. The Tri-Cities Airport handled about 188,000 passengers (enplanements) in 1994. Projections indicate that the terminal can serve almost 300,000 passengers annually. Two additional airports, located in Richland and Kennewick, are limited to serving private aircraft.

The regional transportation network in the Hanford vicinity includes the areas in Benton and Franklin counties from which most of the commuter traffic associated with the Hanford Site originates. Interstate highways that serve the area are I-82, I-182, and I-90. Interstate-82 is 8 km (5 mi) south-southwest of the Hanford Site. Interstate-182, a 24-km- (15-mi-) long urban connector route, located 8 km (5 mi) south-southeast of the Hanford Site, provides an east-west corridor linking I-82 to the Tri-Cities area. I-90, located north of the Hanford Site, is the major link to Seattle and Spokane and extends to the East Coast; I-82 serves as a primary link between Hanford and I-90. State Route 224, south of the Hanford Site, serves as a 16-km (10-mi) link between I-82 and SR 240. State Route 24 enters the Hanford Site from the west, continues eastward across the northernmost portion of the Hanford Site, and intersects SR 17 approximately 24 km (15 mi) east of the Hanford Site boundary. State Route 17 is a north-south route that links I-90 to the Tri-Cities and joins U.S. Route 395, which continues south through the Tri-Cities. State Route 14 connects with I-90 at Vantage, Washington, and provides ready access to I-84 at several locations along the Oregon and Washington border. State Routes 240 and 24 traverse the Hanford Site and are maintained by Washington State. Other roads within the Hanford Site are maintained by the DOE (Cushing 1995).

4.6.9 Utilities

The principal source of water in the Tri-Cities and the Hanford Site is the Columbia River. The water systems of Richland, Pasco, and Kennewick draw a large portion of the 49 billion L (12.94 billion gal) used in 1994 from the Columbia River. Each city operates its own supply and treatment system. The Richland water supply system derives about two-thirds of its water from the Columbia River, while the remainder is split between a well field in North Richland and groundwater

wells. The City of Richland's total usage in 1994 was 26 billion L (6.90 billion gal). This usage represents approximately 63% of the maximum supply capacity. The city of Pasco system also draws from the Columbia River for its water needs. In 1994, Pasco consumed 8.6 billion L (2.27 billion gal). The Kennewick system uses two wells and the Columbia River for its supply. These wells serve as the sole source of water between November and March and can provide approximately 62% of the total maximum supply of 27.6 billion L (7.3 billion gal). Total 1994 usage in Kennewick was 14.6 billion L (3.86 billion gal).

The major incorporated areas of Benton and Franklin counties are served by municipal wastewater treatment systems, whereas the unincorporated areas are served by onsite septic systems. Richland's wastewater treatment system is designed to treat a total capacity of 113.5 million L/d (30 million gal/d) and processed an average flow of 71.4 million L/d (18.87 million gal/d) in 1994. In 1993, the system processed an average 65.9 million L/d (17.4 million gal/d). The Kennewick system similarly has significant excess capacity; with a treatment capability 83.2 million L/d (22 million gal/d), 1994 usage was 40 million L/d (10.56 million gal/d). Pasco's waste treatment system processed an average 23.5 million L/d (6.22 million gal/d) while the system is capable of treating 94.6 million L/d (25 million gal/d).

In the Tri-Cities, electricity is provided by the Benton County Public Utility District, Benton Rural Electrical Association, Franklin County Public Utility District, and City of Richland Energy Services Department. All the power that these utilities provide in the local area is purchased from the Bonneville Power Administration (BPA), a federal power marketing agency. The average rate for residential customers served by the three local utilities is approximately $0.052/kWh. Electrical power for the Hanford Site is purchased wholesale from the BPA. Energy requirements for the Hanford Site during fiscal year 1994 exceeded 338 million kWh for a total cost of nearly $9 million.

Natural gas, provided by the Cascade Natural Gas Corporation, serves a small portion of residents, with 6,000 residential customers in December 1994.

In the Pacific Northwest, hydropower, and to a lesser extent, coal and nuclear power, constitute the region's electrical generation system. The system is capable of delivering approximately 20,300 average megawatts of guaranteed energy. Of that, approximately 62% is derived from hydropower, 16% from coal, and less than 7% from nuclear plants. One commercial nuclear power plant remains in service in the Pacific Northwest, with an average generating capability of 833 megawatts. The Trojan nuclear power plant, in Oregon, was permanently shut down on January 4, 1993.

The region's electrical power system, more than any other system in the nation, is dominated by hydropower. In a given peak demand hour, the hydropower system is capable of providing nearly 30,000 megawatts of capacity. Variable precipitation and limited storage capabilities alter the system's output from 12,300 average megawatt under critical water conditions to 20,000 average megawatt in record high-water years. The Pacific Northwest system's reliance on hydroelectric power means that it is more constrained by the seasonal variations in peak demand than in meeting momentary peak demand.

Additional constraints on hydroelectric production are measures designed to protect and enhance the production of salmon, as many salmon runs have dwindled to the point of being threatened or endangered. These measures, outlined by the Northwest Power Planning Council's (NPPC) Columbia River Basin Fish and Wildlife Program, include minimum flow levels and a "water budget," which

refers to water in the Columbia and Snake rivers that is released to speed the migration of young fish to the sea. Generation capacity of the hydroelectric system is decreased with these measures, as less water is available to pass through the turbines.

Throughout the 1980s, the Pacific Northwest had more electric power than it required and was operating with a surplus. This surplus has been exhausted, however, and there is only enough power supplied by the system to meet regional electricity needs. In the 1991 Northwest Power Plan, the NPPC set a goal of purchasing more than 1,500 megawatts of energy savings by the year 2000 to help the existing system meet with rising electricity demand. NPPC estimates that the Pacific Northwest will need an additional 2,000 megawatts over 1991 consumption by the turn of the century.

4.6.10 Site Infrastructure

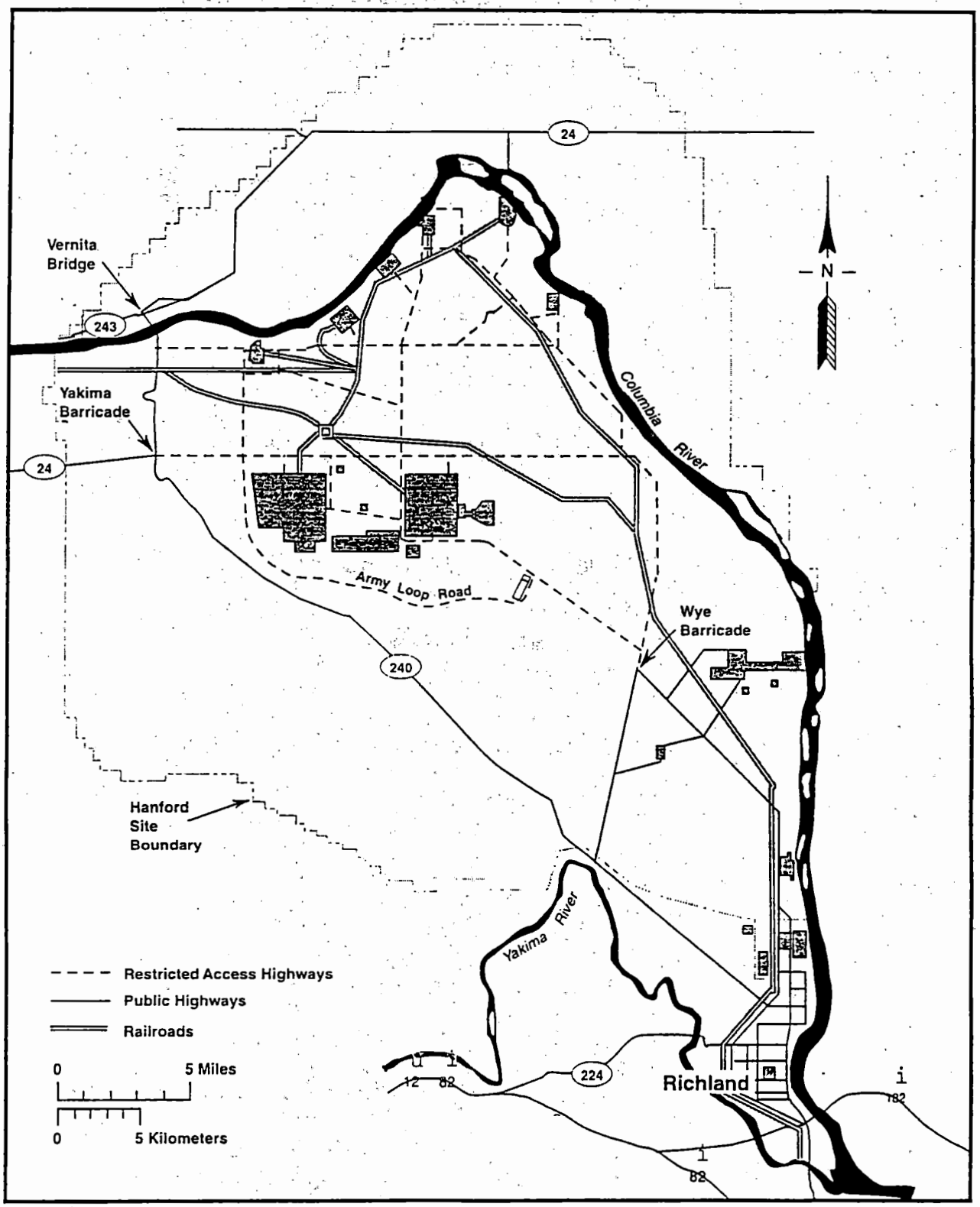
The Hanford Site infrastructure is a significant resource for furthering industrial development of the region. Key elements of this infrastructure include facilities, road and rail systems, utilities, and support services (DOE-RL 1994).

4.6.10.1 Facilities. Onsite programmatic (60%) and general purpose facilities (40%) total 600,000 m^2 (6.5 million ft^2) of space. General purpose facilities include offices, laboratories, shops, warehouses, and other facilities. The programmatic space supports an evaporator, filter, waste recovery, waste treatment, waste storage, and research and development laboratories. Many of these facilities are over 30 years old; however, upgrades and expansion of these facilities could occur as cleanup progresses.

4.6.10.2 Road and Rail Systems. The transportation network is well developed on the Hanford Site with 460 km (288 mi) of roads onsite (Figure 4-24). State Route 24 crosses the Hanford Site primarily in the North geographic area. State Route 240 crosses the Hanford Site on the southwest and serves as the dividing line between the ALE Reserve and the All Other Areas geographic area. A new site access road from State Route 240 to the 200 West Area was completed in December 1994. A four-lane highway is planned for the 200 East Area. Upgrades are planned for road capacities north of the Wye Barricade and the road network in the 300 Area. The 1100 Area roads are currently being upgraded to improve traffic circulation and access to the area.

There are about 204 km (127 mi) of rail system on the Hanford Site (see Figure 4-24). The DOE plans to upgrade the system to handle the projected increases in use during cleanup activities. The system begins at the Richland Junction (Columbia Center), where it joins the Union Pacific commercial tracks and runs to the abandoned Chicago, Milwaukee, St. Paul, and Pacific right of way near the Vernita Bridge located on the north boundary of the Hanford Site. Approximately 35 km (22 mi) of track are in "out-of-service" condition. The in-service track accommodates 4,000 movements of 1,500 rail cars annually. On-site rail transport between facilities accounts for 1,000 movements annually.

Figure 4-24. Transportation Network on the Hanford Site (DOE-RL 1990a).



4.6.10.3 Utilities. The Hanford Site water system comprises numerous buildings, pumps, valve houses, reservoirs, wells, and distribution piping that delivers water from the Columbia River to all areas of the Hanford Site. The export water system, which is the largest, delivers water to the 100, 200, and parts of the 600 Areas from the Columbia River (Figure 4-25). The 300 Area and the WPPSS also draw water direct from the Columbia River. Water is purchased from the City of Richland for the 700, 1100, and 3000 Areas while the 400 Area and part of the 600 Area draws some water from groundwater wells.

The BPA, a federal power marketing agency, sells electricity to the Hanford Site and the agencies that serve the Tri-Cities. The BPA provides electrical power to three distinct systems on the Hanford Site (Figure 4-26). The systems are located in the 100/200 Areas, 300 Area, and the 400 Area. Power for the 700, 1100, and the 3000 Areas is provided by the City of Richland. Major upgrades or replacements of these systems to accommodate the Hanford cleanup are being implemented or planned.

The Hanford Site has two separate steam systems in operation, located in the 200 and 300 Areas. The function of the 200 East and 200 West Area system is to satisfy process and heating needs by producing and delivering steam to the process plants, tank farms, and general purpose facilities. The function of the 300 Area system is to provide steam to the buildings for heating and humidification. The steam is produced by both oil- and coal-fired boilers. The coal-fired boilers are the primary source of heat. The oil-fired boilers are used as backup when the coal-fired boilers are undergoing maintenance or repair. The use of natural gas and a decentralized system is being evaluated to replace coal-fired steam production.

4.6.10.4 Support Services. Other support services on the Hanford Site include sewers, fire stations, telecommunications, landfills, and safeguards and security. Businesses in the City of Richland provide a number of important services such as laundry.

4.6.10.4.1 Sewer. Sanitary wastes in the 200 East and 200 West Areas are currently disposed of through septic tanks and drain fields. A central collection and treatment evaporation plant is being constructed in the 200 East and 200 West Areas to handle the sanitary sewer system. The sewer system in the 300 Area is being connected to the city system in the City of Richland.

4.6.10.4.2 Fire Stations. Fire stations are located in the 100, 200, and 300 Areas. Water supply, alarm and sprinkler system upgrades are planned for the 300 Area laboratory and general support buildings. New and upgraded fire protection systems are planned for the 100-K Area facilities currently in use for interim fuel storage. The Hanford Fire Department is continuing to explore the potential for sharing responsibilities with the City of Richland in the 300 Area.

4.6.10.4.3 Telecommunications. A new fiber optic communications network was recently installed. This system provides a fully connected internal network of shared computing resources and capabilities to support future voice and data communication activities.

4.6.10.4.4 Solid Waste Landfill. A 12-ha (66-ac) nonradioactive landfill is located onsite. The landfill is expected to reach capacity in 1996. Steps are being taken to extend the life of the landfill through reduced waste input.

4.6.10.4.5 Safeguards and Security. A security force is employed onsite and a number of systems are in place to control site access.

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Figure 4-25. Export Water System for the Hanford Site (DOE-RL 1990a).

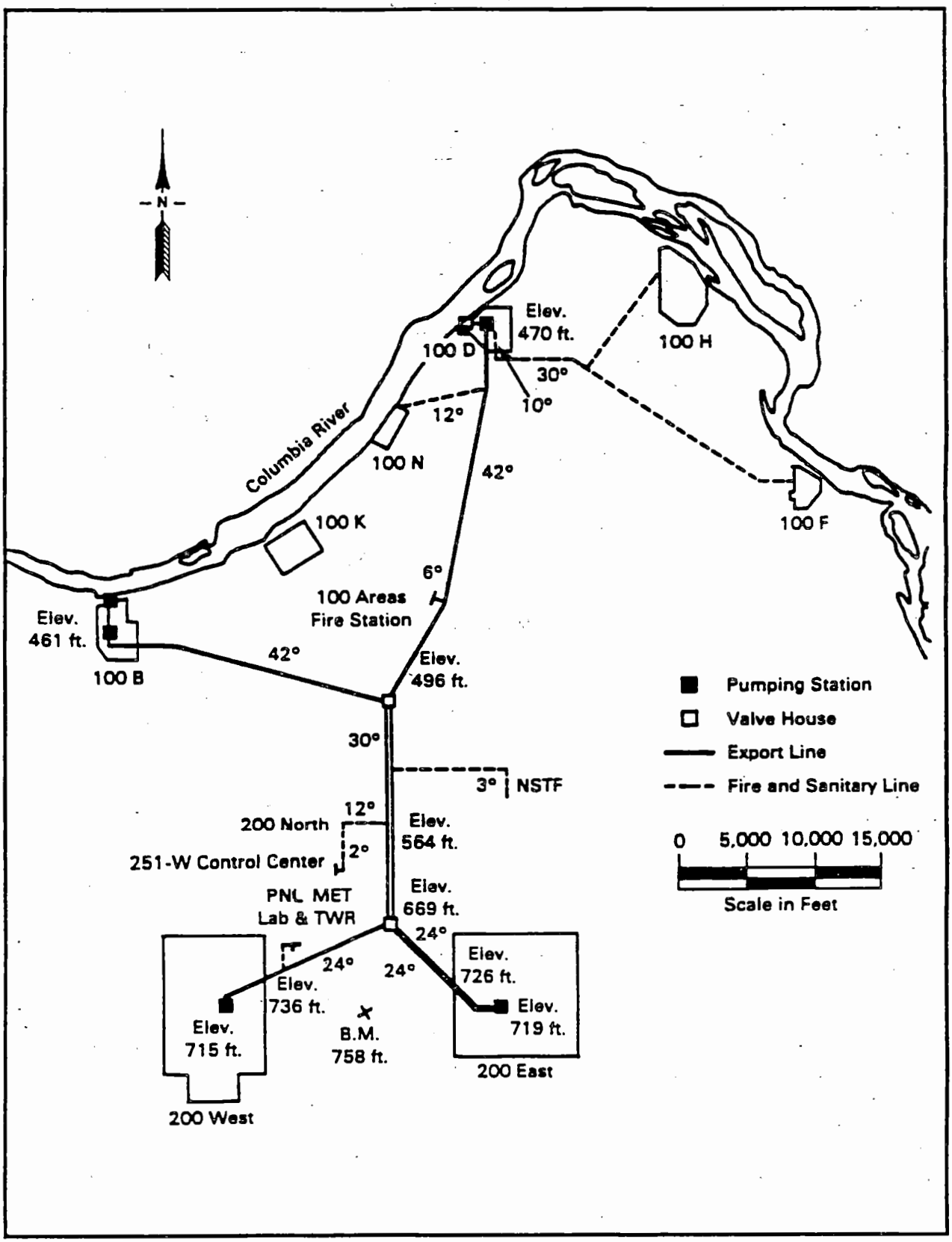
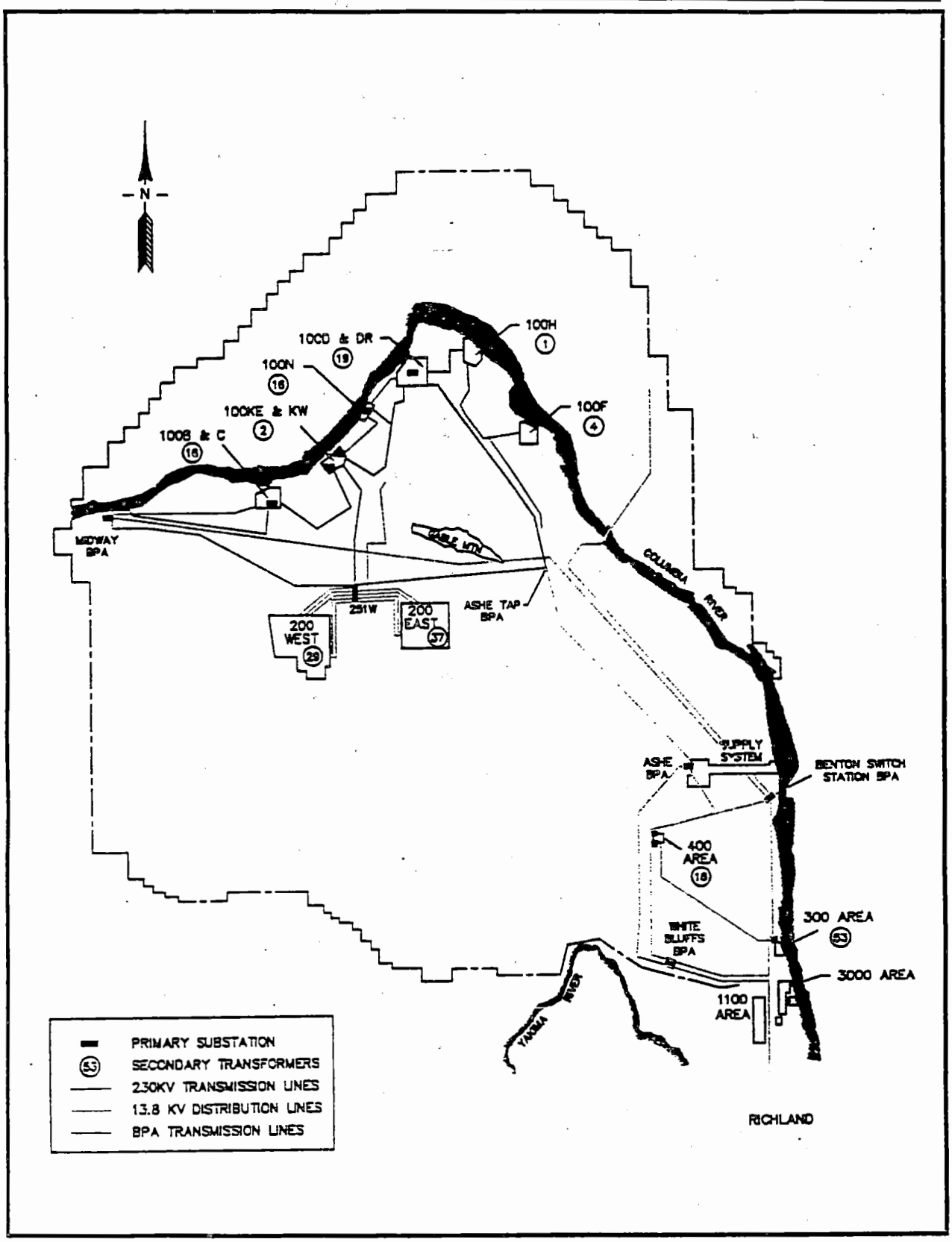


Figure 4-26. Electrical System for the Hanford Site (DOE-RL 1990b).



4.6.10.4.6 Environmental Restoration Disposal Facility. A 65-ha (160-ac) landfill is under construction directly south of the 200 East and 200 West Areas to address the disposal of radioactive, hazardous, asbestos, PCB, and mixed wastes resulting from the remediation of operable units on the Hanford Site. The facility will be expanded as necessary, to a maximum of 414 ha (1.6 mi^2).

4.7 Visual and Aesthetic Resources

The land in the vicinity of the Hanford Site is generally flat with little relief. Rattlesnake Mountain, rising to 1,060 m (3,477 ft) above mean sea level, forms the southern boundary of the site. Gable Mountain and Gable Butte are the highest land forms within the site. The view toward Rattlesnake Mountain is visually pleasing, especially in the springtime when wildflowers are in bloom. Large rolling hills are located to the west and far north. The Columbia River, flowing across the northern part of the site and forming the eastern boundary, is generally considered scenic, with its contrasting blue against a background of brown basaltic rocks and desert sagebrush. The White Bluffs, steep whitish-brown bluffs adjacent to the Columbia River, are a striking feature of the landscape.

This EIS addresses potential land-use objectives for four of the six geographic areas identified by the Hanford Future Site Uses Working Group (HFSUWG 1992). The other two geographic regions, the ALE Reserve and North Slope, are outside the scope of this EIS but are discussed briefly in this Section because they contain dominant physiographic features (Rattlesnake Mountain, Saddle Mountain, and the White Bluffs) that are integral components of the overall site landscape.

State Route 240 provides public access through the southwestern portion of the Hanford Site. Viewsheds along this highway include the flat, open lands of the ALE Reserve in the foreground to the west with the prominent peak of Rattlesnake Mountain and the extended ridgelines of the Rattlesnake Hills in the background. To the east, the views include relatively flat terrain with the structures of the 200 East and 200 West Areas visible in the middleground with Gable Butte and Gable Mountain in the background. From the highway, the Saddle Mountains can be seen in the distance to the north and steam plumes from the WPPSS reactor cooling towers are visible in the distance to the east. The views along State Highway 240 are expansive due to the flat terrain and the predominantly short, treeless, vegetative cover. There are no key observation points along the road, only a few small turnouts along the shoulder.

State Route 24 provides public access through the northern portion of the Hanford Site, primarily on the north side of the Columbia River. Viewsheds along this highway include limited views of the Columbia River when the road drops down into the river valley, crosses the river over the Vernita Bridge, and climbs up out of the valley to a level plateau north of the river. A turnout on the north side of the river offers views of the river and the B and C Reactors. An interpretive sign is located here. A rest stop along the road just to the south of the river provides views of the Umtanum Ridge to the west, the Saddle Mountains to the north, and the Columbia River valley to the east and west.

4.8 Noise

This EIS defines noise as "any undesirable or unwanted sound or audible disturbance that interferes with normal activity." Typically, intrusive noise events are those that disrupt normal human activity, especially verbal communication. Under certain circumstances, people are willing to endure noise as a tradeoff for accomplishing some meaningful activity or because certain noises

represent tangible evidence of progress. For example, loud power tools usually are preferred to quieter manual tools because of the savings in time and human labor. In the context of transportation systems, a certain amount of noise is tolerable.

4.8.1 Public Health Implications

Noise impacts on public health usually are analyzed in terms of a dose-response relationship because noise effects are cumulative. Prolonged exposure to loud noises can impair hearing. The impairment can be temporary or permanent, depending on intensity and duration of the noise. Normally, hearing degeneration does not occur if the duration of the event is brief. Off-property noise impacts are the sound-exposure levels that interfere with normal speech, disrupt sleep, or produce secondary effects such as increased levels of stress among community members.

4.8.2 Hanford Site Sound Levels

Most industrial facilities on the Hanford Site are located far enough away from the site boundary that noise levels at the boundary are not measurable or are barely distinguishable from background noise levels. Modeling of environmental noises has been performed for commercial reactors and SR 240 through the Hanford Site. These data are not concerned with background levels of noise and are not reviewed here. Two studies of environmental noise were done at the Hanford Site. One study reported environmental noise measurements taken in 1981 during site characterization of the Skagit/Hanford Nuclear Power Plant Site (DOE 1995). The second was a series of site characterization studies performed in 1987 that included measurement of background environmental noise levels at five places on the Hanford Site. Additionally, such activities as well drilling and sampling have the potential for producing noise in the field apart from major permanent facilities. Noise can be disruptive to wildlife and studies have been done to compile noise data in remote areas.

Recently, the potential impact of traffic noise resulting from Hanford Site activities has been evaluated for a draft environmental impact statement addressing the siting of a proposed New Production Reactor (Cushing 1995). While this environmental impact statement does not include any new baseline measurements, it does address the traffic component of noise and provides modeled "baseline" measurements of traffic noise for the Hanford Site and adjacent communities. Baseline noise estimates were determined for two locations: State Route 24, leading from the Hanford Site west to Yakima, and State Highway 240, south of the site and west of Richland where it handles maximum traffic volume. Traffic volumes were predicted based on the presence of both operational and construction work forces. Noise levels were expressed in Leq for 1-hour periods in dBA at a receptor located 15 m (49 ft) from the road. Adverse community responses would not be expected at increases of 5 dBA over background noise levels.

4.8.3 Skagit/Hanford Data

Measurements of environmental noise were taken in June 1981 prior to the construction of the WPPSS plants on the Hanford Site (DOE 1995). Monitoring was conducted at 15 sites, showing point noise level reading ranging from 30 to 60.5 dBA. The corresponding values for more isolated areas ranged from 30 to 38.8 dBA. Measurements taken in the vicinity of the sites where the WPPSS was constructing nuclear power plants ranged from 50.6 to 64 dBA, reflecting operation of construction equipment. Measurements taken along the Columbia River near the intake structures for

WNP-2 were 47.7 and 52.1 dBA, compared to more remote river noise levels of 45.9 dBA (measured about 4.8 km [3 mi] upstream of the intake structures). Community noise levels from point measurements in North Richland (3000 Area at Horn Rapids Road and Stevens Road [Route 240]) were 60.5 dBA, largely attributed to traffic.

4.8.4 Basalt Waste Isolation Project Data

Background noise levels were determined at five sites located within the Hanford Site. Noise levels are expressed as equivalent sound levels for 24 hours (Leq-24). The average noise level for these five sites was 38.8 dBA on the dates tested. Wind was identified as the primary contributor to background noise levels, with winds exceeding 19 km/hr (12 mi/hr) significantly affecting noise levels. This study concluded that background noise levels in undeveloped areas at the Hanford Site are generally in the range of 24 to 36 dBA (Cushing 1992). Periods of high wind, which normally occur in the spring, would elevate background noise levels.

4.8.5 Noise Levels of Hanford Field Activities

In the interest of protecting Hanford workers and complying with Occupational Safety and Health Administration (OSHA) standards for noise in the workplace, the Hanford Environmental Health Foundation has monitored noise levels resulting from several routine operations performed in the field at Hanford. These included well drilling, pile driving, compressor operations, and water wagon operation. Occupational sources of noise propagated in the field from outdoor activities ranged from 74.8 to 125 dBA (Cushing 1995).

4.9 Environmental Monitoring Programs

Environmental surveillance at the Hanford Site consists of monitoring for potential radiological and nonradiological constituents and includes monitoring of external radiation, air, surface water, ground water, soil, vegetation, wildlife, and food and farm products. Monitoring is performed to ensure protection of human health and safety, and is conducted in compliance with DOE Order 5400.1, *General Environmental Protection Program* (DOE 1990), and DOE Order 5400.5, *Radiation Protection of the Public and Environment* (DOE 1993). A detailed discussion of the Hanford environmental monitoring program is found in the *Hanford Site Environmental Monitoring Plan* (DOE-RL 1991), and monitoring data are discussed in the *Hanford Site Environmental Report for Calendar Year 1994* (PNL 1995a).

4.10 Land Use

This section provides a brief description of land uses at the Hanford Site and in the surrounding region. The discussion of land uses at the Hanford Site focuses on the six geographic areas developed by the Hanford Future Site Uses Working Group (HFSUWG 1992) (Figure 1-2). Currently, the DOE is developing a Comprehensive Land-Use Plan for the Hanford Site.

4.10.1 Existing Land Uses at the Hanford Site

Land use categories at the Hanford Site include reactor operations, waste operations, administrative support, operations support, sensitive areas, and undeveloped areas. Only about 6% of the land has been disturbed by the DOE and is actively used. Remedial activities are currently focused within the disturbed areas. Much of the Hanford Site is open space that provides a buffer for the smaller areas used for operations. Public access to most facility areas is restricted.

The *Hanford Site Development Plan* (Reference) provides an overview of land use, infrastructure, and facility requirements to support the DOE missions at Hanford. The *Hanford Site Development Plan* includes a Master Plan section that outlines the relationship of the land and the infrastructure required to support the Hanford Site missions. The primary objective of the Master Plan is to develop and maintain the site infrastructure required to meet ongoing and future program requirements. A goal of the *Hanford Site Development Plan* is to maximize the amount of land available for other beneficial uses, including protection of cultural and ecological resources (DOE-RL 1994).

A description of land uses in the six Hanford Site geographical areas identified by the Working Group is provided below.

4.10.2 Fitzner/Eberhardt Arid Lands Ecology Reserve Geographic Area

The ALE Reserve is an area of about 315 km^2 (120 mi^2) and is currently managed as a habitat/wildlife reserve and nature research center under the National Environmental Research Park Program. Because public access to ALE Reserve has been restricted since 1943, the shrub-steppe habitat is virtually undisturbed. This area, which is located in the southwest portion of the Hanford Site, contained small, nonradioactively contaminated sites that have been remediated.

4.10.3 North of the River Geographic Area

The area North of the Columbia River encompasses about 365 km^2 (140 mi^2) of relatively undisturbed or returning shrub-steppe habitat. Known as the North Slope, part of this area is managed by the U.S. Fish and Wildlife Service (USFWS) as the Saddle Mountain National Wildlife Refuge, and part of the area is managed by the State Department of Fish and Wildlife as the Wahluke Slope Wildlife Recreation Area. This area has remained mostly undeveloped since 1943. The Wahluke Slope Wildlife Recreation Areas was opened for daytime public recreational use in 1978. This area also contained small, nonradioactively contaminated sites that DOE remediated in 1994 and 1995. Revegetation using native species occurred during 1995.

4.10.4 Columbia River Geographic Area

The Columbia River, which is adjacent to and runs through the Hanford Site, provides access to the public for boating, water skiing, fishing, and hunting of upland game birds and migratory waterfowl. Some land access along the shore and on certain islands is available for public use.

The area known as the Hanford Reach includes the quarter-mile strip of public land on either side of the Columbia River. The Hanford Reach is the last free-flowing, nontidal segment of the Columbia River in the United States. In 1988, Congress passed Public Law 100-605, known as the *Comprehensive River Conservation Study Act of 1988*, which required the Secretary of the Interior to prepare a study in consultation with the Secretary of Energy to evaluate the outstanding features of the Hanford Reach and its immediate environment. Alternatives for preserving those features also were examined, including the designation of the Hanford Reach as part of the National Wild and Scenic Rivers System. The results of the study can be found in the two-volume report, *Hanford Reach of the Columbia River - Comprehensive River Conservation Study and Environmental Impact Statement Final-June 1994* (NPS 1994). The preferred alternative was to designate the Hanford Reach as a recreational river.

4.10.5 Reactors on the River Geographic Area

The Reactors on the River geographic area is located along the southern shorelines of the Columbia River. The area contains all the facilities in the 100 Areas, including the nine reactor sites, associated facilities, and structures. The Reactors on the River area occupies about 68 km^2 (26 mi^2). The facilities in the 100 Areas are being placed in a stabilized state for ultimate decommissioning.

4.10.6 Central Plateau Geographic Area

The Central Plateau occupies approximately 115 km^2 (44 mi^2) in the central region of the Hanford Site. Facilities in the Central Plateau are situated in the 200 East and 200 West Areas, and were built to process irradiated fuel from the production reactors. The subsequent operation of these facilities resulted in the storage, disposal, and unplanned release of radioactive and nonradioactive waste.

4.10.7 All Other Areas Geographic Area

The All Other Areas geographic area comprises an area of approximately 624 km^2 (241 mi^2) and includes the 300, 400, 600 (exclusive of the North Slope and the ALE Reserve), and the 1100 Areas. All Other Areas is the largest of the geographic areas, and includes large area of undeveloped land between the developed operational areas described in the following sections.

4.10.7.1 300 Area. The 300 Area is located just north of the City of Richland and covers 1.5 km^2 (0.6 mi^2). The 300 Area is the site of former reactor fuel fabrication facilities and also is the principal location of nuclear research and development (R&D) facilities serving the Hanford Site. Wastes in the 300 Area have resulted from the fuel fabrication process and various R&D projects. Kaiser Aluminum and Chemical Corporation is leasing the 313 Building in the 300 Area to use an extrusion press that was formerly owned by the DOE.

4.10.7.2 400 Area. The 400 Area, located southeast of the 200 East Area, is the site of the Fast Flux Test Facility (FFTF), used in the testing of breeder reactor systems. In December 1993, the Secretary of Energy ordered the FFTF to be shut down, and the process has begun. The goal is to reach a radiologically and industrially safe shutdown in about 5 years (Cushing 1995).

4.10.7.3 600 Area. Land uses in the 600 Area include:

- The Hazardous Materials Management and Emergency Response (HAMMER) Training Center will be used to train hazardous materials response personnel. The Center is being constructed north of the 1100 Area and is expected to cover about 32 ha (80 ac).

- The Environmental and Molecular Sciences Laboratory (located south of the 300 Area) and its associated research program provide quality research capability to advance technologies in support of the DOE long-term mission of environmental restoration and waste management.

- In the 1970s land was leased to the Washington Public Power Supply System (WPPSS) to construct three commercial power reactors. One plant, Washington Nuclear Plant 2 (WNP-2), was completed and is operating.

- A 410-ha (1,000-ac) tract was leased to the State of Washington to promote nuclear-related development. A commercial low-level radioactive waste disposal facility run by US Ecology, Inc., currently operates on 41 ha (100 ac) of the leasehold. The rest of the leasehold was not used by the State, and this portion of the leasehold recently reverted to the DOE. The DOE is constructing the Environmental Restoration Disposal Facility (ERDF) on this tract, directly west of the US Ecology facility.

- The ERDF currently is under construction immediately adjacent to the US Ecology commercial low-level waste disposal facility south of the 200 East and 200 West Areas. The ERDF is to provide disposal capacity for environmental remediation waste generated during cleanup of the 100, 200, and 300 Areas of the Hanford Site. The facility currently is about 65 ha (160 ac) in size, and will expand to up to 414 ha (1.6 mi^2) if additional waste disposal capacity is required.

- In 1980, the Federal government sold the State of Washington a 259-ha (640-ac) section of land south of the 200 East Area, near State Route 240, for the purpose of extremely hazardous waste disposal. This parcel is uncontaminated (although the underlying groundwater is contaminated) and undeveloped. Under the deed, if it is used for any purpose other than hazardous waste disposal, ownership would revert to the Federal government.

- The National Science Foundation is building the Laser Interferometer Gravitational-Wave Observatory (LIGO) facility on the Hanford Site. The facility will detect cosmic gravitational waves for scientific research. When complete, the facility will consist of two optical tube arms arrayed in an "L" shape.

4.10.7.4 1100 Area. The 1100 Area, located just north of Richland, serves as the central warehousing, vehicle maintenance and transportation operations center for the Hanford Site.

4.10.8 Land Use in the Vicinity of the Hanford Site

Regional land use includes urban and industrial development, irrigated and dry-land farming, and grazing. In 1993, wheat represented the largest single crop in terms of area planted in Benton, Franklin, and Grant counties. Total acreage planted in the three counties was 207,890 ha

(513,700 ac) and 24,120 ha (59,600 ac) for winter and spring wheat, respectively. Alfalfa, apples, asparagus, cherries, corn, grapes, and potatoes are other major crops in Benton, Franklin, and Grant counties (Cushing 1995).

In 1992, the Columbia Basin Project, a major irrigation project to the north of the Tri-Cities, produced gross crop returns of $552 million, representing 12.5% of all crops grown in Washington State. In 1992, the average gross crop value per irrigated acre was $1,042. The largest percentage of irrigated acres produced alfalfa hay (26.1% of irrigated acres), wheat (20.2%), and feed-grain corn (5.8%). Other significant crops are apples, dry beans, potatoes, and sweet corn (Cushing 1995).

In addition, Allied Technology Group Corporation operates a low-level radioactive waste decontamination, super-compaction, and packaging disposal facility, and Siemens Power Corporation operates a commercial nuclear fuel fabrication facility in the vicinity of the Hanford Site.

4.10.9 Hanford Site Protective Buffer Zones

Existing and planned waste disposal sites, waste remediation areas, and waste processing facilities are found throughout the Hanford Site. In order to protect the public from routine or accidental releases of radiological contaminants and/or hazardous materials, the use of adequate buffer zones surrounding the waste remediation, processing, and disposal areas must be considered. Adequate buffer zones are required by state and federal regulations, as well as the DOE, in an attempt to limit public exposure to radiological and hazardous chemicals from routine operations and accidents at waste remediation, processing, and disposal areas. A methodology was developed to determine the location, size, shape, and characteristics of the buffer zones needed for the Hanford Site, using existing Safety Analysis Reports (SAR), Hazard Assessments (HA), and Emergency Planning Zone (EPZ) studies. The results of this methodology will allow decisionmakers to restrict potential land uses in areas where waste sites or facilities could pose an unacceptable risk to human health.

Buffer zones necessary to protect human health and safety are divided into two main regions--an inner Exclusive Use Zone (EUZ) and an outer Emergency Planning Zone (EPZ).

- The EUZ is an area designated for activities associated with the waste site or facility at the center of the buffer-zone. The land use designation for the EUZ is "reserved for waste management operations," with severely restricted public access. This zone extends from the facility fence line to a distance at which threat to the public from routine and accidental releases diminish to the point where public access can be routinely allowed. The size and shape of the EUZ is determined by the most restrictive SAR or HA boundary and is based on the inventory of contaminants, potential release mechanisms, and atmospheric transport parameters.

- The EPZ is an area surrounding a facility for which planning and preparedness efforts are carried out to ensure that prompt and effective actions can be taken to minimize the impact to onsite personnel, public health and safety, and the environment in the event of an operational emergency. The EPZ begins at the boundary of the EUZ and ends at a distance for which special planning and preparedness efforts would not be required.

The protective buffer-zones for the Hanford Site (Figure 4-27), were established using boundaries calculated for individual limiting facilities (i.e., facilities with accidents of maximum potential public health impact). The boundaries provide a conservative buffer-zone that should be sufficient to address buffer-zone needs for the multiple facilities present in each area on the Hanford Site.

In an effort to consider non-Hanford protective buffer zone requirements that could be affected by Hanford Site public access and land use decisions, the emergency preparedness needs of the WPPSS were considered. Under NRC procedures, the WPPSS WNP-2 Reactor requires a 1.6 km (10-mi) EPZ and 1.9 km (1.2-mi) EUZ.

Within portions of the EPZ, certain types of public access may be restricted, while other types of public access within that same area are acceptable. Criteria are needed to evaluate, on a case-by-case basis, the types of public access possible within an EPZ. Six different types of public access have been defined for the EPZ. These types of access are presented below in decreasing order of restrictions:

Very Limited Access. Very limited access, such as passing through on transportation corridors. Special arrangements would be required to leave the designated access point. The evacuation time for this type of access would be no more than 30 minutes. The maximum amount of time the MEI[4] would spend in this area is estimated to be about 100 hours per year.

Restricted Routine Access. This type of access area would include activities such as industrial and commercial usage of a specifically designated area. It could also include short special interest uses such as short nature trails. All users of the area must have ready access to transportation to facilitate a rapid evacuation. Evacuation time for this type of access would be no more than 1 hour. The maximum amount of time the MEI would spend in this area is estimated to be about 3,000 hours per year.

Restricted Short Term Access. This type of access may include locations adjacent to transportation corridors. Public access might involve short stops to view sights or engage in short duration activities. Access to areas more than 0.4 km (.25 mi) from a designated access point would be prohibited. The evacuation time for this type of access would be no more than 1.5 hours. The maximum amount of time the MEI would spend in this area is estimated to be about 2,000 hours per year.

Moderately Restricted Periodic Access. This type of access would allow for periodic activities such as limited agricultural activities. Public access to this area would tend to be more periodic and seasonal. No permanent residences, schools, or hospitals would be allowed. The evacuation time for this type of access would be no more than 2 hours. The maximum amount of time the MEI would spend in this area is estimated to be about 3,000 hours per year.

Moderately Restricted Occasional Access. This type of access area would allow for more diverse activities for a longer, but controlled, periods of time than those defined for the

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[4]The Maximally Exposed Individual (MEI) is defined as an hypothetical person who lives near the Hanford Site who, by virtue of location and living habits, could receive the highest possible radiation dose.

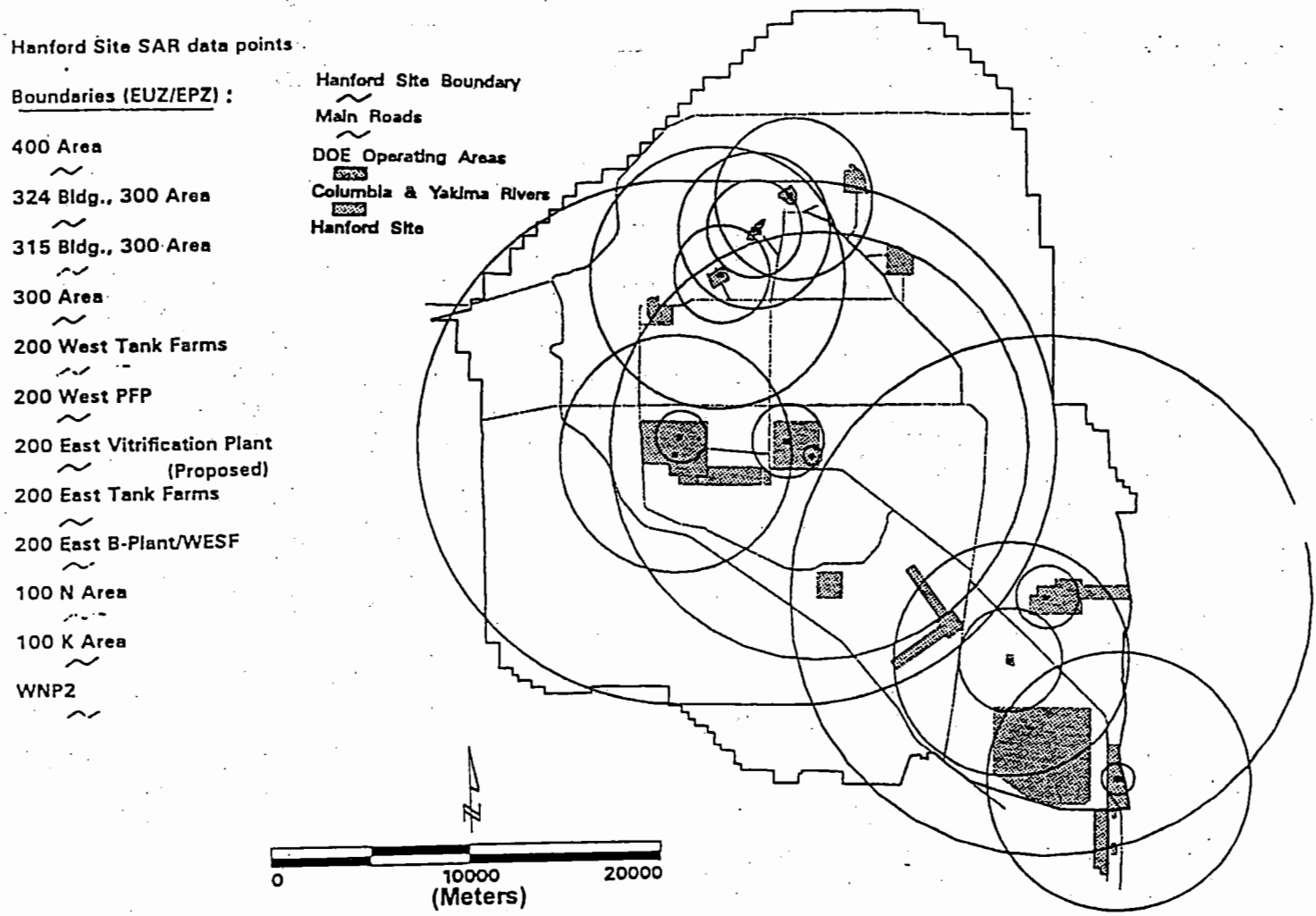
Moderately Restricted Periodic Access areas. For example, overnight stays for short periods would be allowed. The evacuation time for this type of access would be no more than 2.5 hours. The maximum amount of time the MEI would spend in this area is estimated to be about 1,000 hours per year.

Minimally Restricted Access. This would allow access with only minimal restrictions to ensure timely evacuation. This type of access would consider limited residential type usage of the area, and could accommodate small schools and commercial businesses. The evacuation time for this type of access would be 2.5 hours. The maximum amount of time the MEI would spend in this area s estimated to be about 8,700 hours per year.

4.10.10 Native American Treaty Rights

Under the Treaties of 1855, lands occupied by the Hanford Site were ceded to the United States by the confederated tribes and bands of the Yakama Indian Nation and Confederated Tribes of Umatilla Indian Reservation. Under these treaties, the tribes retained the right to perform certain activities on those lands, including the rights to hunt, to fish at all usual and accustomed places and to erect temporary buildings for curing fish, to gather roots and berries, and to pasture horses and cattle on open and unclaimed lands into perpetuity. The Wanapum, who never signed a treaty and are not currently a federally-recognized tribe, claim similar rights to these lands. The Nez Perce Tribe's treaty with the U.S. Government retained their rights to fish at all usual and accustomed places, including the Hanford Reach. Tribal members have expressed an interest in renewing their use of these resources in accordance with the Treaties of 1855.

Figure 4-27. Protective Buffer Zones.



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Environmental Consequences

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5.0 Environmental Consequences

This chapter describes the potential environmental consequences resulting from the degree of remediation necessary to achieve a desired land-use objective for each of the four geographic areas. The analysis focuses on the resource categories described in Chapter 4.0, Affected Environment. A summary of potential environmental consequences and mitigation measures is presented in Section 3.4 of this Environmental Impact Statement (EIS).

5.1 Analysis Approach

The environmental consequences analysis involved estimating impacts on the physical environment, human health risks, and ecological risks. The methods used to estimate impacts and risks are described briefly in the following sections. These methods also are described in detail in the supporting Appendices.

5.1.1 Geographic Information System Analysis

Analyses of effects of remediation activities on geological resources, soils, floodplains, wildlife habitat, and cultural resources were performed using a geographic information system (GIS). The GIS provided for rapid analysis of large volumes of data regarding natural resources, waste site remediation, and facilities decommissioning. This analysis generated tables and figures that show remediation impacts, waste volumes, and costs for the alternatives for each geographic area (Appendix H). Summary tables provide estimates of the extent of disturbances to various Hanford Site resources for each future land-use alternative and the No-Action Alternative.

Use of the GIS required that a variety of data be obtained and incorporated into the GIS database. Data obtained include:

- geology and soils
- water resources
- habitat types and vegetation
- wetlands
- species of concern
- wildlife
- cultural resources
- topography
- land use
- transportation systems
- waste sites
- treatment, storage, and/or disposal (TSD) facilities
- buildings
- effluent lines.

All GIS data files used in this project represent geographic locations through the use of the State Plane Coordinate System, Washington South Projection. The State Plane Coordinate System is designed for mapping the United States and is used primarily by government organizations. Its use in this EIS ensures that results will be compatible with government (and many nongovernment) databases covering the same geographic area.

The GIS was used to calculate the Hanford Site areas, potential excavation areas, capping areas, and the associated trample zones caused by soil excavation, soil stockpiling, and cap construction. The resulting impact areas were integrated into a single, discrete layer of information. This layer was then overlaid and passed through each resource layer (e.g., vegetation, wetlands, cultural resources). The information associated with each resource layer then could be examined. These pieces defined the area where impacts likely would occur. The impacts on the potentially affected resource (e.g., shrub-steppe habitat in the vegetation layer) were analyzed and the percentage of resource type disturbed was calculated for each alternative of the geographic areas relative to the Hanford Site.

5.1.2 Human Health Risk Assessment Methodology

This section provides a brief description of the human health risk assessment methodology for this EIS. A detailed discussion of methodology and key data are presented in Appendix B.

Three types of potential health risks were assessed: cancers caused by radionuclides, cancers caused by chemical carcinogens, and noncancerous toxic effects. Incremental lifetime cancer risks (ILCR) were estimated for cancer-causing radionuclides and chemicals, and the resulting values were compared to the 10^{-4} to 10^{-6} (1 in 10,000 to 1 in 1,000,000) range suggested by the EPA in "National Oil-and Hazardous Substances Pollution Contingency Plan," 40 *Code of Federal Regulations* (CFR) 300 as a target risk level following remediation of hazardous waste sites. The total cancer risk in this EIS was determined by summing the radionuclide and chemical carcinogen risk. Noncancer risks were estimated using the hazard index (HI), which is the ratio of the estimated exposure to a threshold value below which toxic effects would not be expected. The risk is considered small if the ILCR to an individual is no greater than 10^{-4} to 10^{-6}, or if the HI is less than 1.0.

> The HI is equal to the sum of the hazard quotients for individual chemicals. Further discussion of the concepts of the hazard quotient and the HI is presented in Appendix B5.

5.1.2.1 Baseline Risk Assessment. A baseline risk assessment was used to evaluate the potential threat to human health and the environment in the absence of any remedial action. This baseline risk assessment describes the risk conditions under the No-Action Alternative (see Section 3.3.1 for more information on the No-Action Alternative). The baseline risk assessment provides the basis for determining whether remedial action is necessary (DOE-RL 1993a). Under the No-Action Alternative, potential risks were estimated for the four geographic areas for agricultural, residential, industrial, and recreational exposure scenarios. Assumptions concerning the type and magnitude of contact with contaminated media (e.g., soil, water, air, food) were made for each of these scenarios (see Appendix B4). In addition, for purposes of analysis, current restrictions or institutional controls were assumed to be no longer in effect. A baseline risk assessment was undertaken for the Reactors on the River, Central Plateau, and All Other Areas geographic areas.

An approach grouping the waste sites and integrating the effects of potential releases was necessary, because of the sheer magnitude of information needed to assess risk at every waste site on the Hanford Site.. This was accomplished by grouping waste sites by waste form (i.e., soils, groundwater), then aggregating them into cells by overlaying a grid of 1-km^2 (0.4-mi^2) cells over the Hanford Site. The potential contaminant release and transport through the environment from each cell was estimated using the Multimedia Environmental Pollutant Assessment System (MEPAS)

computer model (Droppo et al. 1991) found in Appendix B. Modeling results from multiple cells were combined to provide environmental concentrations in the soil, groundwater, surface water, and air to which a human or ecological receptor might be exposed. Source-term data were compiled from the Waste Information Data System (WIDS), Solid Waste Information Tracking System (SWITS), and Hanford Environmental Information System (HEIS) databases; field investigation reports; and other sources, when applicable.

The risk to a given receptor was determined by estimating the quantity of contaminant transported from a source to that receptor. Risk calculations were simplified by separating the computational process into discrete modules that were developed separately and then combined. These modules include the source (waste) terms, contaminant transport mechanisms, exposure scenarios, and the variables used to calculate risk or HI from a given exposure. The MEPAS model (Droppo et al. 1991), developed by the Pacific Northwest National Laboratory (PNL), was used to estimate risk.

5.1.2.2 Accident Risks. Risk caused by remediation operations can be separated into risk from routine activities and risk from accidents. Risk from routine activities refers to risk to workers and the general public resulting from daily activities and processes associated with remediation efforts. Accident risk refers to the risk to workers and the general public from accidents that could occur as a result of the remediation activities.

Remediation activities would be conducted in compliance with applicable laws, regulations, and U.S. Department of Energy (DOE) orders. In addition, appropriate engineering and administrative measures would be applied during routine remediation activities so that workers, the general public, and the environment were ensured of protection, and that exposures to radioactive and hazardous chemicals remain below applicable regulatory and administrative limits. Therefore, this EIS does not assess risk from routine remediation activities.

This EIS analyzes several possible accident scenarios that could result in the release of hazardous and radioactive materials to the environment. These scenarios include a shoreline excavation accident, a range fire, a soil dispersion accident, and a fire in a groundwater filtration unit.

A shoreline excavation accident could occur during remediation of the Columbia River and would release contaminants to the river. A range fire, which could occur under any alternative for the other three geographic areas, would release contaminants taken up by plants. A soil dispersion accident, caused by the ignition of reactive material in a container encountered during the excavation of a waste site, would disperse contaminants through the air. A fire in a filtration unit used for treating groundwater would release contaminants to the air.

In addition to accidents resulting from remediation activities, one accident scenario was evaluated for the No-Action Alternative. This accident scenario is a widespread (2.59 km^2 , 1 mi^2) range fire that would release contaminants taken up by vegetation. This accident was selected because of the high likelihood of occurrence and lack of dependence on the alternative selected.

5.1.3 Ecological Risk Assessment Methodology

The ecological risk assessment methodology builds on the human health risk assessment methodology. Potential long-term exposures to chemicals and radionuclides in the geographic areas were estimated for the No-Action Alternative for a generic plant, the Great Basin pocket mouse, the

coyote, and the red-tailed hawk. Potential hazards to ecological receptors caused by exposure to nonradioactive chemicals were expressed as the HI, the ratio of:

estimated exposure : exposure expected to have no adverse effect.

A HI greater than 1.0 was considered a potentially significant impact. The ecological HI is directly analogous to that described above for human health.

Chemical exposures were estimated as follows:

- Chemical exposure of plants was estimated as the maximum soil concentration of contaminants occurring in the 1-km^2 (0.4-mi^2) cell.

- Chemical exposure of wildlife was estimated as the intake rate by a pocket mouse consuming contaminated vegetation and by a coyote or hawk consuming the pocket mouse.

- Radiation doses were estimated in a similar fashion and compared to the benchmark dose of 1 rad/d suggested by the National Council on Radiation Protection and Measurements (NCRP) as protective of aquatic organisms and the 0.1 rad/d suggested by the International Atomic Energy Agency (IAEA) as protective of terrestrial organisms. DOE Order 5400.5 (DOE 1993a) also recognizes the 1-rad/d benchmark for aquatic organisms (NCRP 1991). Maintaining doses to individual organisms below these benchmarks is considered protective of populations. Estimated doses above the benchmarks were considered potentially significant.

A complete description of the ecological risk assessment methodology and detailed results are provided in Appendix C.

5.1.4 Topics Covered in this Chapter

This chapter analyzes each alternative for its potential impact on 11 different resource areas for each geographic area:

- geology
- soils
- air
- ecology
- water quality
- noise
- cultural resources
- visual resources
- socioeconomics
- human health risk
- industrial health and safety.

Information regarding excavation volumes, areas of disturbance, and costs also is provided.

Later sections of this chapter address:

- means to mitigate impacts
- cumulative impacts
- unavoidable adverse impacts
- irreversible and irretrievable commitments of resources
- conflict with land use plans of other federal and state agencies and Tribal governments
- environmental justice
- relationship between near-term use and long-term productivity.

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Columbia River

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5.2 *Columbia River Geographic Area*

The scope of proposed actions in the Columbia River geographic area includes contaminated riverbank sediments, riverbottom sediments, river island sediments, river discharge pipelines, and other areas within 0.4 km (1/4 mi) of both shores of the Columbia River. For analysis purposes, the river discharge pipelines considered to be within the Columbia River geographic area are those extending from the outfall structures on the riverbank into the river (Figure 5-1). The effluent lines, which extend from the reactors to the outfall structures, are discussed under the Reactors on the River geographic area (Section 5.3). Potential impacts of the No-Action and future land-use alternatives are described in the following sections.

In accordance with "Compliance with Floodplain/Wetlands Environmental Review Requirements," (10 CFR 1022), a Floodplain/Wetlands Assessment has been prepared to incorporate floodplain management goals and wetland protection considerations into the DOE planning, regulatory, and decisionmaking processes. The Floodplain/Wetlands Assessment is included in Appendix J.

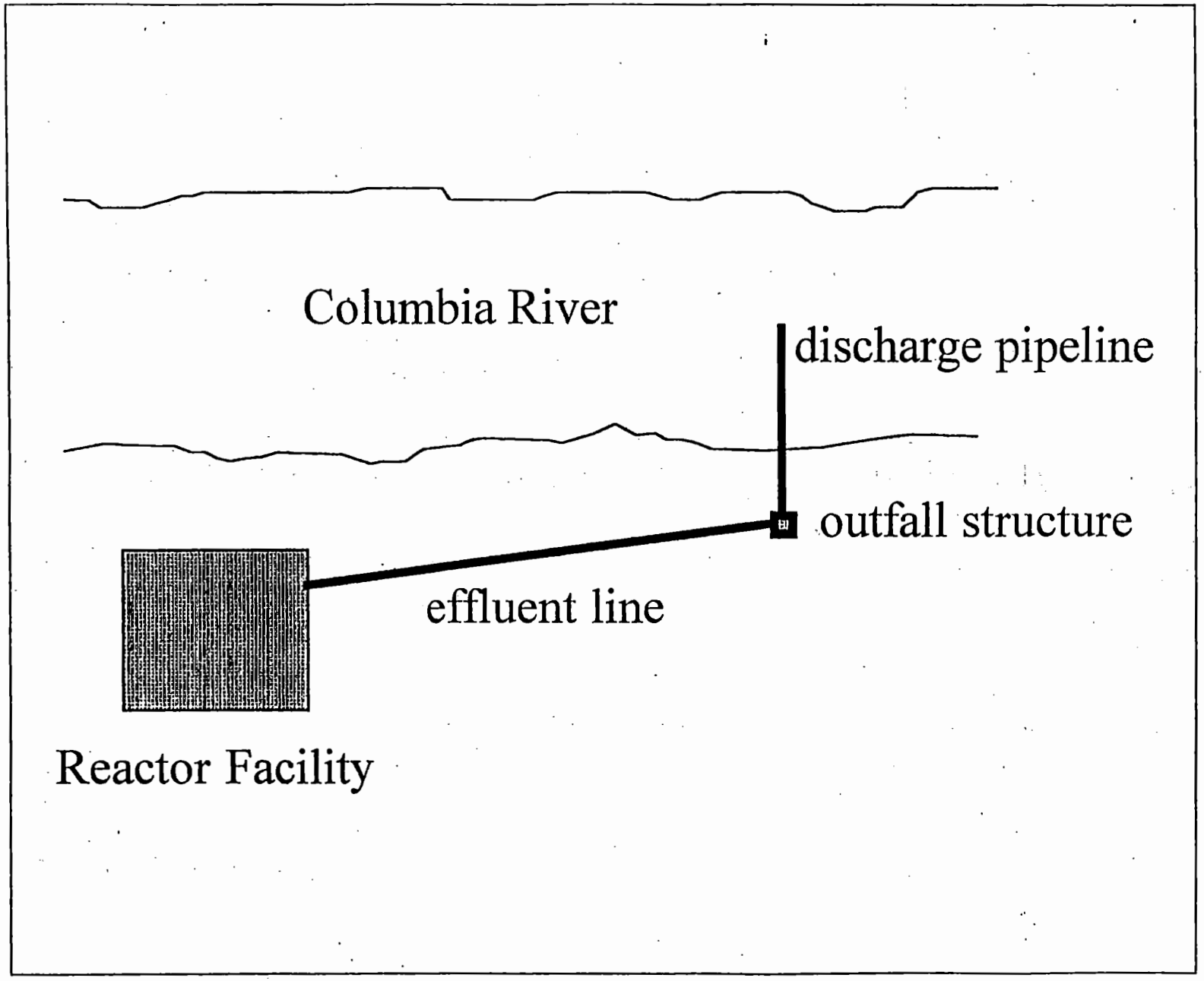
5.2.1 Geology

5.2.1.1 Effects on Geologic Resources, No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments and continuation of the current environmental monitoring and maintenance activities. Under this alternative, the river discharge pipelines and contaminated sediment would be left in place, requiring continued restrictions on public access to the Hanford Reach of the Columbia River (Hanford Reach) for exploration or exploitation of mineral deposits. No mining activity currently is conducted in this area and historical mining activity has been very limited. There are currently no known mineral leases in the Hanford Reach, and a formal evaluation of the mineral potential of the Hanford Reach has never been prepared. Continuing to exclude geologic resources in the Hanford Reach from development would not be expected to result in significant short- or long-term adverse impacts. Continued environmental monitoring and maintenance activities would have no significant impact on the geologic resources of the Hanford Reach.

5.2.1.2 Effects on Geologic Resources, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve excavation and removal of contaminated riverbank, riverbottom, and island sediments, and decommissioning of river discharge pipelines. The extent of excavation required would be determined through site characterization under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) process. Up to 17 km (11 mi) of shoreline, where groundwater plumes enter the river, could be affected by excavation activities. Excavation could extend as far inland as 0.18 km (0.1 mi) and could encompass reactor facilities and past-practice waste sites in the Reactors on the River geographic area (Appendix H).

This alternative would involve the short-term continuation of existing restrictions on public access to geologic resources in the Hanford Reach. As in the No-Action Alternative, such access restrictions are not expected to result in significant short- or long-term adverse impacts on development of geologic resources. Complete removal of all contamination under this alternative could allow for the eventual relaxation of these access restrictions.

Figure 5-1. Reactor Outfall Pipeline Schematic.



5.2.1.3 Effects on Geologic Resources, Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would involve stabilizing in place the river discharge pipelines, removing detached pipeline segments, and continuing institutional controls to prevent human exposures to contamination. Estimated volumes of materials needed to stabilize the pipelines under this alternative are presented in Section 5.2.11.

Institutional controls implemented under the Restricted Future Land-Use Alternative would involve the long-term continuation of existing restrictions on public access to geologic resources in the Hanford Reach. As in the No-Action Alternative, such access restrictions are not expected to result in significant short- or long-term adverse impacts on the development of geologic resources.

The Restricted Future Land-Use Alternative would require mining of riprap for use as pipeline capping material from quarry sites. Although the amount of materials involved is small compared to that required for capping in other geographic areas, this alternative would contribute to the depletion of quarry sites. This impact is discussed in Section 5.10 as an irreversible and irretrievable commitment of geologic resources. Appendix E provides additional detail on quarry and borrow sites.

5.2.2 Soils

The potential effects of the alternatives on soils adjacent to the Columbia River are summarized in Table 5-1.

5.2.2.1 Effects on Soils, No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, and continuation of the current environmental monitoring and maintenance activities. These activities would be limited to spot contaminant locations and are not expected to result in significant impacts on soils. Continued environmental monitoring and maintenance activities would not have significant impacts on soils.

5.2.2.2 Effects on Soils, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve excavation and removal of contaminated riverbank, riverbottom, and island sediments, and decommissioning of river discharge pipelines. This alternative would disturb approximately 148 ha (370 ac) of soils in the Columbia River geographic area (see Table 5-1). Soil disturbance would occur primarily in the trample zone around work areas from heavy equipment used to haul contaminated sediments from shoreline and island sites. Short-term impacts would include soil compaction and increased potential for erosion. Ephrata sandy loam and Ephrata stony loam are both susceptible to soil compaction (Brincken 1994). Although these impacts are considered potentially significant, long-term impacts would not be significant if appropriate mitigation measures were implemented.

5.2.2.2.1 Potential Mitigation Measures. Potential mitigation measures for soils include the following:

- restricting heavy equipment to trample zones
- using the same of existing transportation routes to minimize damage to undisturbed soil and vegetation

- using silt fences and dust control measures to reduce soil erosion

- reseeding disturbed areas with native vegetation to reduce long-term soil loss from wind and water erosion.

*Table 5-1. Soils Disturbed under the Columbia River Geographic Area Future Land-Use Alternatives.**

Soil Types	No Action ha (ac)	Unrestricted ha (ac)	Restricted ha (ac)
Riverwash	Negligible	22.4 (56)	0.4 (1)
Ephrata sandy loam	Negligible	9.6 (24)	0.4 (1)
Ephrata stony loam	Negligible	62.4 (156)	3.2 (8)
Rupert (Quincy sand)	Negligible	32.4 (81)	0
Burbank loamy sand	Negligible	21.2 (53)	0
Total	<1	148 (370)	4.0 (10)

*Areal impact information generated from the GIS; includes area disturbed for excavation, outfall capping, trample zones, effluent lines, and trench.

5.2.2.3 Effects on Soils, Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would involve stabilizing in place the river discharge pipelines, removing detached pipeline segments, and continuing institutional controls to prevent human exposures to contamination. Implementation of the Restricted Future Land-Use Alternative would result in the disturbance of 4 ha (10 ac) of soils in the Columbia River geographic area. Impacts would be similar in kind but less extensive than those under the Unrestricted Future Land-Use Alternative, because contaminated sediments would be left in place. Soil disturbance would occur primarily in the trample zone around work areas from heavy equipment used during decommissioning of the river discharge pipelines. Short-term impacts would include soil compaction and increased potential for erosion. Although these impacts are considered potentially significant, long-term impacts would not be significant if appropriate mitigation measures were implemented.

5.2.2.3.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative are the same as for the Unrestricted Future Land-Use Alternative.

5.2.3 Water Resources

5.2.3.1 Effects on Columbia River Flow Characteristics, No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, and continuation of the current environmental monitoring and maintenance activities. This alternative would not affect the existing flow characteristics of the Columbia River.

5.2.3.2 Effects on Columbia River Flow Characteristics, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve excavation and removal of contaminated riverbank, riverbottom, and island sediments, and decommissioning of river discharge pipelines. Removal of contaminated riverbank sediments could require use of a coffer dam along the Columbia River to de-water the area and enable excavation. A coffer dam would constrict the river channel, which could cause a rise (backwater effect) in the river stage just upstream of the coffer dam. The

estimated increase in river stage would be approximately 10 to 20% above the river stage expected under existing baseline conditions (Table 5-2). Increases in river stage would increase flow velocity by approximately 15%, and could result in additional local scour near the coffer dams. This scour could resuspend and transport potentially contaminated sediments from the riverbottom and island areas during riverbank excavation. As discussed in Section 5.2.3.5, releases of contaminants from sediments into the Columbia River could have significant impacts on water quality.

Table 5-2. Estimated Stage Increase on the Columbia River Resulting from a Coffer Dam.

Annual Flow Rates	Stage Increase*
average: 3.400 m^3/s (120,100 ft^3/s)	+0.4 m to +1.6 m (+1.3 ft to 5.2 ft)
low: 1,020 m^3/s (36,040 ft^3/s)	+0.2 m to +0.8 m (+0.7 ft to +2.6 ft)
high: 11,250 m^3/s (401,790 ft^3/s)	+0.9 m to +3.3 m (+2.9 ft to +10.8 ft)

*Stage estimates were calculated assuming steady flow, with a Manning's roughness factor of 0.025 and a friction slope of 0.0002 for the Columbia River (Barnes 1967).

Temporary changes in Columbia River stage could change adjacent alluvial groundwater levels by an amount equal to the changes in river stage. These changes in river stage temporarily could increase or decrease groundwater gradients, and possibly change the direction and rates of contaminant migration in the groundwater system adjacent to the Columbia River. Studies by Gilmore et al. (1990, 1991) indicated that the effects of seasonal river stage fluctuations were noticeable up to 300 m (984 ft) inland, and daily river level fluctuations could be seen up to 230 m (750 ft) inland. Changes to the groundwater system, caused by the temporary increase in river stage, likely would be noticeable a slightly greater distance inland than normal. Because these changes would occur only during the time when the coffer dam is in place, no long-term impacts on groundwater would be expected.

5.2.3.3 Effects on Columbia River Flow Characteristics, Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would involve stabilizing in place the river discharge pipelines, removing detached pipeline segments, and continuing institutional controls to prevent human exposures to contamination. Remedial activities under this alternative would not require the use of a coffer dam and are not expected to have significant impacts on the existing flow characteristics of the Columbia River.

5.2.3.4 Effects on Water Quality, No-Action Alternative. Under the No-Action Alternative, the river discharge pipelines and contaminated sediment would be left in place. This alternative is not expected to degrade water quality in the Columbia River in the short or long term. The release of existing contaminants from the river discharge pipelines and sediments is not expected to increase above current rates, and is expected to diminish with time. However, increased contaminant releases could occur as the result of natural scouring action, which has begun to expose and detach portions of the buried river discharge pipelines. Potentially significant impacts could be avoided with appropriate mitigation measures. Natural shoreline erosion also could mobilize contaminated sediment; however, this process is very slow and is not expected to significantly affect water quality.

Concentrations of tritium, strontium-90, and iodine-129 in the Columbia River have been identified as statistically elevated. Tritium, uranium, and iodine-129 are found in higher concentrations at the Richland Pumphouse compared to Priest Rapids Dam, indicating an influence from Hanford operations (PNL 1995). However, current radionuclide concentrations in Columbia

River water are below applicable drinking water standards (DWS). Downstream surface water supplies for municipal and other uses should not be affected, water quality impacts from the No-Action Alternative are not considered significant.

5.2.3.4.1 Potential Mitigation Measures. The risk of contaminant release from river discharge pipelines would be reduced by periodically inspecting the pipelines and stabilizing exposed sections with riprap.

5.2.3.5 Effects on Water Quality, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve excavation and removal of contaminated riverbank, riverbottom, and island sediments, and decommissioning of river discharge pipelines. These activities could result in increased turbidity and radiological contamination in the Columbia River, which could have significant impacts on downstream municipal, industrial, and agricultural water quality. The quantities of contaminant releases or increases in concentrations cannot be estimated at this time, because the amounts of sediment contamination are not well documented. Site-specific evaluations of potential water quality effects would be performed as part of the CERCLA process. Mitigation measures would be used to minimize water quality degradation. Monitoring would be performed to identify problem areas and determine the need for additional corrective measures.

5.2.3.5.1 Potential Mitigation Measures. Potential mitigation measures for protecting water quality include the following:

- installing runoff barriers during remedial activities that disturb soil or sediment along the Columbia River to prevent contaminated sediments from entering the river
- limiting areas disturbed below the high water mark to minimize resuspension of disturbed materials
- using riprap, biodegradable geotextiles, and other suitable materials to stabilize disturbed areas, as needed
- supplying alternate municipal water downstream of remedial activities if radiological and chemical concentrations indicate substantial water quality degradation.

5.2.3.6 Effects on Water Quality, Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would involve stabilizing in place the river discharge pipelines and removing detached pipeline segments. These activities could result in releases of small amounts of contaminants to the Columbia River. Such releases would be short-term and are not expected to have significant impacts on water quality.

5.2.3.6.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative are the same as for the Unrestricted Future Land-Use Alternative.

5.2.3.7 Effects on the Columbia River Floodplain, No-Action Alternative. The No-Action Alternative would not involve significant disturbance of the Columbia River floodplain.

5.2.3.8 Effects on the Columbia River Floodplain, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve excavation and removal of contaminated riverbank, riverbottom, and island sediments and decommissioning of river discharge pipelines. This alternative would affect 140 ha (346 ac) of Columbia River floodplain, which is approximately 3% of

the floodplain in the Columbia River geographic area and roughly 2% (in J.2.1.2.1) of the floodplain on the entire Hanford Site (Figure 5-2). Excavation of contaminated riverbank sediments would result in the eventual widening of the Columbia River floodplain. The extent to which the floodplain is widened would depend on areal extent and depth of excavations. The remedial activities are not expected to have adverse effects on floodplain functions.

5.2.3.9 Effects on the Columbia River Floodplain, Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would involve stabilizing in-place the river discharge pipelines, removing detached pipeline segments, and continuing institutional controls to prevent human exposures to contamination. The Restricted Future Land-Use Alternative would affect 7 ha (17 ac) of Columbia River floodplain, which is less than 1% of the floodplain in the Columbia River geographic area and less than 1% of the floodplain on the entire Hanford Site (Figure 5-3). Effects on the floodplain would be limited to locations where sediment excavation and pipeline removal is required to protect human health and safety. Remedial activities under this alternative are not expected to have significant effects on floodplain functions.

5.2.4 Ecology

5.2.4.1 Habitat Disturbance. The levels of habitat disturbance associated with each alternative are summarized in Table 5-3.

5.2.4.1.1 Effects on Aquatic Habitat, No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, and continuation of the current environmental monitoring and maintenance activities. These activities would not have significant impacts on aquatic habitat in the Columbia River geographic area.

Table 5-3. Comparison of Habitat Disturbance under the Columbia River Geographic Area Future Land-Use Alternatives.[a]

Habitat	Alternatives		
	No Action	Unrestricted	Restricted
Aquatic	0	20 ha (50 ac)	<0.4 ha (<1 ac)
Wetlands[b]	0	23 ha (57 ac)	<0.4 ha (<1 ac)
Shrub-steppe	0	36 ha (90 ac)	0
Species of Concern[c]	0	9	1

[a]Areal impact information generated from the GIS; includes potential disturbance associated with excavation, outfall capping, trample zones, outfall lines, and trench.

[b]National Wetlands Inventory Data.

[c]Includes bald eagle habitat (roosts and perching locations) within the zone of disturbance.

Figure 5-2. 100-Year Floodplain and Wetland Areas Impacted under the Columbia River Unrestricted Future Land-Use Alternative.

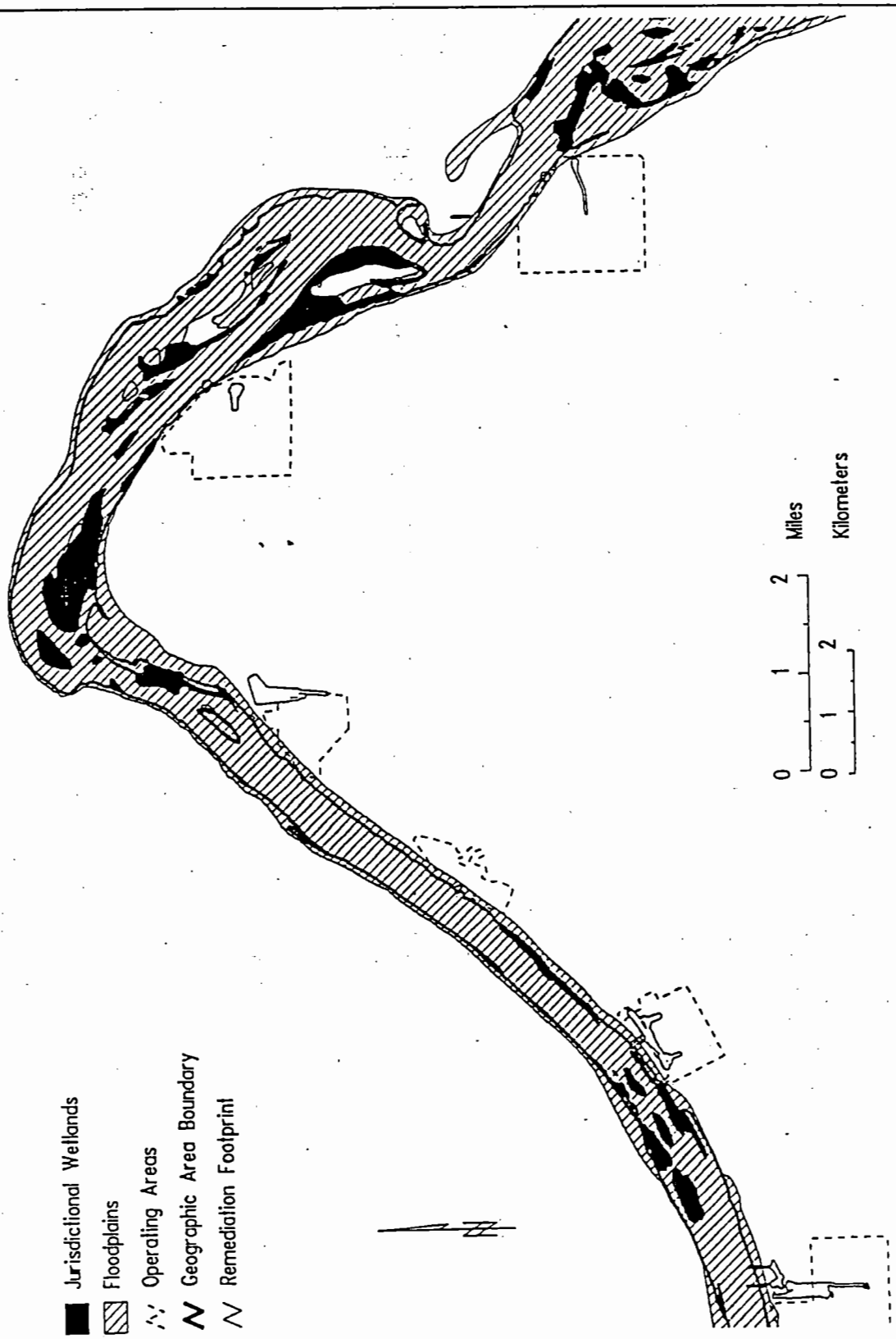
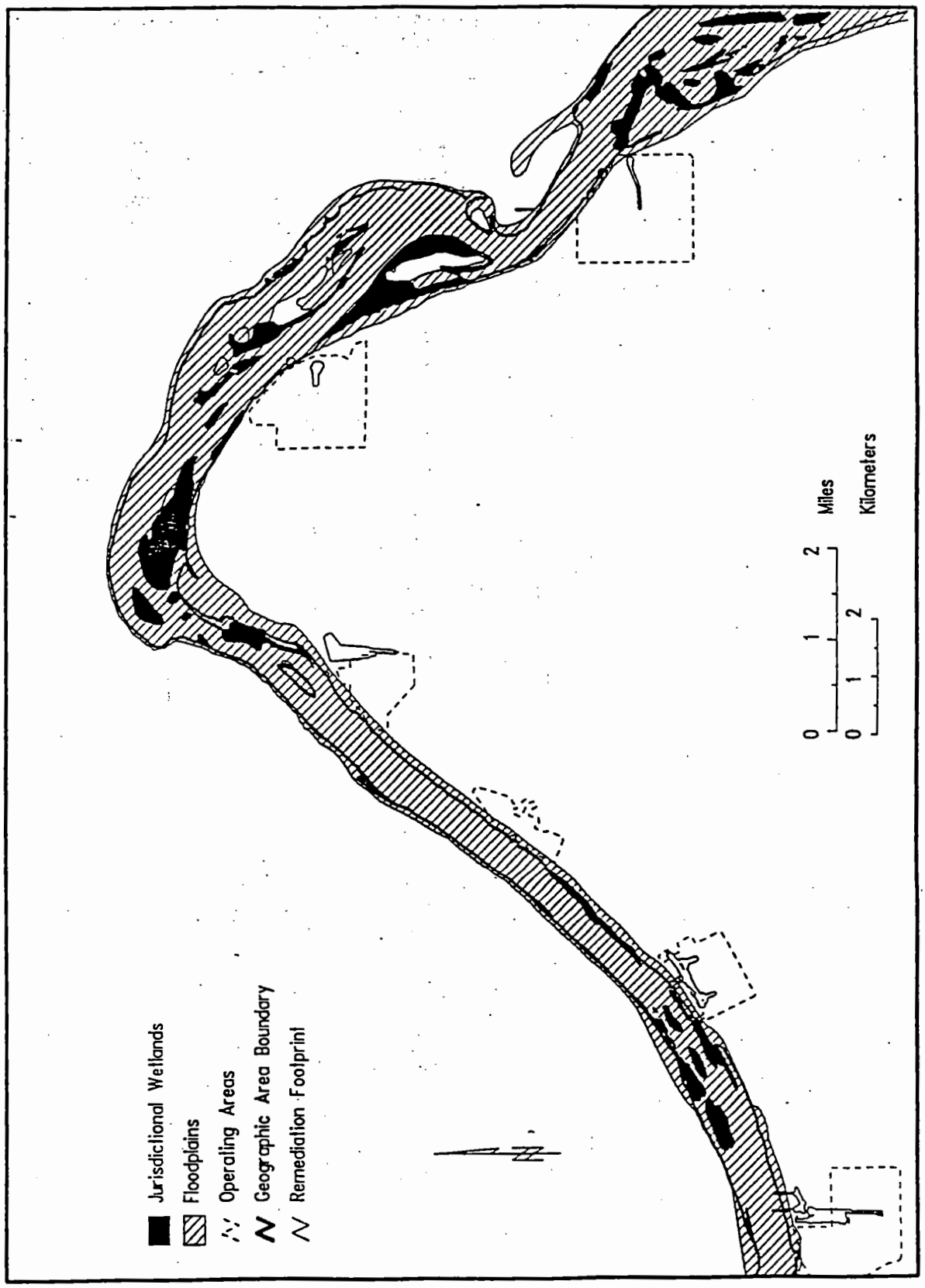


Figure 5-3. 100-Year Floodplain and Wetland Areas Impacted under the Columbia River Restricted Future Land-Use Alternative.



5.2.4.1.2 Effects on Aquatic Habitat, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve excavation and removal of contaminated riverbank, riverbottom, and island sediments, and decommissioning of river discharge pipelines. Removal of river discharge pipelines and associated contaminated sediments would involve disturbance of the riverbottom, resulting in losses of aquatic plants, riverbottom invertebrate species, and other aquatic lifeforms. Remedial activities would increase sediment loading in the river, which could adversely affect spawning areas for anadromous fish species and game fish species.

The loss of spawning habitat could have long-term adverse effects on fish populations. The Hanford Reach provides the only significant remaining spawning habitat, for fall chinook salmon on the mainstem of the Columbia River (NPS 1994). Loss of spawning habitat as a result of contaminated sediment excavation, combined with the effects of other past development activities along the Columbia River, could have a cumulative effect on fall chinook salmon populations. Additional population losses could result in listing the species as threatened or endangered under the *Endangered Species Act of 1973*.

5.2.4.1.2.1 Potential Mitigation Measures. Potential mitigation measures for aquatic habitats include the following:

- limiting activities below the high water mark to periods of lowest river flow and periods when anadromous fish are not spawning or migrating
- consulting with the National Marine Fisheries Service in identifying uncontaminated spawning areas to be avoided
- limiting areas disturbed to minimize resuspension of sediments
- using riprap, biodegradable geotextiles, and other suitable materials to stabilize disturbed areas, as needed
- requiring contractor equipment to be cleaned before entering work zones to prevent establishment or spread of water milfoil and other undesirable species
- reestablishing desirable aquatic vegetation, as needed.

5.2.4.1.3 Effects on Aquatic Habitat, Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would involve stabilizing in place the river discharge pipelines and removing detached pipeline segments. Disturbance of aquatic habitat would be limited to areas adjacent to river discharge pipelines, with some losses of aquatic plants and other lifeforms. Because contaminated riverbank, riverbottom, and island sediments would not be excavated, increased sediment loading would occur only briefly during decommissioning of the river discharge pipelines. Therefore, this alternative is not expected to have significant impacts on aquatic habitats.

5.2.4.1.3.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative are the same as those described for the Unrestricted Future Land-Use Alternative.

5.2.4.1.4 Effects on Wetlands, No-Action Alternative. This alternative would involve stabilization of contaminated sediments, and continuation of the current environmental monitoring and

maintenance activities. These activities would involve minimal disturbance of wetlands and would have no significant impacts.

5.2.4.1.5 Effects on Wetlands, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would result in the potential loss of 23 ha (57 ac) of wetlands, which is 11% of the wetlands in the Columbia River geographic area (see Figure 5-2). This loss would be significant, given the value of sensitive species and unique wetland plant communities identified in the Hanford Reach (NPS 1994).

5.2.4.1.5.1 Potential Mitigation Measures. Potential mitigation measures for wetlands include the following:

- identifying uncontaminated wetlands to be avoided
- using temporary fill structures, and other practices to minimize disturbance of uncontaminated wetland soils and preserve propagules for revegetation
- requiring contractor equipment to be cleaned before entering work zones to prevent establishment or spread of undesirable species in remaining wetlands
- replacing wetlands destroyed through purchase, construction, or restoration of wetlands.

Wetland mitigation plans would be developed in consultation with the State of Washington, U.S. Army Corps of Engineers (USACE), and the U.S. Fish and Wildlife Service (USFWS).[1]

5.2.4.1.6 Effects on Wetlands, Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would affect less than 0.4 ha (less than 1 ac) of wetlands (see Figure 5-3), which is not considered significant.

5.2.4.1.7 Effects on Shrub-Steppe Habitat, No-Action Alternative. This alternative would involve stabilization of contaminated sediments, and continuation of the current environmental monitoring and maintenance activities. These activities would not have significant impacts on shrub-steppe habitat in the Columbia River geographic area.

5.2.4.1.8 Effects on Shrub-Steppe Habitat, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would affect 36 ha (90 ac) of shrub-steppe habitat, mainly in trample zones associated with removal of river discharge pipelines and contaminated sediments (Figure 5-4). This level of disturbance, representing less than 1% of the shrub-steppe habitat on the Hanford Site, is not considered to be significant. The areas disturbed also could include trees used as perching and roosting sites by bald eagles (see Section 5.2.4.3). The disturbed area would be revegetated with native species.

5.2.4.1.9 Effects on Shrub-Steppe Habitat, Restricted Future Land-Use Alternative. Activities in upland areas under the Restricted Future Land-Use Alternative would be limited to previously disturbed areas and would not impact existing shrub-steppe habitat.

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[1]Excavating or filling wetlands as part of a CERCLA remedial action would not require a permit, but would require meeting the substantive requirements of Section 404 of the *Clean Water Act of 1977*. More specific or additional mitigation measures would be negotiated through this process.

5.2.4.2 Effects on Species of Concern, No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, and continuation of the current environmental monitoring and maintenance activities. These activities would be planned to avoid disturbing sensitive species and are not expected to have significant impacts.

5.2.4.3 Effects on Species of Concern, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternatives would involve the removal of river discharge pipelines and contaminated sediments. This alternative could have significant impacts on several species of concern including:

- the bald eagle (federal and state threatened)
- the white pelican (state endangered)
- two mollusk species – the short-face lanx and Columbia pebble snail (federal and state candidates)
- four fish species – the mountain sucker, sand roller, Piute sculpin, and reticulate sculpin (state species of concern)
- the Columbia River tiger beetle (state candidate species)
- two plant species – the Columbia yellowcress and northern wormwood (state endangered and federal candidates).

Remediation activities could disrupt bald eagle use along the Hanford Reach, if remedial activities are located near trees used for roosting and perching. White pelicans, which use the Hanford Reach shoreline and islands, could experience stress or habitat loss. The two mollusk species, two plant species, and the insect species are the most likely to experience direct mortality as the result of sediment excavation. Additional population losses of these candidate species could result in their listing as threatened or endangered under the *Endangered Species Act of 1973*.

5.2.4.3.1 Potential Mitigation Measures. The potential mitigation measures previously described in Section 5.2.4.1.2.1 for aquatic habitats and in Section 5.2.4.1.5.1 for wetlands would help reduce impacts to species of concern. Additional potential mitigation measures include the following: exclude all disturbance within an 800-m (0.5-mi) buffer around winter roosts for bald eagles from November 15 to March 15, and avoid any habitat alteration within 400 m (0.25 mi) of bald eagle roosts (Fitzner et al. 1994); identifying and protecting, to the extent possible, populations or habitats of other species (e.g., Columbia yellowcress, northern wormwood, short-faced lanx, Columbia pebble snail, and Columbia River tiger beetle).

Figure 5-4. Unrestricted Future Land-Use Alternative Impact on Shrub-Steppe Habitat, Columbia River Geographic Area.

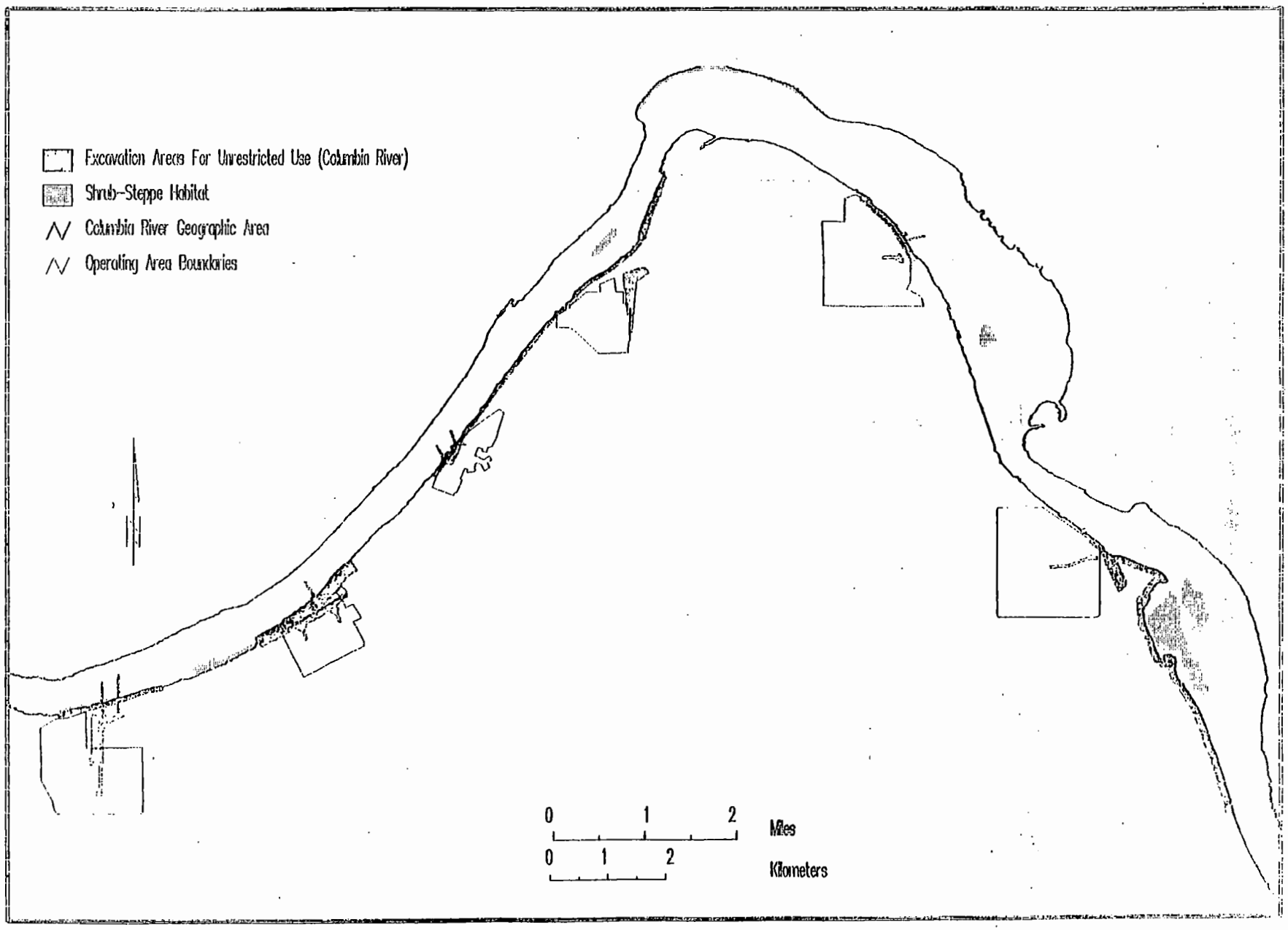

Figure 5-1. Unrestricted Use Alternative impact on shrub-steppe (Columbia River).

5.2.4.4 Effects on Species of Concern, Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would involve stabilizing in place the river discharge pipelines and removing detached pipeline segments. These activities would impact several species of concern, as discussed under the Unrestricted Future Land-Use Alternative; however, remedial activities under this alternative would be shorter in duration and would disturb less area. With limited disturbance and implementation of appropriate mitigation measures, the Restricted Future Land-Use Alternative is not expected to have significant impacts on sensitive species.

5.2.4.4.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative are the same as those described for the Unrestricted Future Land-Use Alternative.

5.2.4.5 Ecological Risk, No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, and continuation of the current environmental monitoring and maintenance activities. Under this alternative, the river discharge pipelines and contaminated sediment would be left in place. The No-Action Alternative is not expected to pose unacceptable risks to species or their habitats in the short or long term. Recent environmental monitoring data indicate that Hanford operations have resulted in small accumulations of some radionuclides in fish and wildlife. However, the concentrations are not sufficient to pose a hazard to the organisms themselves or to humans who might consume them (PNL 1993).

The potential radiological risks to ecological receptors from the No-Action Alternative was evaluated in the ecological risk assessment (Appendix C). Potential radiation doses caused by exposure to radionuclides in surface waters in the Columbia River and other locations were estimated for a generic plant, an invertebrate, a fish, and the muskrat. None of the estimated doses approached the 1 rad/d suggested by the NCRP or the 0.1 rad/d suggested by the IAEA as protective of aquatic and terrestrial organisms, respectively (NCRP 1991, IAEA 1992).

Concentrations of nonradioactive constituents in the Columbia River are comparable upstream and downstream from the Hanford Reach, and do not exceed levels considered protective of aquatic organisms. As described in Section 5.2.3.4, the No-Action Alternative would not have significant impacts on Columbia River water quality with appropriate monitoring and mitigation. Therefore, the potential risks to ecological receptors such as aquatic organisms and associated predator species are not considered significant.

5.2.4.6 Ecological Risk, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve the removal of river discharge pipelines and contaminated riverbank sediments. This alternative could result in increased short-term risk to ecological receptors as a result of resuspension and transport of contaminated sediments. Increased contamination in the Columbia River could result in direct exposures of ecological receptors or subsequent uptake through the food chain. These short-term exposures could be prevented or minimized by the mitigation measures described for water quality in Section 5.2.3.4. Direct exposures of ecological receptors would be expected to decrease over the long term.

5.2.4.7 Ecological Risk, Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would involve stabilizing in place the river discharge pipelines and removing detached pipeline segments. As described in Section 5.2.3.6, these activities could result in some contaminant releases. Such releases would not significantly increase ecological risks.

5.2.4.8 Effects on Biodiversity, No-Action Alternative. The No-Action Alternative is not expected to have significant impacts on biodiversity in the short or long term. The existing riverine ecosystem of the Hanford Reach would remain intact and relatively undisturbed. All of the following would remain unchanged: distribution and proportions of aquatic, wetland, and shrub-steppe habitats associated with the Columbia River, species diversity within those communities, and abundance and genetic diversity of individual species.

5.2.4.9 Effects on Biodiversity, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative could have significant impacts on biodiversity. Removal of river discharge pipelines and contaminated riverbank sediments could result in population losses in sensitive species, especially in aquatic habitats. Reduced populations could have indirect food chain effects on the abundance of other species. Disturbance and subsequent reclamation of plant communities could reduce species diversity, with indirect effects on community functions, such as forage production, cover, and nutrient cycling. Excavation activities would fragment existing habitats and disrupt the connectivity among different habitats. These impacts are expected to be significant in the short term; long-term impacts to biodiversity could be avoided or reduced through implementation of the mitigation measures previously discussed.

5.2.4.10 Effects on Biodiversity, Restricted Future Land-Use Alternative. Under this alternative, disturbance would be limited to areas adjacent to river discharge pipelines. The limited remedial activities could result in mortality among species of concern in aquatic habitats; however, it is unlikely that the abundance of these species would be affected in the long term. Limiting disturbance to small areas would enable recolonization from surrounding areas, reducing the likelihood of permanent changes to community diversity and minimizing habitat fragmentation. Although the Restricted Future Land-Use Alternative would disrupt ecosystem functions in the short term, no significant long-term impacts are expected.

5.2.5 Air Quality

5.2.5.1 Effects on Air Quality, No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, and continuation of the current environmental monitoring and maintenance activities. Generation of airborne pollutants under the No-Action Alternative would not exceed the amounts currently generated by Hanford operations. No significant impacts are expected from implementation of the No-Action Alternative, because current Hanford Site emissions meet air quality standards (PNL 1995).

5.2.5.2 Effects on Air Quality, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve excavation and removal of contaminated riverbank, riverbottom, and island sediments, and decommissioning of river discharge pipelines. Sediment excavation could generate fugitive dust, possibly contaminated with radioactive particles. Airborne pollutants also would be generated in exhaust from equipment used for excavation, loading, and hauling. The potential for air quality impacts was evaluated by estimating radionuclide concentrations in the air resulting from a hypothetical waste site excavation. An excavation rate of 450,000 kg/d

(1 million lb/d) was used for estimating purposes. Excavation sites were assumed to be located closest to the Hanford Site boundary where members of the general public might reside. The amounts of pollutants generated at a site were estimated using the procedures and assumptions described in Appendix G, and concentrations of pollutants downwind from the Hanford Site were projected. The estimated concentrations that workers could be exposed would not exceed appropriate standards (Table 5-4). The same is true for concentrations to which the general public could be exposed.

Concentrations in Table 5-4 are consequences of remedial activities at one remediation site. Simultaneous activities at several sites could result in higher concentrations, particularly if the sites happened to be in line and parallel to the wind direction (Table 5-5). Potential cumulative concentrations were estimated by assuming simultaneous excavation of five sites aligned with the wind direction. The five sites were identical to the one previously described and were assumed to be spaced 200 m (660 ft) apart. Cumulative concentrations that workers and the general public could be exposed do not exceed appropriate standards or guidelines. The pollutant concentrations in Table 5-5 represent short-term impacts that would cease when remedial activity is concluded.

Remediation for unrestricted use would require transport of contaminated waste to an onsite waste disposal facility. Concentrations of fugitive dust from haul roads were estimated using the following procedures and assumptions. To provide a conservative estimate, roadways were assumed to be surfaced with gravel. Vehicles were assumed to be 10-ton truck/trailer units. Emission rates (in grams per vehicle-mile) were estimated by methods and information in *Air/Superfund National Technical Guidance Study Series, Volume II – Estimation of Baseline Air Emissions at Superfund Sites* (EPA 1988a). Downwind concentrations of particulate matter less than 10 microns in size (PM_{10}) were projected by a line source dispersion model, with an assumed 5-m/s (16-ft/s) wind flowing perpendicular to the direction of the roadway. Figure 5-5 shows the estimated concentrations of dust for traffic flow rates from 5 to 500 trucks per hour.

Significant impacts from haul road dust are not expected to occur. Hauling 450,000 kg/d (1 million lb/d), for example, would require about 50 roundtrips. The resulting traffic count, averaging about 12 trucks per hour, would generate a dust concentration of about 100 $\mu g/m^3$.

Significant air quality impacts are not expected to occur from the Unrestricted Future Land-Use Alternative, because the estimates presented in Tables 5-4 and 5-5 do not exceed applicable air quality standards,. However, these estimates are based on typical meteorological conditions and could be greater or lower during unusual conditions (e.g., high or low wind speeds, or extreme conditions of atmospheric stability or instability). During excavation of a waste site, there would be a potential for short-duration emissions requiring mitigation measures.

Substantial amounts of fugitive dust would be produced by quarrying and excavation of materials for backfilling or construction of caps (Appendix E), but no significant impacts are expected. The materials would not be contaminated, so the only applicable air quality standard would be the 8-hour occupational standard for PM_{10} nuisance dust (5,000 mg/m^3). Dust levels are not expected to exceed this limit.

5.2.5.2.1 Potential Mitigation Measures. Mitigation measures for air quality would include covering trucks, rewetting storage piles and haul roads with water or surfactants, limiting the size of disturbed areas, and temporarily enclosing the area being excavated. In heavily contaminated areas, administrative controls, such as a requirement for dust-filtration masks or a limitation on the hours of exposure, would be used to protect workers.

Table 5-4. Estimated Concentrations of Airborne Contaminants from Excavation in the Columbia River Geographic Area.[a]

Type of Air Contaminant	Contaminant Name	Concentration in the Immediate Vicinity[b]	Onsite Occupational Standard or Guideline[c]	Concentration at Nearest Property Line[d]	Offsite Air Quality Standard or Guideline[e]
Fugitive Dust ($\mu g/m^3$)	PM_{10}	390	5,000, 8-h average	63	150, 24-h average
Radioisotopes (pCi/m^3)	Sr-90	7.7 E-04	2,000, annual average	1.2 E-04	50, annual average
	Cs-137	2.3 E-04	60,000, annual average	3.8 E-05	400, annual average
	Pu-239, -240	3.9 E-06	3, annual average	6.3 E-07	0.02, annual average
	U-238	4.2 E-04	300, annual average	6.9 E-05	0.10, annual average
Products of Fuel Combustion ($\mu g/m^3$)	total suspended particulates	72	15,000, 8-h average	12	–
	carbon monoxide	470	55,000 8-h average	75	9,000, 8-h average
	nitrogen dioxide	730	9,000, 8-h average	120[f]	50, annual average
	sulfur dioxide	98	13,000, 8-h average	16	20, annual average

[a]Procedures and assumptions for estimating concentrations of airborne contaminants are discussed in Appendix G. The estimated concentrations of fugitive dust and fuel combustion products do not include background concentrations.

[b]Concentrations immediately downwind from the excavation site are potential concentrations that workers could be exposed.

[c]Occupational standards for fugitive dust and combustion products are PELS listed in 29 CFR 1910. Occupational guidelines for airborne radionuclides are listed in Federal Guidance Report No. 11 (EPA 1988b).

[d]Concentrations at the nearest property line are potential concentrations that the general public could be exposed.

[e]Air quality standards for fugitive dust, CO, and NO_2 are National Ambient Air Quality Standards (40 CFR 50-99). The standard for SO_2 is a Washington State standard. Guidelines for airborne radionuclides are DCGs listed in DOE Order 5400.5 (DOE 1993a).

[f]Concentration of NO_2 appears to exceed air quality standard. All of the estimated concentrations, however, are levels that would be expected during normal daily working hours, whereas air quality standards are average levels during longer periods of time (e.g., during a 365-day year). Using conservative background concentrations during nonworking periods, and in consideration of changes in wind direction, it can be shown that the average level of NO_2 does not exceed the air quality standard.

Table 5-5. Cumulative Impacts of Airborne Contaminants from Excavation of Five Sites in the Columbia River Geographic Area.[a]

Type of Air Contaminant	Contaminant Name	Concentration in the Immediate Vicinity[b]	Onsite Occupational Standard or Guideline[c]	Concentration at Nearest Property Line[d]	Offsite Air Quality Standard or Guideline[e]
Fugitive Dust ($\mu g/m^3$)	PM_{10}	660	5,000, 8-h average	160	150, 24-h average
Radioisotopes (pCi/m^3)	Sr-90	.0013	2,000, annual average	3.1 E-04	50, annual average
	Cs-137	4.0 E-04	60,000, annual average	9.5 E-05	400, annual average
	Pu-239, -240	6.6 E-06	3, annual average	1.6 E-06	0.02, annual average
	U-238	7.2 E-04	300, annual average	1.7 E-04	0.10, annual average
Products of Fuel Combustion ($\mu g/m^3$)	total suspended particulates	12	55,000, 8-h average	29	--
	carbon monoxide	790	55,000 8-h average	190	9,000, 8-h average
	nitrogen dioxide	1,200	9,000, 8-h average	300	50, annual average
	sulfur dioxide	170	13,000, 8-h average	40	20, annual average

[a]Procedures and assumptions for estimating concentrations of airborne contaminants are discussed in Appendix G. The five sites are assumed to be 200 m (660 ft) apart and aligned in the direction the wind is blowing. The estimated concentrations of fugitive dust and fuel combustion products do not include background concentrations.

[b]Concentrations immediately downwind from the excavation site are potential concentrations that workers could be exposed.

[c]Occupational standards for fugitive dust and combustion products are PELS listed in 29 CFR 1910. Occupational guidelines for airborne radionuclides are listed in Federal Guidance Report No. 11 (EPA 1988a).

[d]Concentrations at the nearest property line are potential concentrations that the general public could be exposed.

[e]Air quality standards for fugitive dust, CO, and NO_2 are National Ambient Air Quality Standards (40 CFR 50-99). The standard for SO_2 is a Washington State standard. Guidelines for airborne radionuclides are DCGs listed in DOE Order 5400.5 (DOE 1993a).

[f]Concentrations of PM_{10} and NO_2 appear to exceed air quality standards. All of the estimated concentrations, however, are levels that would be expected during normal daily working hours, whereas air quality standards are average levels during longer periods of time (e.g., during a 365-day year). Using conservative background concentrations during nonworking periods, and in consideration of changes in wind direction, it can be shown that the averaged levels of PM_{10} and NO_2 do not exceed air quality standards.

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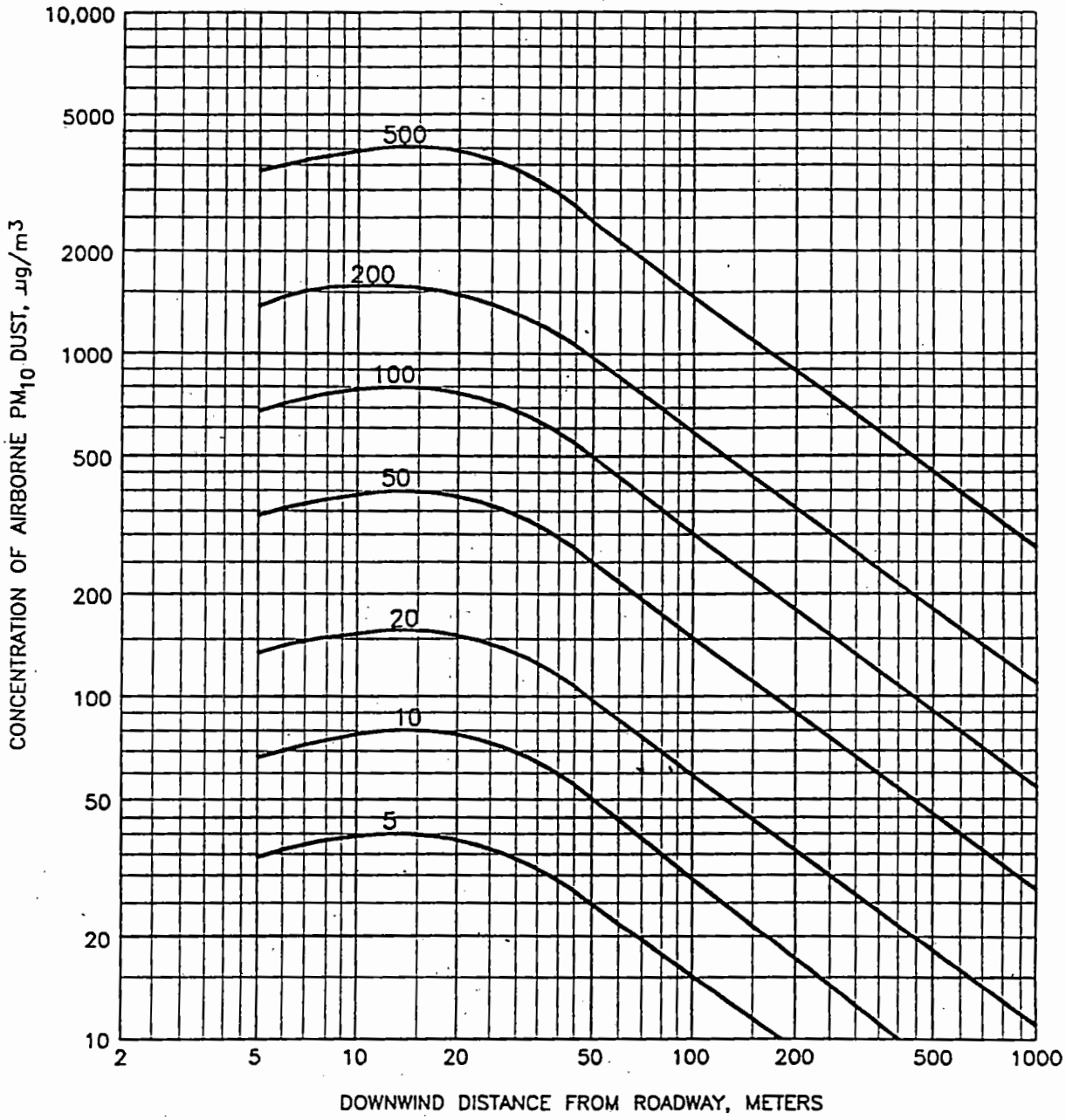
Figure 5-5. Concentration of Dust near Haul Roads, 5 to 500 Trucks per Hour.



5.2.5.3 Effects on Air Quality, Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would involve stabilizing in place the river discharge pipelines, removing detached pipeline segments, and continuing institutional controls to prevent human exposures to contamination. Concentrations of airborne pollutants from this alternative would be lower than those listed in Tables 5-4 and 5-5, because less contaminated sediment would be disturbed. The hauling of pipeline capping materials from quarry sites and borrow areas would generate similar fugitive dust concentrations as estimated for the Unrestricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would not have significant air quality impacts.

5.2.5.3.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative are the same as for the Unrestricted Future Land-Use Alternative.

5.2.6 Noise

5.2.6.1 Noise Effects, No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, and continuation of the current environmental monitoring and maintenance activities. Little or no change in noise impacts to the surrounding environment would occur under this alternative. The sound levels in the ambient environment would remain essentially the same as current noise levels and would not have a significant impact.

5.2.6.2 Noise Effects, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve excavation and removal of contaminated riverbank, riverbottom, and island sediments, and decommissioning of river discharge pipelines. During removal of river discharge pipes and contaminated riverbank sediments, noisy construction equipment used in the operations would temporarily increase ambient noise levels. Noise levels generated by remedial activities throughout the Hanford Site are not expected to differ significantly from one geographic area to another. Therefore, a representative scenario was developed and analyzed for the Reactors on the River geographic area (see Section 5.3.6). Noise levels are not predicted to violate the State of Washington noise standards and are not expected to have significant impacts.

5.2.6.2.1 Potential Mitigation Measures. Potential mitigation measures for reducing potential noise impacts include the following: providing hearing protection for construction and excavation personnel, and monitoring occupational noise exposure to construction and excavation personnel.

5.2.6.3 Noise Effects, Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would not have significant noise impacts. The noise levels would be less than those predicted in the scenario discussed in Section 5.3.6.

5.2.6.3.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative are the same as for the Unrestricted Future Land-Use Alternative.

5.2.7 Cultural Resources

5.2.7.1 Effects on Archaeological and Historic Resources, No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, and continuation of the current environmental monitoring and maintenance activities. Stabilization activities would include scraping surface areas, collection and consolidation of contaminated sediments, and site revegetation

(WHC and USACE 1994a). These activities would be limited to spot contaminant locations and are not expected to result in significant impacts on archaeological or historic sites.

Environmental monitoring and maintenance activities would not have significant impacts on archaeological or historic sites in the Hanford Reach. Routine sampling and other activities would be planned to avoid disturbing identified sites. These resources would continue to be protected by public access restrictions.

5.2.7.2 Effects on Archaeological and Historic Resources, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve excavation and removal of contaminated riverbank, riverbottom, and island sediments, and decommissioning of river discharge pipelines. These activities would have significant impacts on the archaeological resources in the Hanford Reach. Several archaeological sites within the Hanford North Archaeological District and the Wahluke Archaeological District could be adversely impacted under the Unrestricted Future Land-Use Alternative. In the Wahluke Archaeological District, a Native American occupation area that could be eligible for the *National Register of Historic Places* (National Register) could be affected.

In the Hanford North Archaeological District, one National Register-listed archaeological site representing Native American occupation and two sites that are not listed, but are contributing elements to the Hanford North Archaeological District, could be adversely affected by the Unrestricted Future Land-Use Alternative.

Several other sites that could be potentially eligible for the listing also are situated within the areas affected by the Unrestricted Future Land-Use Alternative. In addition to these sites, eight other prehistoric sites that have not been evaluated for National Register eligibility could be affected by the Unrestricted Future Land-Use Alternative. One multicomponent site consisting of an historic dump site lying over a prehistoric site has been identified. This site is potentially eligible for the National Register.

In addition to direct impacts to identified sites, the Unrestricted Future Land-Use Alternative could have additional indirect effects on other sites. Numerous prehistoric and historic archaeological sites within the immediate vicinity of direct impact areas also could be affected by haul roads and other disturbances associated with the remedial actions.

5.2.7.2.1 Potential Mitigation Measures. Potential mitigation measures for archaeological and historic resources include the following.

- A determination of National Register eligibility would be performed for affected sites not listed.

- Before any ground disturbance activities, consultations would be conducted with the DOE, Richland Operations Office (RL) Historic Preservation Officer, the Hanford Cultural Resource Laboratory, the Washington State Historic Preservation Officer (SHPO), and concerned Native American Tribal groups and governments.

- All cultural resources-related work would be conducted in accordance with the *Hanford Cultural Resources Management Plan* (Chatters 1989).

- Whenever possible, avoidance of cultural resource areas identified during project planning and before field operations would serve as the primary form of mitigation.

- Whenever practicable, a full survey of the affected areas would be conducted.

- Surface mapping of all artifact material and data recovery for surface and subsurface materials would be performed only if this action does not pose a potential health risk to field investigators.

- When practicable, an archaeological monitor would be onsite during ground disturbing activities to ensure that construction impacts are limited to the remediation area only. This action would be taken only if it does not pose any potential health risk to the archaeological monitor.

- An interpretive program outlining the history of the Hanford Site would be presented to personnel involved in the remedial activities to create greater awareness and sensitivity for the cultural resources in the area.

- Remediation and maintenance personnel also would be made aware of the significance of cultural resources in the area, and of the consequences regarding destruction of sites or pedestrian collection of artifact materials.

5.2.7.3 Effects on Archaeological and Historic Resources, Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would involve stabilizing in place the river discharge pipelines, removing detached pipeline segments, and continuing institutional controls to prevent human exposures to contamination. This alternative could have impacts on archaeological and historic sites similar to those described for the Unrestricted Future Land-Use Alternative. However, because the extent of surface disturbance is expected to be less, fewer sites are likely to be affected under this alternative.

5.2.7.3.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative are the same as for the Unrestricted Future Land-Use Alternative.

5.2.7.4 Effects on Areas of Concern to Native Americans, No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, and continuation of the current environmental monitoring and maintenance activities. Stabilization activities would include scraping surface areas, collection and consolidation of contaminated sediments, and site revegetation (WHC and USACE 1994a). These activities would be limited to spot contaminant locations and are not expected to result in significant impacts on sacred or traditional use areas important to Native Americans. Access to these areas would continue to be restricted because of contamination.

5.2.7.5 Effects on Areas of Concern to Native Americans, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve excavation and removal of contaminated riverbank, riverbottom, and island sediments, and decommissioning of river discharge pipelines. These activities could have significant impacts on sacred or traditional use areas important to Native Americans. In addition to impacting the archaeological and historic values, as described in Section 5.2.7.2, the remedial activities could impact the salmon fishery and other natural resources important to Native Americans. These impacts, described in Section 5.2.4, could affect the future exercise of treaty rights and could be considered by the tribes to be an abrogation of the 1855 Treaties.

Remedial activities under the Unrestricted Future Land-Use Alternative temporarily would preclude access to areas where remediation is occurring. This alternative would eventually allow unrestricted access to sacred or traditional areas important to Native Americans.

5.2.7.5.1 Potential Mitigation Measures. Potential mitigation measures for addressing Native American concerns include:

- consulting with Native American Tribal governments and organizations to identify project-specific concerns before implementation of project activities
- incorporating recommendations provided by Native American Tribal governments and organizations into project-specific cultural resource mitigation plans for proposed remedial activities
- incorporating recommendations provided by Native American Tribal governments and organizations into revegetation plans for proposed remedial activities
- involving representatives of Native American Tribal governments and organizations in archaeological monitoring during remedial activities.

5.2.7.6 Effects on Areas of Concern to Native Americans, Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would involve stabilizing in place the river discharge pipelines, removing detached pipeline segments, and continuing institutional controls to prevent human exposures to contamination. This alternative is not expected to have significant impacts on sacred or traditional use areas important to Native Americans, because contaminated riverbank, riverbottom, and island sediments would not be excavated, and surface disturbing activities would be limited to previously disturbed areas, as described in Section 5.2.4, the Restricted Future Land-Use Alternative is not expected to have significant impacts on the salmon fishery or other natural resources important to Native Americans.

Because contaminated sediments would remain in place, this alternative would require continued restrictions on access to sacred or traditional use areas.

5.2.7.6.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative are the same as for the Unrestricted Future Land-Use Alternative.

5.2.8 Visual and Aesthetic Resources

5.2.8.1 Effects on Visual and Aesthetic Resources, No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, and continuation of the current environmental monitoring and maintenance activities. These activities would not have significant impacts on visual and aesthetic resources.

5.2.8.2 Effects on Visual and Aesthetic Resources, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve excavation and removal of contaminated riverbank, riverbottom, and island sediments, and decommissioning of river discharge pipelines. Remedial activities under the Unrestricted Future Land-Use Alternative would have short-term impacts on visual and aesthetic resources within the Columbia River geographic area. The appearance of work crews and large construction equipment operating in and along the river

temporarily would detract from the pristine nature of the river environment and would be noticeable primarily to recreational users of the river. For the general population, the limited public access to this stretch of the river would preclude viewing opportunities. These remedial activities may, however, generate noticeable fugitive dust.

Excavation of riverbank sediments, which could affect up to 17 km (11 mi) of shoreline, would involve substantial landscape and viewsheds alteration. The visual impacts of this excavation, although not readily visible to large segments of the population, would be significant. Once remediated, the riverbank would be restored as close as possible to its former condition, minimizing long-term impacts.

5.2.8.2.1 Potential Mitigation Measures. Potential mitigation measures for visual and aesthetic resources include the following:

- minimizing overall disturbance to extent possible
- controlling fugitive dust (see Section 5.2.5)
- completing remediation in a timely manner
- restoring remediated areas by reshaping excavations to approximate original conditions and revegetating with native species
- conducting restoration activities immediately in remediated areas and contemporaneous with ongoing remedial activities in other areas.

5.2.8.3 Effects on Visual and Aesthetic Resources, Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would involve stabilizing in place the river discharge pipelines, removing detached pipeline sediments, and continuing institutional controls to prevent human exposures to contamination. Under this alternative, disturbance would be limited to areas adjacent to river discharge pipeline. This alternative would not have significant long term impacts, because only small areas would be disturbed.

5.2.8.3.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative would be the same as for the Unrestricted Future Land-Use Alternative.

5.2.9 Human Health Risks

5.2.9.1 Human Health Risks, No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, continuation of the current environmental monitoring and maintenance activities, and continuation of institutional controls restricting public access. The No-Action Alternative would not have significant short-term impacts on human health. Hanford Site monitoring data (PNL 1995) suggest that existing human health risks in the Columbia River geographic area are low, as long as institutional controls are maintained. The long term effects of the eventual loss of institutional controls under the No-Action Alternative have not been evaluated because of insufficient data. Data on potential contamination in shoreline, island, and riverbed sediments are limited, as are data on possible contamination associated with buried and/or exposed pipelines. Although no current hazards are known to exist, the long-term impacts of the No-Action

Alternative on human health are considered potentially significant because of the lack of characterization data.

5.2.9.1.1 Potential Mitigation Measures. Potential mitigation measures for the No-Action Alternative include continuing existing institutional controls and environmental monitoring to minimize potential hazards to human health.

5.2.9.2 Human Health Risks, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve excavation and removal of contaminated riverbank, riverbottom, and island sediments, and decommissioning of river discharge pipelines. Remedial activities under this alternative are not expected to have significant impacts on the health of site workers or the public. Site-specific evaluations of potential risk to workers and the public would be performed as part of the CERCLA Remedial Investigation and Feasibility Study (RI/FS) process. The use of good health physics and industrial hygiene practices would ensure that exposures to radioactive and hazardous chemicals, as a result of routine remedial activities, remain below applicable regulatory and administrative limits.

The potential effects of an accidental release of contaminants during remedial activities were evaluated. The accident scenario chosen, which is described in Appendix B, involves the accidental release of contaminants in the sediments to the Columbia River. The radionuclide concentrations released are assumed to be the same as the maximum concentrations found in the waste buried in the Reactors on the River geographic area. This worst case scenario was assumed because data on shoreline contaminants, which are likely to have lower concentrations, are limited. The scenario involves transport of contaminants downriver and consumption of untreated drinking water by the residents of Richland, Kennewick, and Pasco.

The results of the accident analysis indicate the impacts to human health would not be significant. The estimated maximum individual radiation dose to a member of the public would be 1.0 mrem, which corresponds to an increased probability of fatal cancer of 5×10^{-7} (see Appendix B).

The maximum collective population dose was determined to be 3.0 person-rem, which corresponds to an increase in latent cancer fatalities[2] (LCF) in the exposed population of 1.5×10^{-3}. Releases from any soils or sediments with contaminant concentrations lower than the maximum found in the Reactors on the River geographic area would result in proportionately lower doses. Long-term impacts to human health would be beneficial, because existing risks would be reduced to a level permitting unrestricted human use.

5.2.9.2.1 Potential Mitigation Measures. Appropriate engineering and administrative measures would be applied during routine remedial activities so that the workers, general public, and environment are protected. For remediation workers and other nearby workers, this would involve:

- wearing appropriate protective clothing

[2]The factor used this EIS to relate a dose to its effect was 0.0004 LCFs/person-rem for workers and 0.0005 LCFs/person-rem for individuals among the general population. The latter factor is slightly higher, because the general population may include sensitive subpopulations (e.g., young children). These factors are consistent with "U.S. Nuclear Regulatory Commission (NRC) Standards for the Protection Against Radiation" (56 FR 23363).

- using respiratory protection, where necessary

- limiting exposures to contaminants in accordance with as low as reasonably achievable (ALARA) guidelines, and good health physics and industrial hygiene practices.

For the general public, it involves practices and procedures designed to reduce the transport of radioactive and hazardous materials offsite. These include the mitigation measures for water quality discussed in Section 5.2.3 and those for air quality discussed in Section 5.2.5.

5.2.9.3 Human Health Risks, Restricted Future Land-Use Alternative. The accident analysis for Unrestricted Future Land-Use Alternative (see Section 5.2.9.2) is applicable to the Restricted Future Land-Use Alternative. However, because the scale of activities would be lower than for the Unrestricted Future Land-Use Alternative, the probability of an accident is assumed to be similarly lower. The accident evaluated for the Unrestricted Future Land-Use Alternative was not found to have significant consequences. Therefore, the short-term impacts of the Restricted Future Land-Use Alternative on human health also are not considered significant.

The Restricted Future Land-Use Alternative would include continued restrictions on disturbance of contaminated riverbank, riverbottom, and island sediments. If the restrictions are not complied with, the risk could be higher than that for the Unrestricted Future Land-Use Alternative. However, risks would be lower than any existing risk for the No-Action Alternative, because the river discharge pipelines would be stabilized and, therefore, less likely to release contaminants; thereby producing long term impacts to human health that would be beneficial.

5.2.9.3.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative are the same as for the Unrestricted Future Land-Use Alternative.

5.2.10 Occupational Impacts

Potential occupational impacts associated with implementing the future land-use alternatives in the Columbia River geographic area were estimated by comparing the field labor hours identified in Appendix H for each alternative with Bureau of Labor Statistics (BLS) and DOE incident rates (NSC 1993; EG&G 1993). The estimates assume that all remediation waste is transported by truck for onsite disposal, as truck transport requires more labor than rail transport. Other assumptions used in this analysis are presented in Appendix I.

5.2.10.1 Occupational Impacts, No-Action Alternative. Labor hour estimates are not available for the No-Action Alternative; therefore, no occupational impacts were estimated, and mitigation measures were not evaluated.

5.2.10.2 Occupational Impacts, Unrestricted Future Land-Use and Restricted Future Land-Use Alternatives. Table 5-6 presents the potential occupational impacts for the Unrestricted Future Land-Use and Restricted Future Land-Use Alternatives for the Columbia River geographic area based on BLS incident rates. Total cases include all work-related deaths and illnesses, as well as those work-related injuries that result in loss of consciousness, restriction of work or motion, transfer to another job, or a requirement for medical attention. Total cases are the sum of lost workday cases and nonfatal cases without lost workdays. Lost workdays are those days that, because of occupational injury or illness, an employee was away from work or limited to restricted work activity. Lost workdays are estimated from lost workday cases.

Table 5-6. Summary of Occupational Impacts per BLS Statistics.

Remediation Alternative (Labor hours)	Estimated Total Cases	Estimated Lost Workday Cases	Estimated Nonfatal Cases Without Lost Workdays	Estimated Lost Workdays
Unrestricted (20,532,379)	1,442	810	632	21,621
Restricted (436,457)	31	18	14	471

Table 5-7 presents the potential occupational impacts based on DOE incident rates. The occupational impacts estimated using DOE incident rates are substantially lower than the impacts estimated using BLS incident rates. DOE incident rates historically have compared favorably to private industry rates. The analysis using DOE incident rates is expected to more accurately reflect potential occupational impacts.

Potential occupational impacts are greatest for remediation to unrestricted use. This is expected, as remediation to unrestricted use would require the most labor hours. The higher labor hours are associated with removal of contaminated riverbank sediments.

5.2.10.2.1 Potential Mitigation Measures. Potential mitigation measures include continued emphasis on safety awareness and worker training.

5.2.11 Volumes, Disturbed Areas, and Costs

The assumptions and methodology used to develop cost estimates for each future land-use alternative are discussed in Appendix H. The costs and volumes presented in the following sections include only the remediation of the Columbia River areas adjacent to the reactors in the 100 Areas. Potential contamination in other areas along the Columbia River is uncharacterized at this time and, therefore, it could not be addressed. The cost analysis is summarized in Table 5-8.

Table 5-7. Summary of Occupational Impacts per DOE Statistics.

Remediation Alternative (Labor hours)	Estimated Total Cases	Estimated Lost Workday Cases	Estimated Lost Workdays
Unrestricted (20,532,379)	354	154	2,374
Restricted (436,457)	8	3	50

Table 5-8. Comparison of Volumes, Disturbed Areas, and Costs Associated with the Columbia River Geographic Area Future Land-Use Alternatives.

Resources	Alternatives		
	No Action	Unrestricted	Restricted
Capping Materials LCM[a] (thousands)	0	0	339
Excavated Volumes BCM[a] (thousands)			
Uncontaminated Soil	0	10	0
Contaminated Soil	0	10,643	0
Area of disturbance (ha)	0	177	4.1
Projected Cost in 1994 Dollars (millions)	2,400[b]	4,691 (truck haul) 2,678 (rail haul)	93 (truck haul) 46 (rail haul)

[a]Loose Cubic Meter (LCM) = 1.31 Loose Cubic Yard (LCY).
Bank Cubic Meter (BCM) = 1.31 Bank Cubic Yard (BCY).
[b]Costs for 100 years of institutional control for the Hanford Site. The Costs are not broken down by geographic area. No-Action Alternative costs are further described in Section 5.3.11.1.

5.2.11.1 Effects on Volumes, Disturbed Areas, and Costs, No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, and continuation of the current environmental monitoring and maintenance activities. There are no volumes associated with the No-Action Alternative, because contaminated sediments and river discharge pipelines would be left in place. Site-wide costs for the No-Action Alternative are summarized in Section 5.3.11.1 in the discussion of the Reactors on the River geographic area. The costs for the No-Action Alternative have not been broken down by geographic area; however, it was assumed for the purposes of this analysis that as much as 10% of the total costs would be incurred to control access and maintain institutional control to the Columbia River.

5.2.11.1.1 Potential Mitigation Measures. Measures to reduce the need for institutional controls could reduce the costs for this alternative. Access restrictions, for example, could be enforced through the use of fences and signs.

5.2.11.2 Effects on Volumes, Disturbed Areas, and Costs, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve excavation and removal of contaminated riverbank, riverbottom, and island sediments, and decommissioning of river discharge pipelines. Removal of contaminated riverbank sediments would require the excavation of about 10.7 million Bank Cubic Meter (BCM) (14 million Bank Cubic Yard [BCY]). Removal of other contaminated sediments below the high-water mark would require excavation of 800 BCM (1,050 BCY) of contaminated material and about 9,600 BCM (12,600 BCY) of clean material.

The portions of the five river discharge pipelines to be removed as part of the remedial actions for the Columbia River geographic area are those extending from the outfall structure into the river. Approximately 7,500 Loose Cubic Meter (LCM) (9,800 Loose Cubic Yard [LCY]) of contaminated

soil, equipment, and concrete and 160 LCM (210 LCY) that could be taken to a solid waste landfill would be generated.

The cost of remediating the portion of the Columbia River adjacent to the 100 Areas for the Unrestricted Future Land-Use Alternative ranges from $2.7 billion to $4.7 billion, depending on whether rail or truck hauling is assumed (see Table 5-8). These costs were estimated using the models developed from *Preconceptual Baseline Cost Estimates for the Remediation of Hanford Past Practices* (USACE 1994). Costs include excavation of unsaturated sediments; however, they do not include dewatering saturated sediments or excavating island shoreline or shoreline downstream of the Reactors on the River geographic area (Table 5-9). Costs include transportation of contaminated soil to the Environmental Restoration Disposal Facility (ERDF).

5.2.11.2.1 ***Potential Mitigation Measures.*** Potential mitigation measures include use of technologies such as soil washing to reduce the amount of contaminated waste to be transported to the ERDF.

Continuing emphasis would be placed on the development and implementation of new remedial technologies to reduce the volumes, levels of disturbance, and costs associated with remediating waste sites in the All Other Areas geographic area. These new technologies may include *in-situ* treatments, which could significantly reduce the volumes of contaminated soils requiring excavation and disposal.

5.2.11.3 ***Effects on Volumes, Disturbed Areas, and Costs, Restricted Future Land-Use Alternative.*** The Restricted Future Land-Use Alternative would involve stabilizing in place the river discharge pipelines, removing detached pipeline segments, and continuing institutional controls to prevent human exposures to contamination. The land-based portions of the river discharge pipeline would be capped. The total volume of pipeline capping materials to be excavated and transported for the Restricted Future Land-Use Alternative of the Columbia River geographic area is summarized in Table 5-10.

Table 5-9. Breakdown of Potential Costs for the Unrestricted Future Land-Use Alternative, Columbia River Geographic Area.

Resource	Project Cost in 1994 Dollars (millions)				
	Shoreline Trench	Waste Sites	D&D of River Discharge Pipelines	Transportation	
				Truck	Rail
Mobilization and Preparatory Work	0.1	0.1	0.3		
Monitoring, Sampling, and Analysis	1,800	0.7	--		
Surface Water Collection and Control	--	--	--		
Decommissioning	--	--	36		
Solids Collection and Disposal	410	0.2	0.2		
Site Restoration	350	0.2	--		
Demobilization	--	--	0.7		
Total Costs	2,560.1	1.2	37.2	2,100	93
Fuel Use (millions) L	100	0.08	2.2	100	17
(gal)	(27)	(0.02)	(0.6)	(27)	(4.6)
Labor Hours (millions)	9.5	0.006	0.035	1	0.4

D&D = decommissioning.

Volumes are based on the reference cap design (Appendix E). The cost for remediating the Columbia River geographic area under the Restricted Future Land-Use Alternative is $93 million with truck transport or $46 million with rail transport (Table 5-11).

Table 5-10. Volumes of Capping Materials Required for the Restricted Future Land-Use Alternative, Columbia River Geographic Area.

Material	Volume (x 10^3) LCM	(LCY)
Drainage Gravel	15	(20)
Gravel	15	(20)
Basalt	152	(199)
Asphalt Base	5	(7)
Contour Fill	30	(39)
Lower Silt	51	(67)
Upper Silt	51	(67)
Sand	8	(11)
Asphalt	12	(16)
Total	339	(446)

LCM = Loose Cubic Meter.
LCY = Loose Cubic Yard.

Table 5-11. Summary of Potential Costs for the Restricted Future Land-Use Alternative, Columbia River Geographic Area.

Resource	Project Cost in 1994 Dollars (millions)			
	Pipelines	Waste Sites	Transportation	
			Truck	Rail
Mobilization and Preparatory Work	0.83	0.19	--	--
Monitoring, Sampling, and Analysis	2.4	0.61	--	--
Surface Water Collection and Control	0.03	0.01	--	--
Solids Collection and Control	14	3.4	--	--
Site Restoration	18	4.1	--	--
Demobilization	0.18	0.04	--	--
Total Costs	35.44	8.35	49	2.5
Fuel Use (millions) L (gal)	1.2 (0.3)	0.3 (0.08)	2.4 (0.6)	0.2 (0.04)
Labor Hours (millions)	0.1	0.03	0.3	0.01

5.2.11.3.1 Potential Mitigation Measures. Mitigation measures to reduce the volumes of capping materials required for river discharge pipelines, associated areas of disturbance, and the costs of remedial actions include the use of a *Resource Conservation and Recovery Act of 1976* (RCRA) Subtitle C cap or modified RCRA cap. The minimum technology requirements for a RCRA Subtitle C cap are specified in "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," (40 CFR 264.310). The modified RCRA cap is conceptually similar to the RCRA Subtitle C cap, but it has been modified to better suit the conditions at the Hanford Site. The unit costs for a RCRA Subtitle C cap and modified RCRA cap are $51/m^2$ ($5/ft^2$) and $72/m^2$ ($7/ft^2$), respectively. The unit cost for the reference cap is $134/m^2$ ($12/ft^2$) (DOE-RL 1994a).

Continuing emphasis would be placed on the development and implementation of new remedial technologies to reduce the volumes, levels of disturbance, and costs associated with remediating waste sites in the All Other Areas geographic area. These new technologies may include *in-situ* treatments, which could significantly reduce the volumes of contaminated soils requiring excavation and disposal.

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Reactors on the River

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5.3 Reactors on the River Geographic Area

The scope of the proposed actions in the Reactors on the River geographic area includes the past-practice waste sites, TSD facilities, and surplus facilities in the 100 Area, as listed in Appendix A. For analysis purposes, the effluent lines considered to be within the Reactors on the River geographic area are those extending from the reactors to the outfall structures adjacent to the Columbia River (see Figure 5-1). The river discharge pipelines, which extend from the outfall structures into the river, are discussed under the Columbia River geographic area (see Section 5.2). Contaminated groundwater plumes recognized in the Reactors on the River geographic area include chromium, nitrate, strontium-90, trichlorethylene, tritium, and uranium. Potential impacts of the No-Action and future land-use alternatives for these areas are described below in the following sections.

5.3.1 Geology

*5.3.1.1 **Effects on Geologic Resources, No-Action Alternative.*** Under the No-Action Alternative, the past-practice waste sites, effluent lines, and surplus and TSD facilities would be left in place, requiring continued restrictions on public access to the Reactors on the River geographic area for exploration or exploitation of mineral deposits. No mining activity currently is conducted in this area and historical mining activity has been very limited. Continuing to exclude geologic resources in the Reactors on the River geographic area from development is not expected to result in significant short- or long-term adverse impacts. Continued environmental monitoring and maintenance activities would not have significant impact on the geologic resources of the Reactors on the River geographic area.

*5.3.1.2 **Effects on Geologic Resources, Unrestricted Future Land-Use Alternative.*** The Unrestricted Future Land-Use Alternative would include complete excavation and removal of contaminated soils and effluent lines. Total waste volumes to be excavated include 5.6 million BCM (7.3 million BCY) of contaminated soil and 3.8 million BCM (5.0 million BCY) of uncontaminated soil. Removal of effluent lines would require excavation of 1.1 million BCM (1.4 million BCY) of contaminated soil and 3.2 million BCM (4.2 million BCM) of uncontaminated soil (Appendix H).

This alternative would involve the short-term continuation of existing restrictions on public access to geologic resources in the Reactors on the River geographic area. As in the No-Action Alternative, such access restrictions are not expected to result in significant short- or long-term adverse impacts on development of geologic resources. Complete removal of all contamination under this alternative could allow for the eventual relaxation of these access restrictions.

Geologic features relevant to the study of the region's glacial flood events (e.g., bergmounds and giant ripple marks) are found in the Reactors on the River geographic area. A small number of these features potentially could be destroyed during remediation. This would not be a significant impact, because such features also occur at other areas within the Hanford Site and would continue to be available for study. Therefore, geologic impacts of this alternative are not expected to be significant.

5.3.1.3 Effects on Geologic Resources, Restricted Future Land-Use Alternative (R1). The Restricted Future Land-Use Alternative (R1) would include excavation and removal of past-practice waste sites and effluent lines, combined with institutional controls. The extent of excavation would vary, depending on the extent of contamination present and the desired remediation level established for each contaminant.

The desired remediation levels for waste sites in the Reactors on the River geographic area would be determined through the CERCLA process using the recreational exposure scenario. Excavation and removal of contaminated past-practice waste sites and effluent lines would continue until the contaminant concentrations meet the desired remediation levels established under the recreational exposure scenarios.

Although the extent of excavation would be determined through the CERCLA process, as described above, it was necessary for this analysis to make assumptions on the extent of excavation to estimate excavation volumes. For purposes of estimating excavation volumes, the maximum excavation depth was assumed to be 4.6 m (15 ft) below the surface for the Restricted Future Land-Use Alternative (R1). This value, which is based on the State of Washington's *Model Toxics Control Act of 1989*, was combined with WIDS data to calculate volumes to be excavated under this alternative. The models used to calculate volumes are described in Appendix H.

Waste volumes to be excavated and the resulting disturbed areas for the Restricted Future Land-Use Alternative (R1) include 2.4 million BCM (3.1 million BCY) of uncontaminated soil and 3.5 million BCM (4.6 million BCY) of contaminated soil. Excavation of effluent lines would require removal of 1.1 million BCM (1.4 million BCY) of contaminated soil and 3.2 million BCM (4.2 million BCY) of uncontaminated soil. Because some contamination would be left in place, this alternative would involve the long-term continuation of existing restrictions on public access to sand and gravel resources. As in the No-Action Alternative, such access restrictions are not expected to have significant impacts. Disturbance of unique geologic features under this alternative would be less than that described under the Unrestricted Future Land-Use Alternative, and would not be a significant impact.

5.3.1.4 Effects on Geologic Resources, Restricted Future Land-Use Alternative (R2). Remediation to restricted use (R2) would include construction of caps over past-practice waste sites, effluent lines, and TSD facilities, combined with institutional controls. Estimated volumes of cap materials that would be used under this alternative are presented in Section 5.3.11. This alternative would result in significant depletion of the geologic resources of quarry and borrow sites. The depletion of geologic resources for quarry and borrow sites is discussed in Section 5.10 as an irreversible and irretrievable commitment of resources.

This alternative would involve the long-term continuation of existing restrictions on public access to sand and gravel resources, because contamination would be left in place. As in the No-Action Alternative, such access restrictions are not expected to have significant impacts. This alternative would have the same minimal impacts on natural features important to geologic study as the Unrestricted Future Land-Use and Restricted Future Land-Use (R1) Alternatives. These impacts are not expected to be significant.

5.3.2 Soils

The potential effects of the alternatives on soils in the Reactors on the River geographic area are summarized in Table 5-12.

5.3.2.1 Effects on Soils, No-Action Alternative. Potential impacts on soils under the No-Action Alternative would be related to surface decontamination and/or stabilization of inactive waste sites. Approximately 85 ha (213 ac) would be disturbed (see Table 5-12). Surface decontamination and stabilization activities would include scraping surface areas, collection and consolidation of contaminated soil, and site revegetation (WHC and USACE 1994a). Potential short-term impacts on soils would include some soil compaction and added potential for wind and water erosion. Long-term impacts would not be significant if appropriate mitigation measures were implemented. Continued environmental monitoring and facility maintenance activities would have no significant impact on soils.

*Table 5-12. Soils Disturbed under Reactors on the River Geographic Area Future Land-Use Alternative[3].**

Soil Types	No Action ha (ac)	Unrestricted ha (ac)	Restricted	
			R1 ha (ac)	R2 ha (ac)
Quincy (Rupert) sand	16 (41)	68 (170)	63 (157)	54 (133)
Burbank loamy sand	15 (38)	82 (205)	78 (196)	83 (204)
Ephrata sandy loam	21 (53)	88 (219)	67 (167)	83 (206)
Ephrata stony loam	29 (73)	164 (409)	149 (373)	141 (349)
Pasco silt loam	<1 (2.5)	0.8 (2)	0.8 (2)	1 (3)
Kiona silt loam	0	0	0	0
Riverwash	3 (8)	8 (21)	9 (17)	8 (21)
Total	85 (213)	410 (1,026)	365 (912)	371 (915)

*Areal impact information generated from the GIS; includes area disturbed for full excavation, trample zones, effluent lines, haul roads, and wells.

5.3.2.1.1 Potential Mitigation Measures. Potential mitigation measures for soils include the following: using silt fences and dust control measures to reduce soil erosion; and reseeding disturbed areas with native vegetation to reduce long-term soil loss from wind and water erosion.

5.3.2.2 Effects on Soils, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve complete excavation and removal of contaminated soils and inactive effluent lines, closure of TSD facilities, decommissioning of surplus facilities, and groundwater remediation. This alternative would have potentially significant impacts on soils in the Reactors on the River geographic area. Approximately 410 ha (1,026 ac) would be disturbed. The use of heavy equipment (e.g., bulldozers, scrapers, and trucks) could be expected to compact soils at waste sites caused by repeated travel over the same areas. Soil compaction would cause increased water runoff during storm events, resulting in less infiltration of water into the soil. Compaction also would inhibit plant growth. Soil types in the Reactors on the River geographic area most susceptible to soil compaction are Ephrata sandy loam, Pasco silt loam, and Ephrata stony loam (see Table 5-12).

Soil disturbance during remediation activities also would increase soil erosion. The use of heavy equipment, particularly in undisturbed shrub-steppe habitat adjacent to waste sites, would crush or scrape off existing vegetation such as sagebrush, reducing the ability of soils to resist erosion. Soil types in the Reactors on the River geographic area most susceptible to wind erosion are Quincy sand, Burbank loamy sand, and Pasco silt loam (see Table 5-12). None of these soils are highly susceptible to water erosion. Mitigation measures would reduce but not eliminate the potential impacts to soils associated with the Unrestricted Future Land-Use Alternative.

5.3.2.2.1 Potential Mitigation Measures. Potential mitigation measures for soils include the following:

- restricting heavy equipment to trample zones
- using the same or existing transportation routes to minimize damage to undisturbed soil and vegetation
- using silt fences and dust control measures to reduce soil erosion
- reseeding disturbed areas with native vegetation to reduce long-term soil loss from wind and water erosion.

5.3.2.3 Effects on Soils, Restricted Future Land-Use Alternative (R1). The Restricted Future Land-Use Alternative (R1) would involve excavation and removal of past-practice waste sites and effluent lines, closure of TSD facilities, decommissioning of surplus facilities, and groundwater remediation, combined with institutional controls. Remediation to restricted use (R1) would have potentially significant impacts on soils in the Reactors on the River geographic area. Remediation activities would disturb approximately 365 ha (912 ac), and would increase soil compaction and erosion, as described under the Unrestricted Future Land-Use Alternative. Mitigation measures would reduce but not eliminate the potential impacts associated with Restricted Future Land-Use Alternative (R1).

5.3.2.3.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative (R1) are the same as for the Unrestricted Future Land-Use Alternative.

5.3.2.4 Effects on Soils, Restricted Future Land-Use Alternative (R2). Remediation to restricted use (R2) would involve construction of caps over past-practice waste sites, effluent lines, and TSD facilities, and groundwater remediation, combined with institutional controls. Remediation to restricted use (R2) would have potentially significant impacts on soils in the Reactors on the River geographic area. Remediation activities would disturb approximately 371 ha (915 ac), and would increase soil compaction and erosion, as described under the Unrestricted Future Land-Use Alternative. Mitigation measures would reduce but not eliminate the potential impacts associated with Restricted Future Land-Use Alternative (R2).

5.3.2.4.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative (R2) are the same as for the Unrestricted Future Land-Use Alternative.

5.3.3 Water Resources

5.3.3.1 Effects on Groundwater, No-Action Alternative. The No-Action Alternative would involve no treatment of existing groundwater contamination, and would not have significant short-term impacts on groundwater. Over the long term, groundwater contamination would be reduced as contaminants continue to migrate to the Columbia River. Contaminant plumes identified in the Reactors on the River geographic area include chromium, nitrate, strontium-90, trichlorethylene, tritium, and uranium. Low concentrations and isolated occurrences of other contaminants have been detected. Currently, there are no estimates for natural attenuation of groundwater contaminants in the Reactors on the River geographic area. Current restrictions on the use of groundwater in the Reactors on the River geographic area would continue until natural attenuation allows for human use.

Other potential groundwater contaminants are present in the soils above the water table, the area referred to as the vadose zone (DOE-RL 1994b). The effect of any migration from the vadose zone is not expected to be significant under existing conditions. Although natural groundwater recharge rates at the Hanford Site have not been definitively determined, they are considered to be very low and may be zero (DOE-RL 1993b). This assumption is based on the presence of native plant communities adapted to dry conditions, where plants tend to use all available water. Studies conducted elsewhere have found that precipitation does not penetrate below the root zone if annual precipitation is less than 30 cm (12 in.) (Durbin 1978).

Some contaminant migration could occur where vegetation cover is lacking and precipitation is allowed to infiltrate beyond the root zone. Contaminants that are not readily adsorbed to the soil (e.g., nitrate, chromium, and tritium) would be flushed from the vadose zone sooner than the adsorbed contaminants (e.g., strontium-90). Although some more mobile contaminants contained in the soil may continue to migrate downward to the water table, they would be diluted to low concentrations as they mix with the groundwater. In some locations, the presence of these contaminants could extend natural attenuation times for groundwater.

5.3.3.2 Effects on Groundwater, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve groundwater remediation to reduce contamination to levels that would allow human use. In addition to excavating contaminated soils to remove potential sources, remediation efforts would include pumping and treating groundwater plumes within the Reactors on the River geographic area to reduce contamination to levels protective of the Columbia River.

Pumping and treating groundwater in the Reactors on the River geographic area would result in the localized drawdown of the water table and temporary changes in direction of groundwater flow. These effects would not have significant impacts on the use of groundwater, as groundwater use during remediation activities would continue to be restricted by contamination levels. Groundwater remediation under the Unrestricted Future Land-Use Alternative would have beneficial effects on groundwater, eventually allowing any human use.

5.3.3.3 Effects on Groundwater, Restricted Future Land-Use Alternative (R1). Remediation to restricted use (R1) would involve groundwater remediation, as described under the Unrestricted Future Land-Use Alternative. This alternative would not have significant adverse impacts on groundwater and would have beneficial impacts over the long term. Some potential for additional

groundwater contamination would remain, as some contaminated soil would remain in place at waste sites. The removal of vegetation cover during remediation activities could temporarily increase the rate of percolation and transport of contaminants. Some of the more mobile contaminants could reach groundwater under these conditions. It is likely that these contaminants would reach groundwater during the pump-and-treat phase and could be removed.

5.3.3.4 Effects on Groundwater, Restricted Future Land-Use Alternative (R2). Remediation to restricted use (R2) would involve groundwater remediation, as described under the Unrestricted Future Land-Use Alternative. Groundwater remediation under this alternative would have short-term impacts on groundwater levels and movement similar to those described for the Unrestricted Future Land-Use Alternative. Caps installed over waste sites would prevent precipitation from percolating into the vadose zone and transporting contaminants to groundwater. This alternative would not have significant adverse impacts on groundwater and would have beneficial impacts over the long term.

5.3.3.5 Effects on the Columbia River, No-Action Alternative. The No-Action Alternative would involve surface decontamination and/or stabilization of past-practice waste sites. Surface decontamination and stabilization activities would include scraping surface areas, collection and consolidation of contaminated soil, and site revegetation. Large-scale soil disturbance could result in erosion and sediment transport to the Columbia River. Long-term impacts would not be significant if appropriate mitigation measures are implemented (see Section 5.3.2.1.1).

A hypothetical flood caused by the failure of a Columbia River dam could affect the water quality in the Columbia River by mobilizing contaminated sediments located above the current high-water mark; however, this is an extremely low probability event. Natural shoreline erosion also could mobilize contaminated sediments. However, this process is very slow and is not expected to significantly affect water quality.

Under the No-Action Alternative, contaminated groundwater would continue to migrate and discharge into the Columbia River. Radionuclides consistently detected in the Columbia River during 1993 were tritium, strontium-90, iodine-129, and uranium (PNL 1995). However, current radionuclide concentrations in Columbia River water are below applicable DWSs. Because water quality is not expected to deteriorate, downstream surface water supplies for municipal and other uses should not be affected.

Environmental monitoring and maintenance activities under the No-Action Alternative would not have significant impacts on water quality in the Columbia River.

5.3.3.6 Effects on the Columbia River, Unrestricted Future Land-Use Alternative. Groundwater remediation under the Unrestricted Future Land-Use Alternative would not have significant adverse effects on the water quality or flow characteristics of the Columbia River. Because protection of the Columbia River and its ecosystem would be a primary goal of groundwater remediation, the long-term effects would be beneficial. Groundwater remediation would immediately reduce the rate of contaminant migration toward the Columbia River, because the pumping wells would reverse or reduce the hydraulic head gradient toward the river. Eventually, the groundwater contaminant concentrations would be reduced below applicable remediation standards so that the pumping could be discontinued and groundwater allowed to discharge freely to the river. The reduction or reversal of groundwater flow is not expected to adversely affect the flow characteristics of the Columbia River.

Remediation activities involving earthmoving have the potential to increase erosion and result in increased delivery of sediments and contaminants to the Columbia River. With application of the mitigation measures for controlling erosion, described in Section 5.3.2.2.1, the impacts to Columbia River water quality are not expected to be significant.

Should groundwater pump-and-treat systems discharge treated effluent to the river, the effluent may not have the same composition as normal groundwater because of the chemical effects of the treatment. These discharges would be in accordance with the substantive requirements of the *Clean Water Act of 1977* (CWA). No significant impacts to aquatic ecosystems or downstream water users, including municipal water systems, are anticipated.

5.3.3.7 ***Effects on the Columbia River, Restricted Future Land-Use Alternative (R1).*** Remediation to restricted use (R1) would involve contaminated soil excavation and groundwater remediation, with impacts similar to those described for the Unrestricted Future Land-Use Alternative. Contaminated soil would be left in the subsurface at some remediated waste sites and could be a potential source of contamination in the Columbia River. As was discussed in Section 5.3.3.3, if they reach groundwater, these contaminants would likely be removed by the groundwater remediation system and would not significantly affect water quality in the Columbia River.

5.3.3.8 ***Effects on the Columbia River, Restricted Future Land-Use Alternative (R2).*** Remediation to restricted use (R2) would involve construction of caps and groundwater remediation. Groundwater remediation would have impacts similar to those described for the Unrestricted Future Land-Use Alternative. Caps installed over waste sites would prevent precipitation from percolating into the vadose zone and transporting contaminants to groundwater and to the Columbia River. Application of the mitigation measures for controlling erosion described in Section 5.3.2.2.1 would minimize impacts to Columbia River water quality during construction of waste site caps.

5.3.3.9 ***Effects on the Columbia River Floodplain, No-Action Alternative.*** The No-Action Alternative is not expected to have significant effects on the Columbia River 100-year floodplain. Surface decontamination and waste site stabilization under the No-Action Alternative would affect approximately 4 ha (10 ac) of the Columbia River floodplain (Figure 5-6). This corresponds to roughly 1% of the floodplain within the Reactors on the River geographic area and less than 1% of the floodplain on the Hanford Site. Environmental monitoring and maintenance activities would involve minimal disturbance of floodplains, and would not have significant impacts.

5.3.3.10 ***Effects on the Columbia River Floodplain, Unrestricted Future Land-Use Alternative.*** Remediation to unrestricted use would involve disturbance of 14 ha (35 ac) of the Columbia River 100-year floodplain (Figure 5-7). This corresponds to roughly 4% of the floodplain within the Reactors on the River geographic area and less than 1% of the floodplain on the Hanford Site. This level of disturbance is not expected to have significant effects on floodplain function.

5.3.3.11 ***Effects on the Columbia River Floodplain, Restricted Future Land-Use Alternative (R1).*** Remediation to restricted use (R1) would involve disturbance of 15 ha (36 ac) of the Columbia River 100-year floodplain (Figure 5-8). This corresponds to roughly 4% of the floodplain within the Reactors on the River geographic area and less than 1% of the floodplain on the Hanford Site. This level of disturbance is not expected to have significant impacts on floodplain function.

5.3.3.12 Effects on the Columbia River Floodplain, Restricted Future Land-Use Alternative (R2). Remediation to restricted use (R2) would involve disturbance of 9 ha (21 ac) of the Columbia River 100-year floodplain (Figure 5-9). This corresponds to roughly 2% of the floodplain within the Reactors on the River geographic area and less than 1% of the floodplain on the Hanford Site. This level of disturbance is not expected to have significant impacts on floodplain function.

5.3.4 Ecology

5.3.4.1 Habitat Disturbance. The levels of habitat disturbance associated with each alternative are summarized in Table 5-13.

5.3.4.1.1 Effects on Wetlands, No-Action Alternative. Potential impacts on wetlands under the No-Action Alternative would be related to surface decontamination and/or stabilization of inactive waste sites (see Section 3.3.1). Less than 0.4 ha (1 ac) of wetlands would be disturbed (see Figure 5-6), which is not considered a significant impact. Environmental monitoring and maintenance activities would involve minimal disturbance of wetlands, and would not have significant impacts.

5.3.4.1.2 Effects on Wetlands, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve complete excavation and removal of contaminated soils and effluent lines, closure of TSD facilities, decommissioning of surplus facilities, and groundwater remediation. These activities would result in the potential loss of 5 ha (12 ac) of wetlands, which is 6% of the wetlands in the Reactors on the River geographic area (see Figure 5-7) and less than 1% of the wetlands on the Hanford Site, and is not considered significant.

5.3.4.1.2.1 Potential Mitigation Measures. Potential mitigation measures for wetlands include the following:

- identifying uncontaminated wetlands to be avoided
- using temporary fill structures, and other practices, to minimize disturbance of uncontaminated wetland soils and preserve propagules for revegetation
- requiring contractor equipment to be cleaned before entering work zones to prevent establishment or spread of undesirable species in remaining wetlands
- replacing destroyed wetlands through purchase, construction, or restoration of wetlands.

Wetland mitigation plans would be developed in consultation with the State of Washington, USACE, and the USFWS[3].

[3]Excavating of filling wetlands as part of a CERCLA remedial action would not require a permit, but would require meeting the substantive requirements of Section 404 of the CWA. More specific or additional mitigation measures would be negotiated through this process.

5.3.4.1.3 Effects on Wetlands, Restricted Future Land-Use Alternative (R1). The Restricted Future Land-Use Alternative (R1) would involve excavation and removal of past-practice waste sites and effluent lines, closure of TSD facilities, decommissioning of surplus facilities, and groundwater remediation. This alternative would affect approximately 4 ha (11 ac) of wetlands (see Figure 5-8), which is approximately 5% of the wetlands in the Reactors on the River geographic area and less than 1% of the wetlands on the entire Hanford Site, which is not considered significant.

5.3.4.1.3.1 Potential Mitigation Measures. Potential mitigation measures for wetlands under the Restricted Future Land-Use Alternative (R1) are the same as for the Unrestricted Future Land-Use Alternative.

Figure 5-6. 100-Year Floodplain and Wetland Areas Impacted under the Reactors on the River No-Action Alternative.

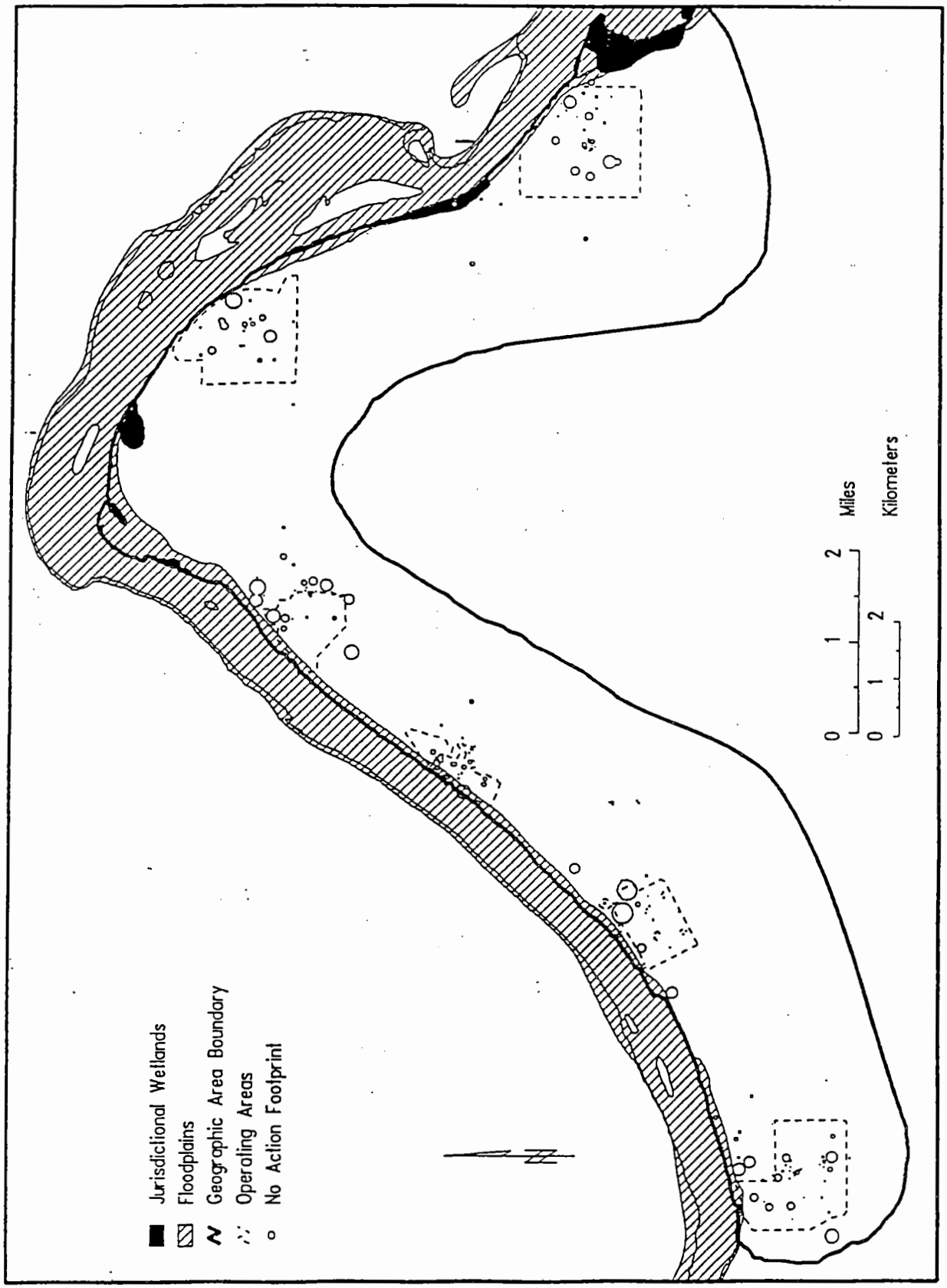

Figure 5-7. 100-Year Floodplain and Wetland Areas Impacted under the Reactors on the River Unrestricted Future Land-Use Alternative.

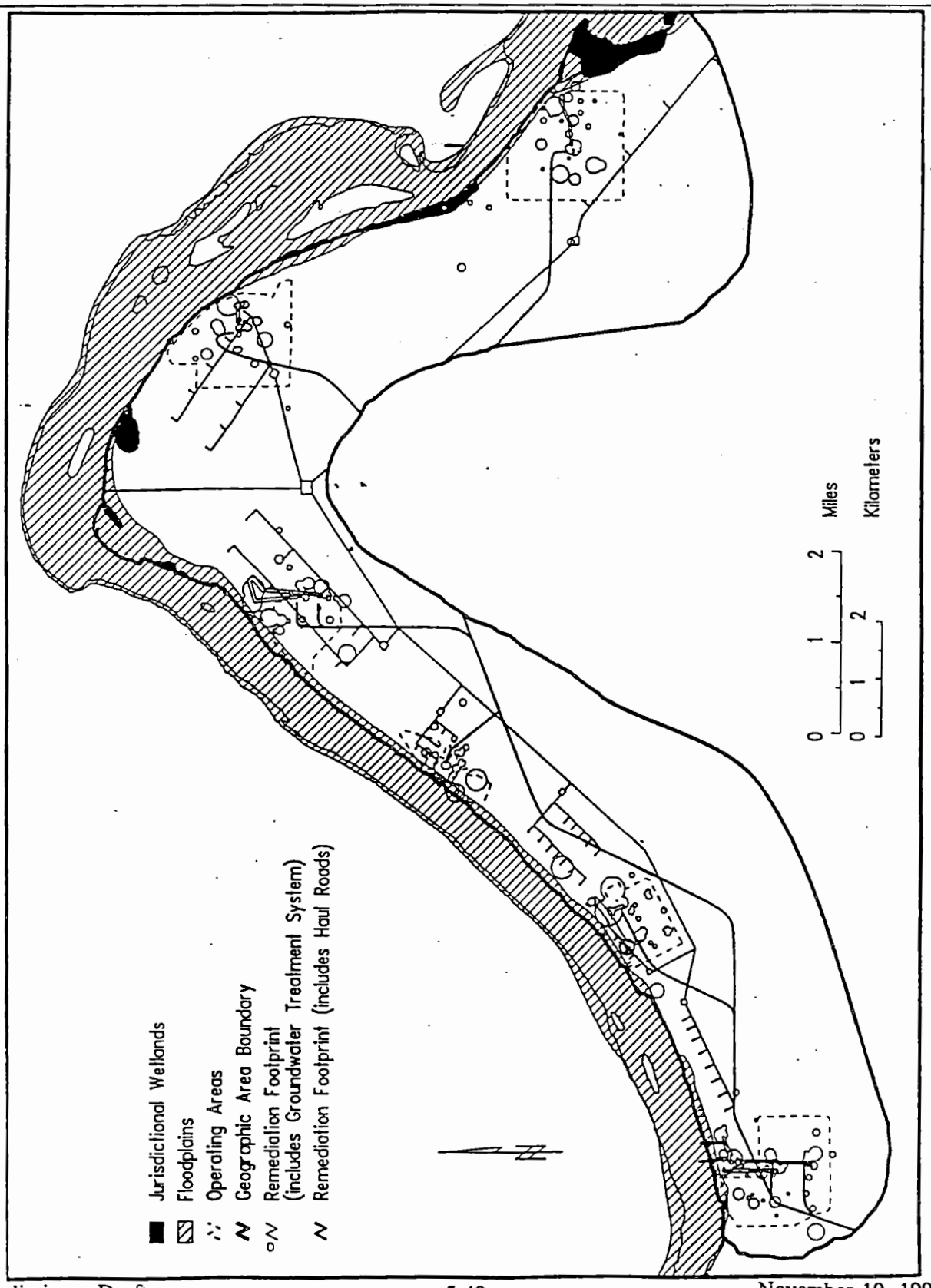

Figure 5-8. 100-Year Floodplain and Wetland Areas Impacted under the Reactors on the River Restricted Future Land-Use Alternative (R1).

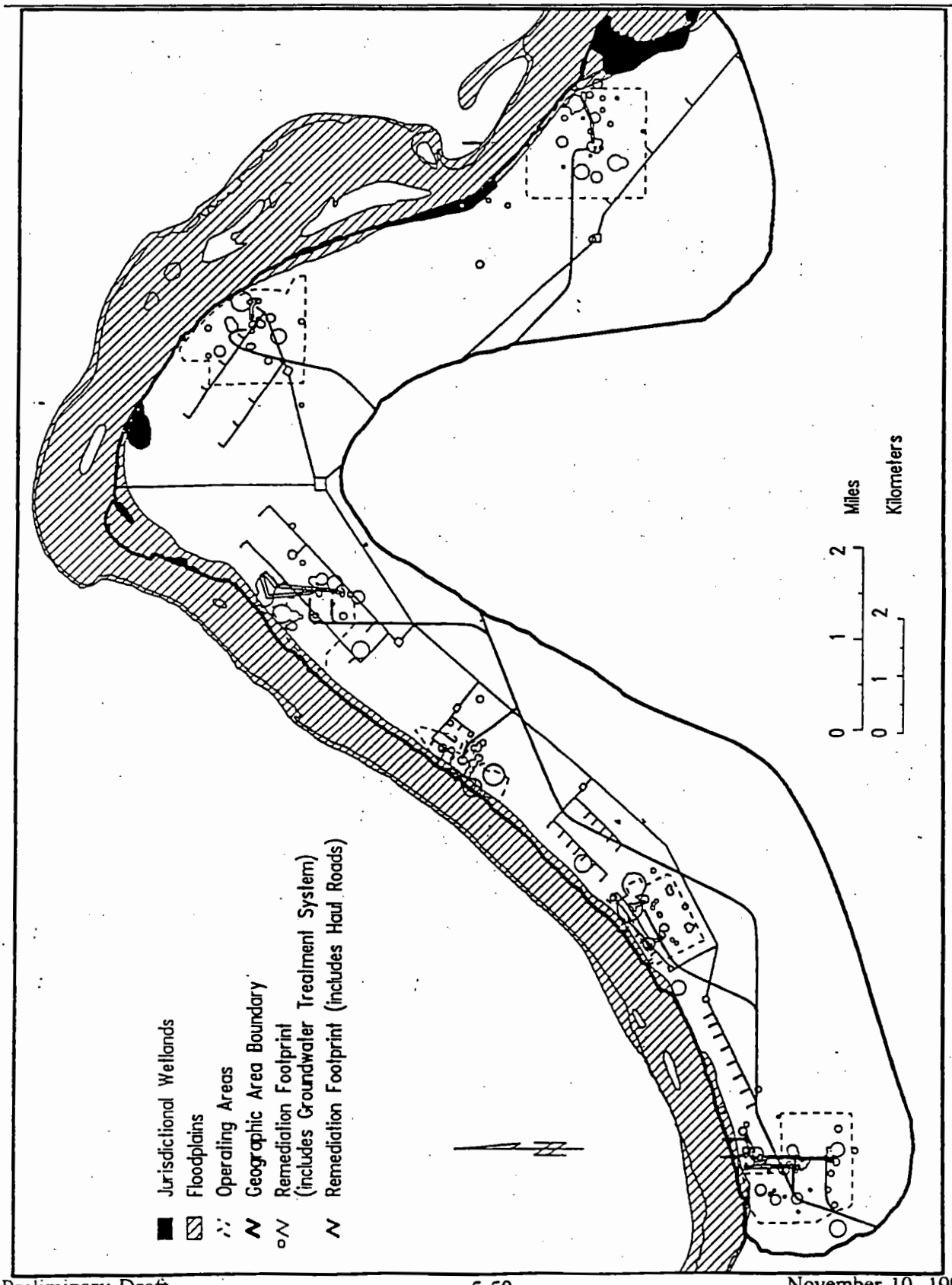

Figure 5-9. 100-Year Floodplain and Wetland Areas Impacted under the Reactors on the River Restricted Future Land-Use Alternative (R2).

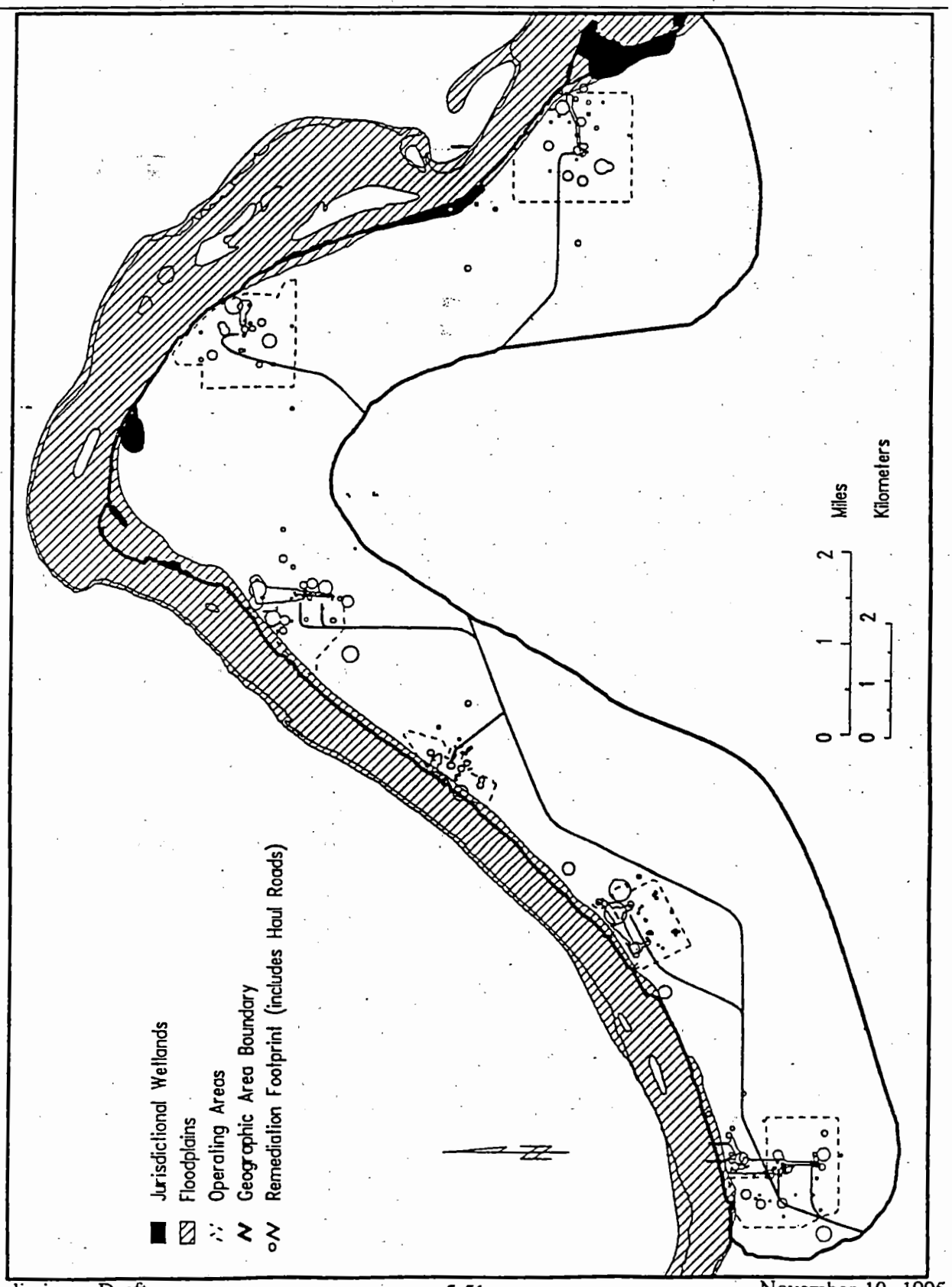

Table 5-13. Comparison of Habitat Disturbance under the Reactors on the River Geographic Area Future Land-Use Alternatives.[a]

Resources Impacted	Alternatives			
	No Action	Unrestricted	Restricted	
			R1	R2
Shrub-steppe Habitat	3 ha (7 ac)	40 ha (101 ac)	39 ha (98 ac)	38 ha (94 ac)
Species of Concern[b]	1	3	3	3
Wetlands[c]	0.4 ha (1 ac)	5 ha (12 ac)	4 ha (11 ac)	3 ha (7 ac)

[a]Areal impact information generated from the GIS; includes potential disturbance associated with excavation, capping, trample zones, effluent lines, haul roads, and wells.

[b]Includes bald eagle roost/perch sites occurring within the zone of disturbance.

[c]National Wetlands Inventory Data.

5.3.4.1.4 Effects on Wetlands, Restricted Future Land-Use Alternative (R2). The Restricted Future Land-Use Alternative (R2) would involve construction of caps over past-practice waste sites, effluent lines, and TSD facilities, and groundwater remediation. Approximately 3 ha (7 ac) of wetlands (see Figure 5-9) would be affected, which is approximately 4% of the wetlands in the Reactors on the River geographic area and less than 1% of the wetlands on the Hanford Site, and is not considered significant.

5.3.4.1.4.1 Potential Mitigation Measures. Potential mitigation measures for wetlands under the Restricted Future Land-Use Alternative (R2) are the same as for the Unrestricted Future Land-Use Alternative.

5.3.4.1.5 Effects on Shrub-Steppe Habitat, No-Action Alternative. The No-Action Alternative would involve surface decontamination and/or stabilization of waste sites (see Section 3.3.1). These activities would disturb approximately 3 ha (7 ac) of shrub-steppe habitat. This represents 0.1% of the shrub-steppe habitat in the Reactors on the River geographic area (Figure 5-10) and is not considered a significant impact. Environmental monitoring and maintenance activities would involve minimal disturbance of shrub-steppe habitat and would not have significant impacts.

5.3.4.1.6 Effects on Shrub-Steppe Habitat, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve complete excavation and removal of contaminated soil and effluent lines, closure of TSD facilities, decommissioning of surplus facilities, and groundwater remediation. This alternative would affect approximately 40 ha (101 ac) of shrub-steppe habitat, which represents 1.8% of the shrub-steppe habitat in the Reactors on the River geographic area (Figure 5-11).

Disturbance of shrub-steppe areas would lead to loss of nesting habitat for birds (e.g., sage sparrow, sage thrasher, and loggerhead shrike). Small mammals (e.g., ground squirrels) and reptiles, would be subjected to habitat fragmentation and displacement, or mortality. Noise and increased vehicle use in these areas would disturb wildlife within hearing or visual distance of remedial activities. This could result in startle behavior by some species and abandonment of nest or den sites. The areas disturbed also could include trees used as perching and roosting sites by bald eagles (Section 5.3.4.2).

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Figure 5-10. No-Action Alternative Impacts on Shrub-Steppe Habitat, or Reactors on the River Geographic Area.

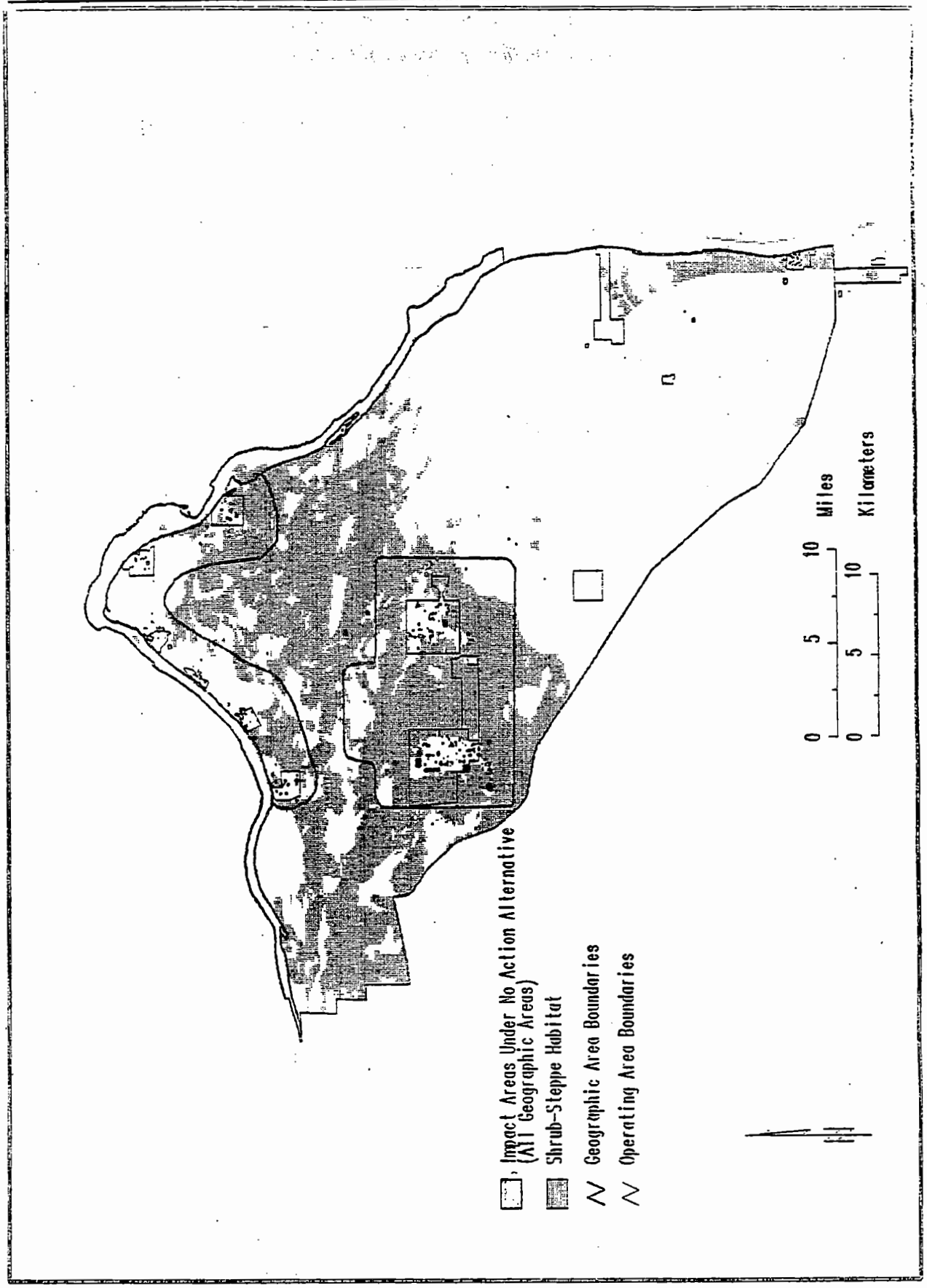
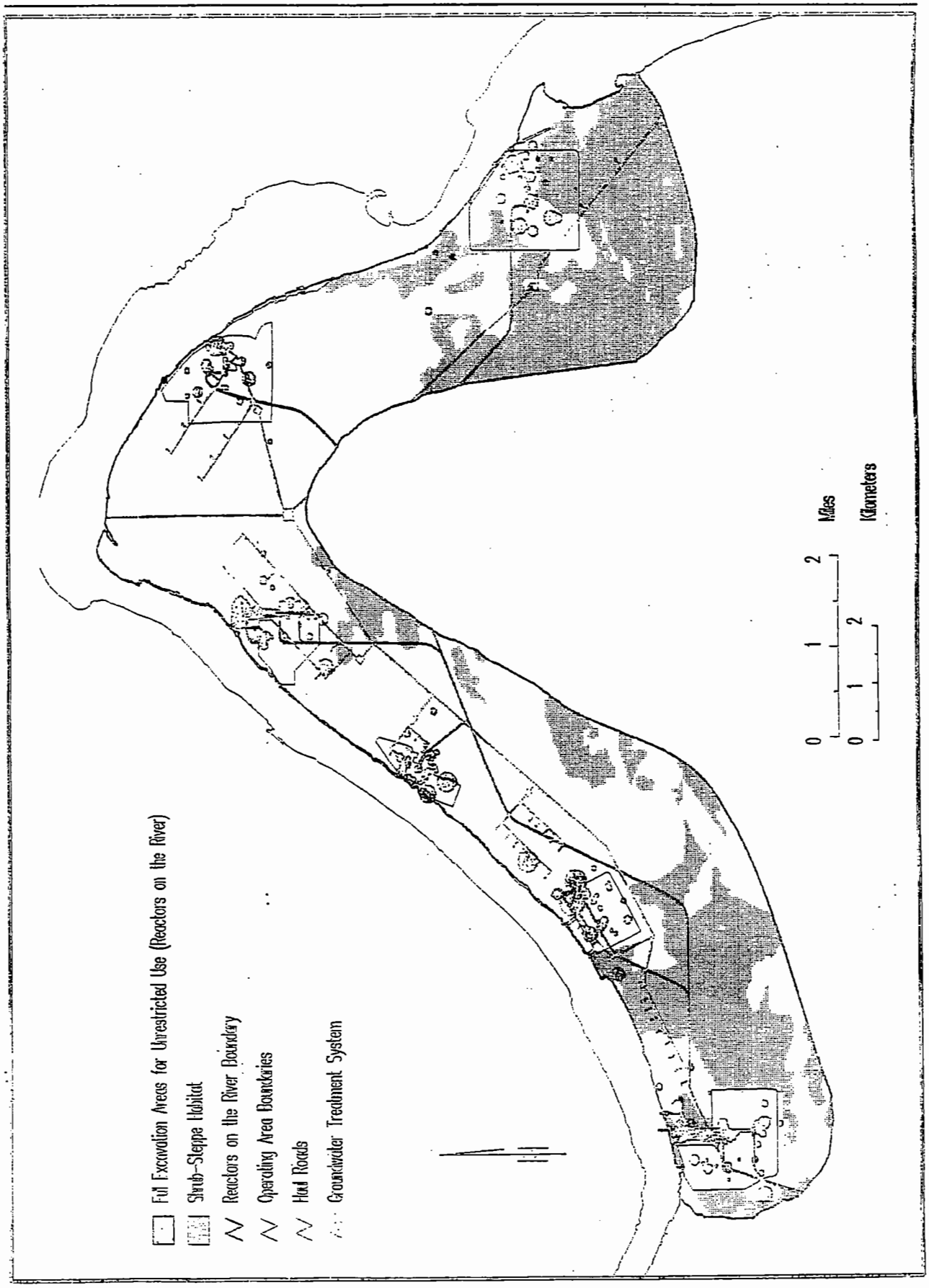


Figure 5-11. Unrestricted Future Land-Use Alternative Impacts on Shrub-Steppe Habitat, Reactors on the River Geographic Area.



Potential long-term impacts would include the permanent loss of habitat for species dependent on dense sagebrush. Much of the shrub-steppe habitat in the Reactors on the River geographic area already has been modified or lost because of wildfire, past agricultural activities, and industrial development. Disturbance of large areas, even if revegetated, would create conditions favorable to introduced species, such as noxious weeds that pioneer quickly on newly disturbed soil. These weed species would compete for available soil moisture and would make establishment of desirable native plants more difficult. The impacts to shrub-steppe habitat would be potentially significant. Restoration efforts would reduce impacts on some habitats, but would not fully replace diverse plant communities that have developed over long time periods.

5.3.4.1.6.1 Potential Mitigation Measures. Potential mitigation measures for shrub-steppe habitat include the following: restricting heavy equipment to trample zones, using the same or existing transportation routes to minimize damage to undisturbed vegetation, and revegetating disturbed areas with native vegetation.

5.3.4.1.7 Effects on Shrub-Steppe Habitat, Restricted Future Land-Use Alternative (R1). The Restricted Future Land-Use Alternative (R1) would involve similar activities as described for the Unrestricted Land-Use Alternative. Approximately 39 ha (98 ac) of shrub-steppe habitat would be disturbed in the Reactors on the River geographic area (Figure 5-12). The impacts of Restricted Future Land-Use Alternative (R1) would be similar to those discussed for the Unrestricted Future Land-Use Alternative, and would include the loss of nesting habitat for some species of song birds, habitat fragmentation, displacement or mortality of some wildlife, and abandonment of nests or dens by some species. Potential long-term impacts also would be similar to those discussed for the Unrestricted Future Land-Use Alternative and would be considered potentially significant. Restoration efforts would reduce impacts on some habitats, but would not fully replace diverse plant communities that have developed over long time periods.

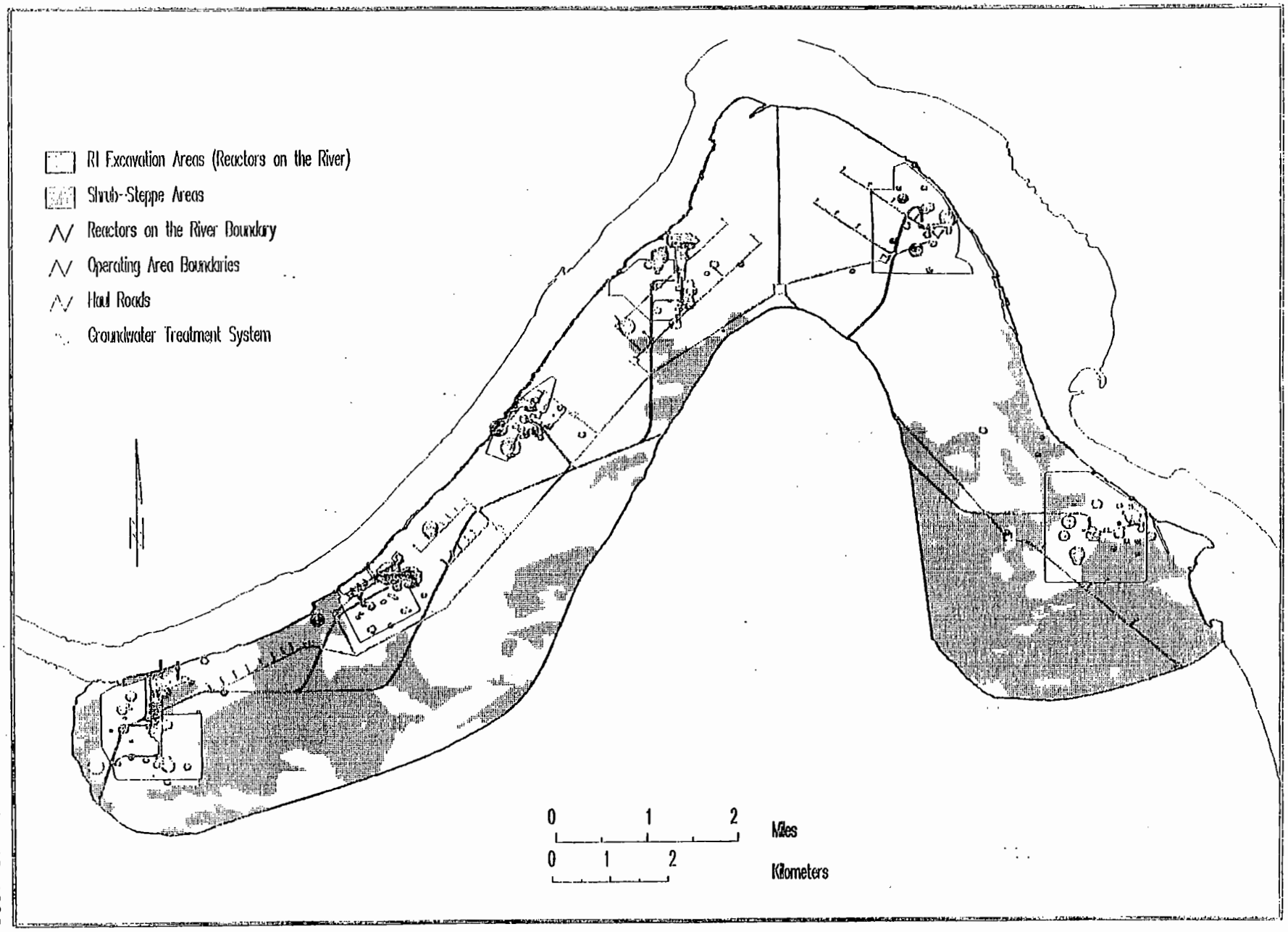
5.3.4.1.7.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative (R1) are the same as for the Unrestricted Future Land-Use Alternative.

5.3.4.1.8 Effects on Shrub-Steppe Habitat, Restricted Future Land-Use Alternative (R2). This alternative (R2) would involve construction of caps over waste sites and construction of perimeter access roads around the caps, which would disturb approximately 38 ha (94 ac) of shrub-steppe habitat in the Reactors on the River geographic area (Figure 5-13). The impacts of Restricted Future Land-Use Alternative (R2) would be similar to those discussed for the Unrestricted Future Land-Use Alternative, and would be considered potentially significant. Restoration efforts would reduce impacts on some habitats, but would not fully replace diverse plant communities that have developed over long time periods

5.3.4.1.8.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative (R2) are the same as for the Unrestricted Future Land-Use Alternative.

5.3.4.2 Effects on Species of Concern, No-Action Alternative. Surface decontamination and waste site stabilization activities under the No-Action Alternative have the potential to affect a ground perch site infrequently used by bald eagles. Disruption of winter roosting activity along the Columbia River would be potentially significant, but could be mitigated. No other species of concern are expected to be affected by the No-Action Alternative.

Figure 5-12. Restricted Future Land-Use Alternative (RI) Impacts on Shrub-Steppe Habitat, Reactors on the River Geographic Area.



ɔ-steppe, Reactors on the River.

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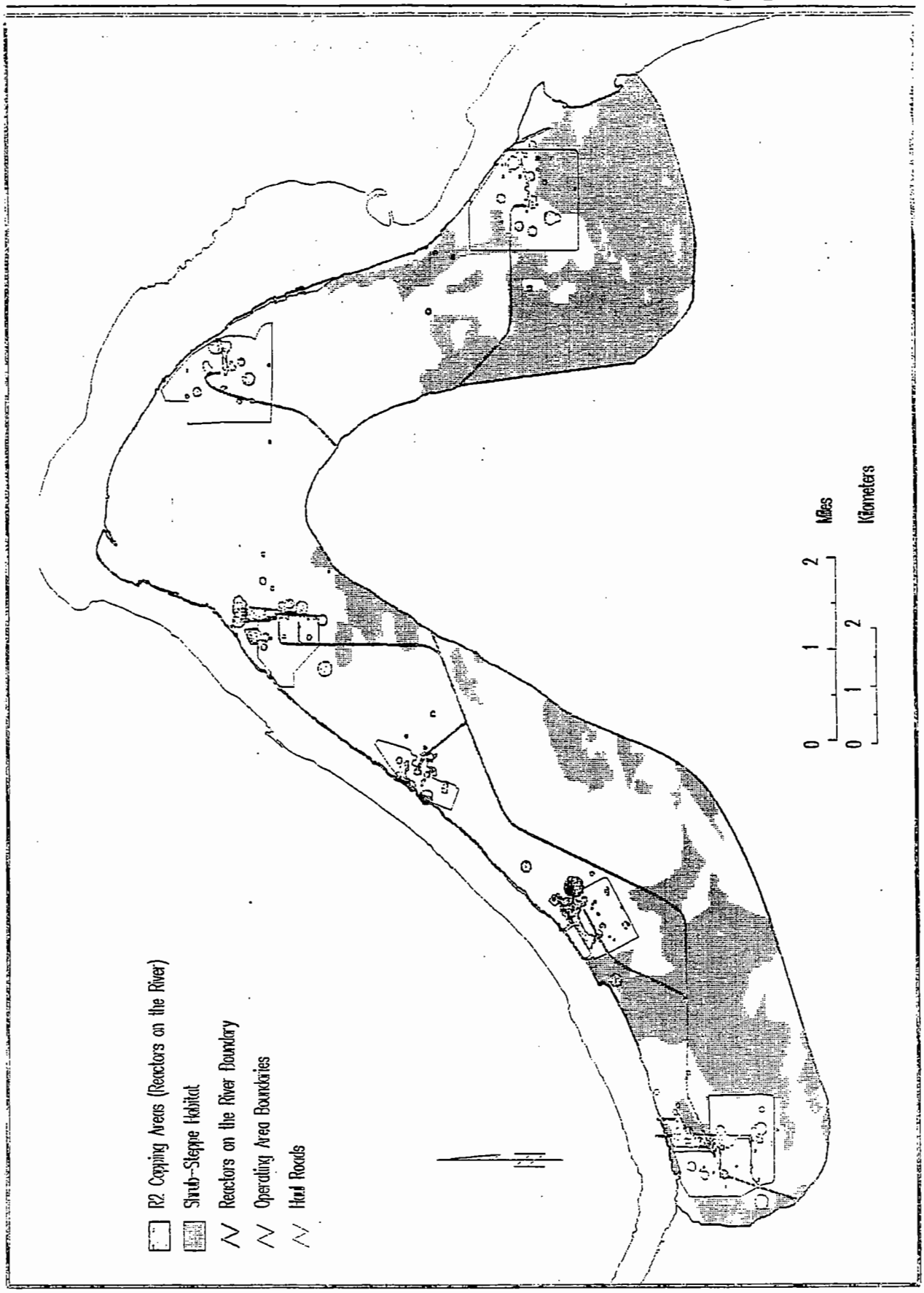
Figure 5-13. Restricted Future Land-Use Alternative (R2) Impacts on Shrub-Steppe Habitat, Reactors on the River Geographic Area.



5.3.4.2.1 Potential Mitigation Measures. Potential mitigation measures for bald eagle habitat include the following: exclude all disturbance within an 800-m (0.5-mi) buffer around winter roosts for bald eagles from November 15 to March 15, and avoid any habitat alteration within 400 m (0.25 mi) of bald eagle roosts (Fitzner et al. 1994)..

5.3.4.3 Effects on Species of Concern, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve large-scale construction activities that could affect bald eagle habitats, including six infrequently used tree roosts and perches, and infrequently used ground perches. Disruption of winter roosting activity along the Columbia River would be potentially significant, but could be mitigated. Plant species of concern known to occur in the Reactors on the River geographic area include the Columbia milk-vetch (state threatened) and northern wormwood (state endangered and federal candidate). Remedial activities could potentially affect both of these plant species if implemented in potential habitat. Long-term impacts on species of concern could involve permanent loss of habitat, resulting in population decline and possible listing of candidate species as a federal threatened or endangered species under the *Endangered Species Act of 1973*.

5.3.4.3.1 Potential Mitigation Measures. Potential mitigation measures for the Unrestricted Future Land-Use Alternative include the following: exclude all disturbance within an 800-m (0.5-mi) buffer around winter roosts of bald eagles from November 15 to March 15, avoid any habitat alteration within 400 m (0.25 mi) of bald eagle roosts (Fitzner et al. 1994), and identify and protect, to the extent possible, populations or habitats of the Columbia milk-vetch and northern wormwood.

5.3.4.4 Effects on Species of Concern, Restricted Future Land-Use Alternatives (R1 and R2). Restricted Future Land-Use Alternatives (R1 and R2) would involve disturbances similar to those described for the Unrestricted Future Land-Use Alternative and would have similar, potentially significant impacts on species of concern.

5.3.4.4.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternatives (R1 and R2) are the same as for the Unrestricted Future Land-Use Alternative.

5.3.4.5 Ecological Risk, No-Action Alternative. The No-Action Alternative could have potentially significant impacts to species as the result of long-term exposures to chemical and radiological contaminants in the Reactors on the River geographic area. Potential long-term exposures to chemicals and radionuclides were estimated for a generic plant, the Great Basin pocket mouse, the coyote, and the red-tailed hawk, as described in the ecological risk assessment (Appendix C). The chemical HI for ecological receptors in the Reactors on the River geographic area ranged from 2.96×10^{-8} to 2.7×10^{4} (Table 5-14). All values for plants, several for the mouse, and one for the red-tailed hawk were equal to or greater than 1.0, indicating a potential for long-term adverse effects. Several estimated radiation doses for the plant, coyote, and hawk were greater than 0.1 rad/d (Table 5-15), the level considered protective of terrestrial organisms (IAEA 1992). The distribution of these potential exposures for the entire Hanford Site is shown on Figures 5-14 through 5-21.

These results indicate potential adverse effects on ecological receptors exposed to the maximum estimated contaminant concentrations in the Reactors on the River geographic area. The use of the maximum estimated contaminant concentrations represents worst-case conditions. Current monitoring data indicate that measured exposures on the Hanford Site are below levels of concern. No significant differences in radionuclide concentrations were found in vegetation samples collected at

Table 5-14. Hazard Index Summed by Cell, Reactors on the River Geographic Area.

Cell ID	Hazard Index			
	Plant	Mouse	Coyote	Hawk
565144	3.83 E+03	5.91 E-01	1.13 E-04	5.41 E-03
565145	1.02 E+00	1.57 E-04	3.00 E-08	1.44 E-06
569146	2.70 E+04	***3.08 E+03***	9.41 E-01	***4.27 E+01***
569147	4.45 E+02	***2.48 E+00***	7.94 E-05	6.47 E-04
573151	1.42 E+04	1.20 E-02	2.28 E-06	1.10 E-04
573152	1.00 E+00	1.55 E-04	2.96 E-08	1.42 E-06
574152	1.93 E+00	2.98 E-04	5.70 E-08	2.73 E-06
577152	4.64 E+03	7.17 E-01	1.37 E-04	6.56 E-03
578152	2.35 E+00	3.63 E-04	6.93 E-08	3.33 E-06
580147	8.49 E+03	***1.31 E+00***	2.50 E-04	1.20 E-02
581147	1.40 E+00	2.17 E-04	4.14 E-08	1.99 E-06

NOTE: These values are presented in engineering notation for brevity. In engineering notation, a value of 3.83 E+03 corresponds to 3,830; a value of 5.91 E-01 corresponds to 0.591.
Bold italics indicates values greater than 1.0.

Table 5-15. Estimated Radiation Dose, Total by Cell, Reactors on the River Geographic Area.

Cell ID	Estimated Total Dose (rad/d)			
	Plant	Mouse	Coyote	Hawk
564143	8.20 E-03	2.09 E-05	2.72 E-02	2.30 E-02
565143	5.60 E-04	3.56 E-07	4.94 E-04	3.96 E-04
565144	***5.16 E+00***	1.27 E-02	***1.66 E+01***	***1.40 E+01***
565145	3.06 E-03	5.95 E-07	1.88 E-03	7.96 E-04
568146	***4.31 E-01***	1.15 E-03	***1.50 E+00***	***1.27 E+00***
569146	***4.98 E-01***	1.13 E-03	***1.47 E+00***	***1.24 E+00***
569147	2.57 E-03	1.68 E-07	2.45 E-04	1.88 E-04
571149	***1.51 E+00***	1.49 E-05	2.06 E-02	1.65 E-02
572150	2.83 E-04	4.76 E-08	6.98 E-05	5.34 E-05
573150	9.55 E-06	6.22 E-10	5.32 E-06	1.26 E-06
573151	4.73 E-02	3.69 E-07	8.54 E-04	4.53 E-04
573152	1.20 E-03	6.41 E-08	1.15 E-04	7.46 E-05
574152	2.30 E-03	1.23 E-07	2.21 E-04	1.44 E-04
577152	8.88 E-04	6.34 E-08	1.04 E-04	7.25 E-05
578152	2.45 E-03	1.70 E-08	3.33 E-05	2.02 E-05
579147	1.71 E-05	1.12 E-09	9.54 E-06	2.26 E-06
580147	***1.59 E-01***	1.52 E-06	2.18 E-03	1.70 E-03
581147	8.38 E-03	5.35 E-08	7.26 E-05	5.93 E-05

NOTE: These values are presented in engineering notation for brevity. In engineering notation, a value of 3.83 E+03 corresponds to 3,830; a value of 5.91 E-01 corresponds to 0.591.
Bold italics indicates values greater than 0.1 rad/d.

Figure 5-14. Distribution of Chemical Hazard Indices for a Generic Plant at the Hanford Site.

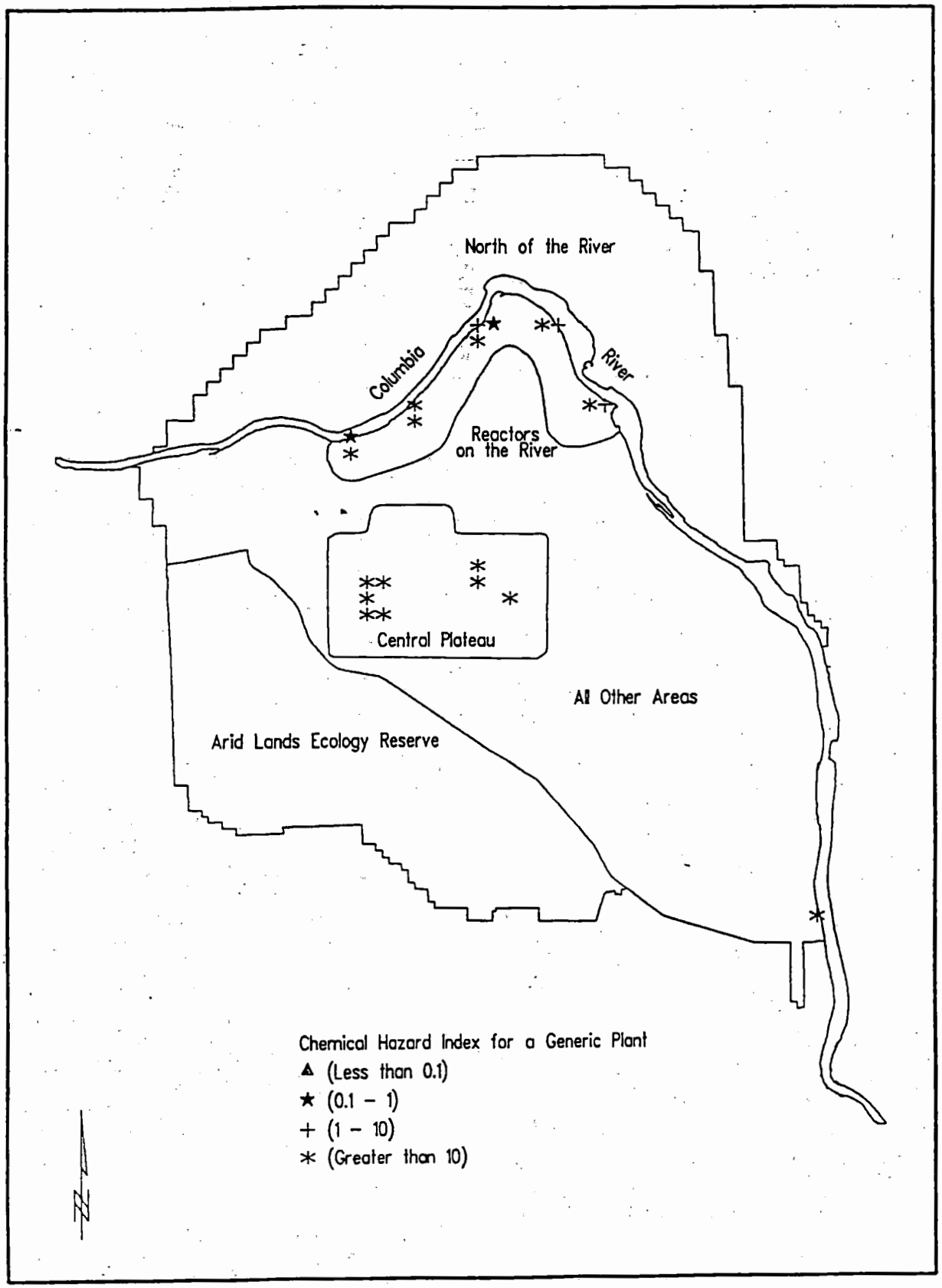


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Figure 5-15. Distribution of Chemical Hazard Indices for a Great Basin Pocket Mouse at the Hanford Site.

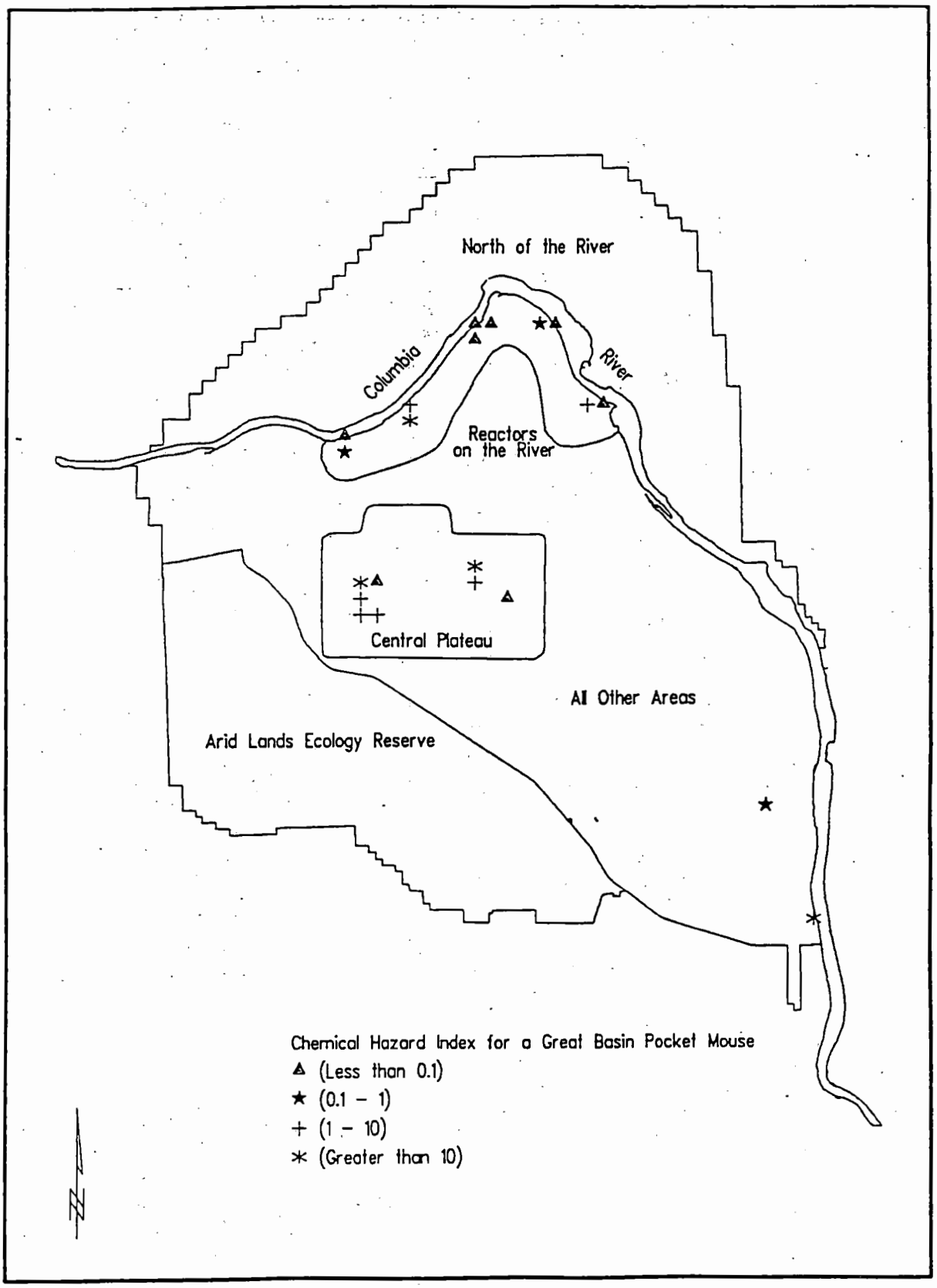

Figure 5-16. Distribution of Chemical Hazard Indices for a Coyote on the Hanford Site.

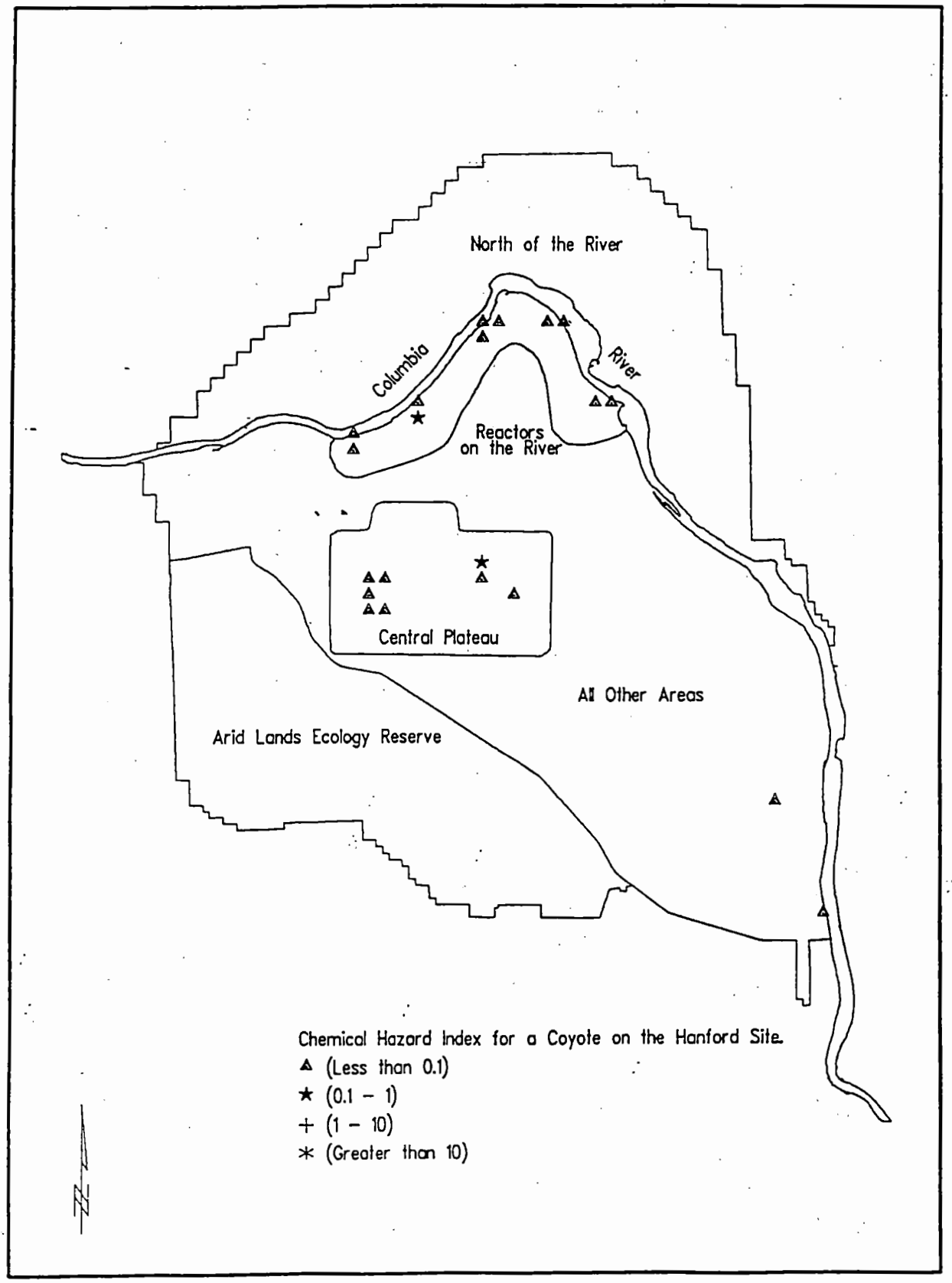

Figure 5-17. Distribution of Chemical Hazard Indices for a Red-Tailed Hawk on the Hanford Site.

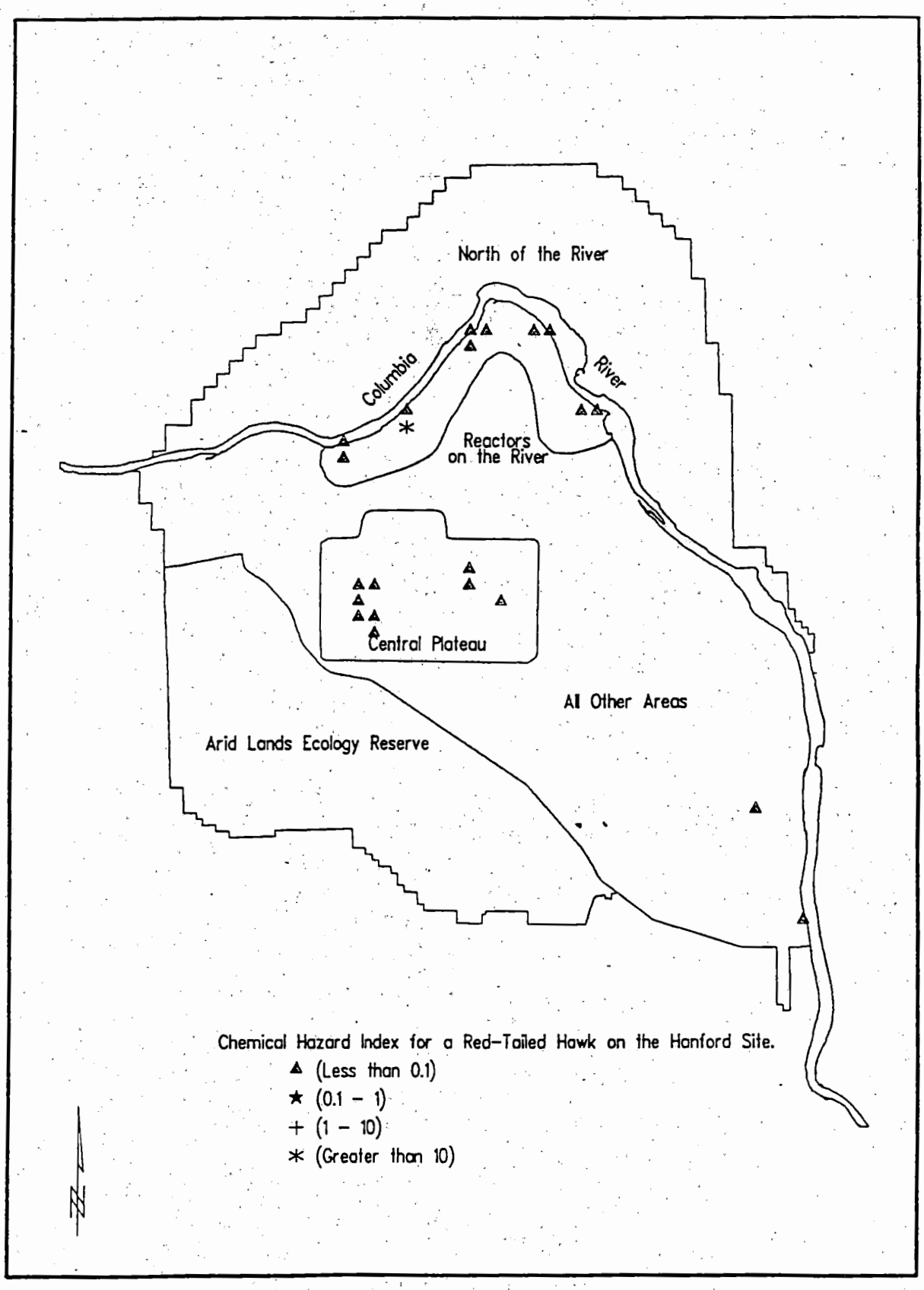

Figure 5-18. Distribution of Estimated Radiation Doses (Rads/day) for a Generic Plant at the Hanford Site.

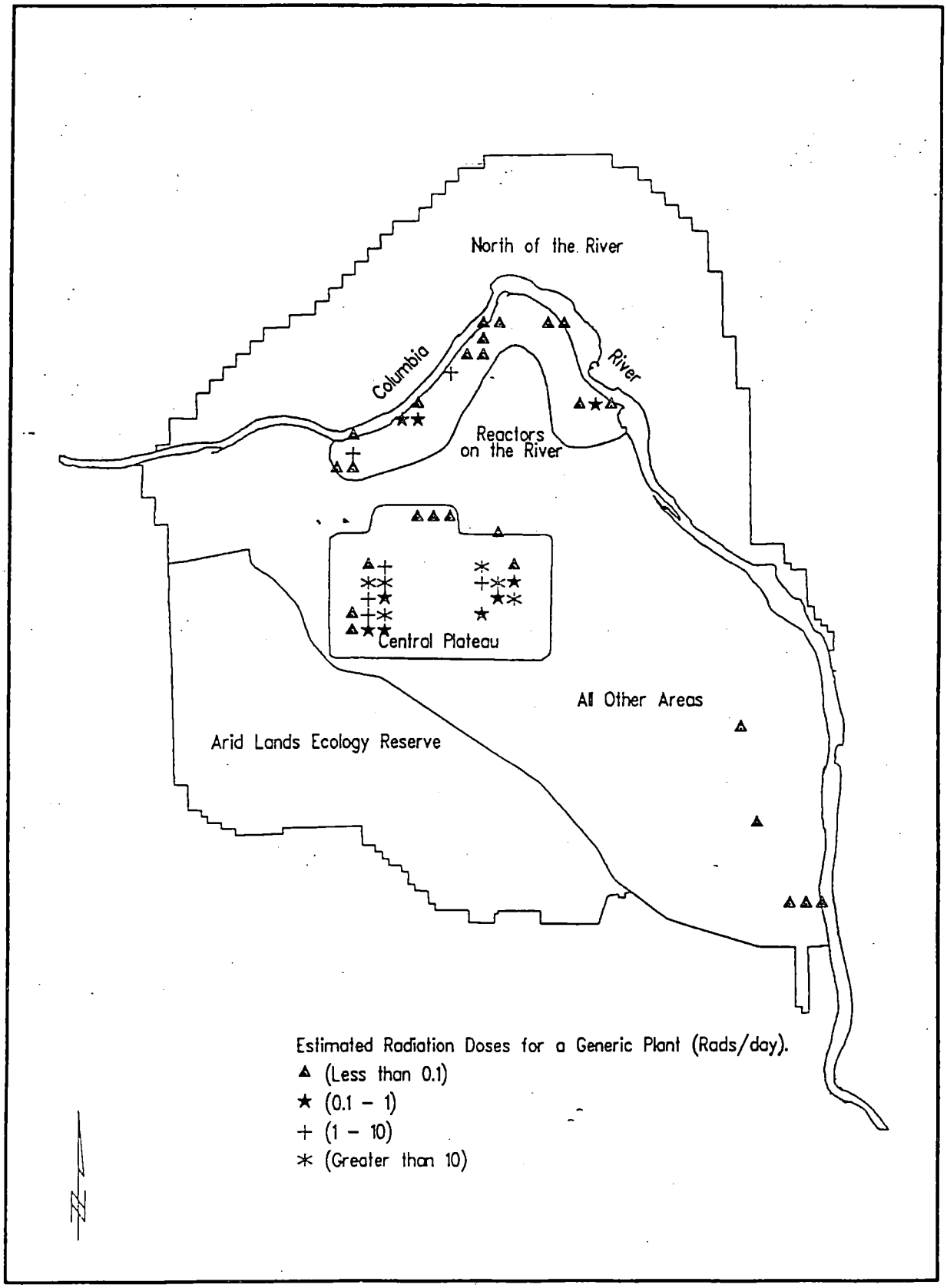

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Figure 5-19. Distribution of Estimated Radiation Doses (Rads/day) for a Great Basin Pocket Mouse at the Hanford Site.

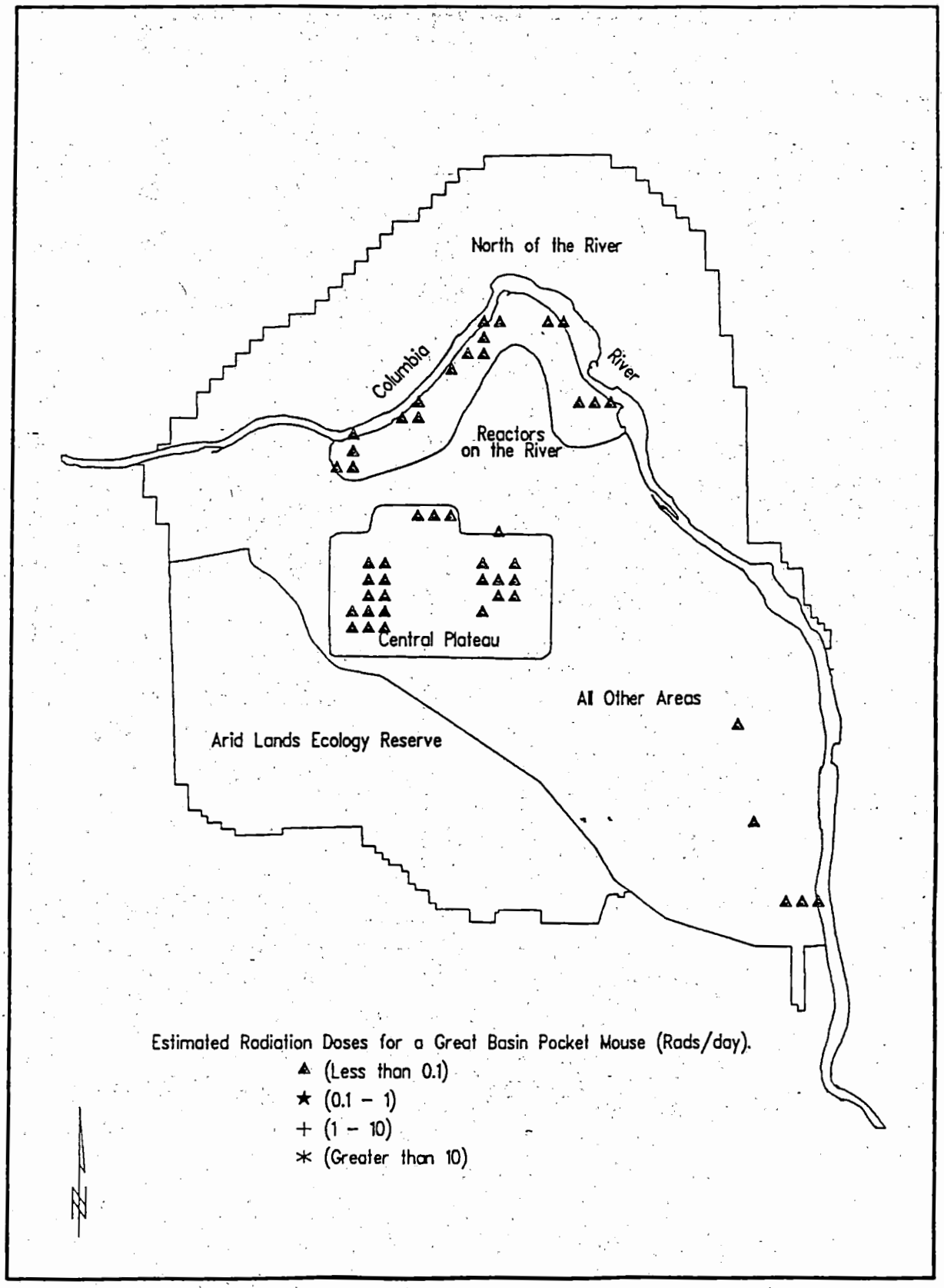

Figure 5-20. Distribution of Estimated Radiation Doses (Rads/day) for a Coyote on the Hanford Site.

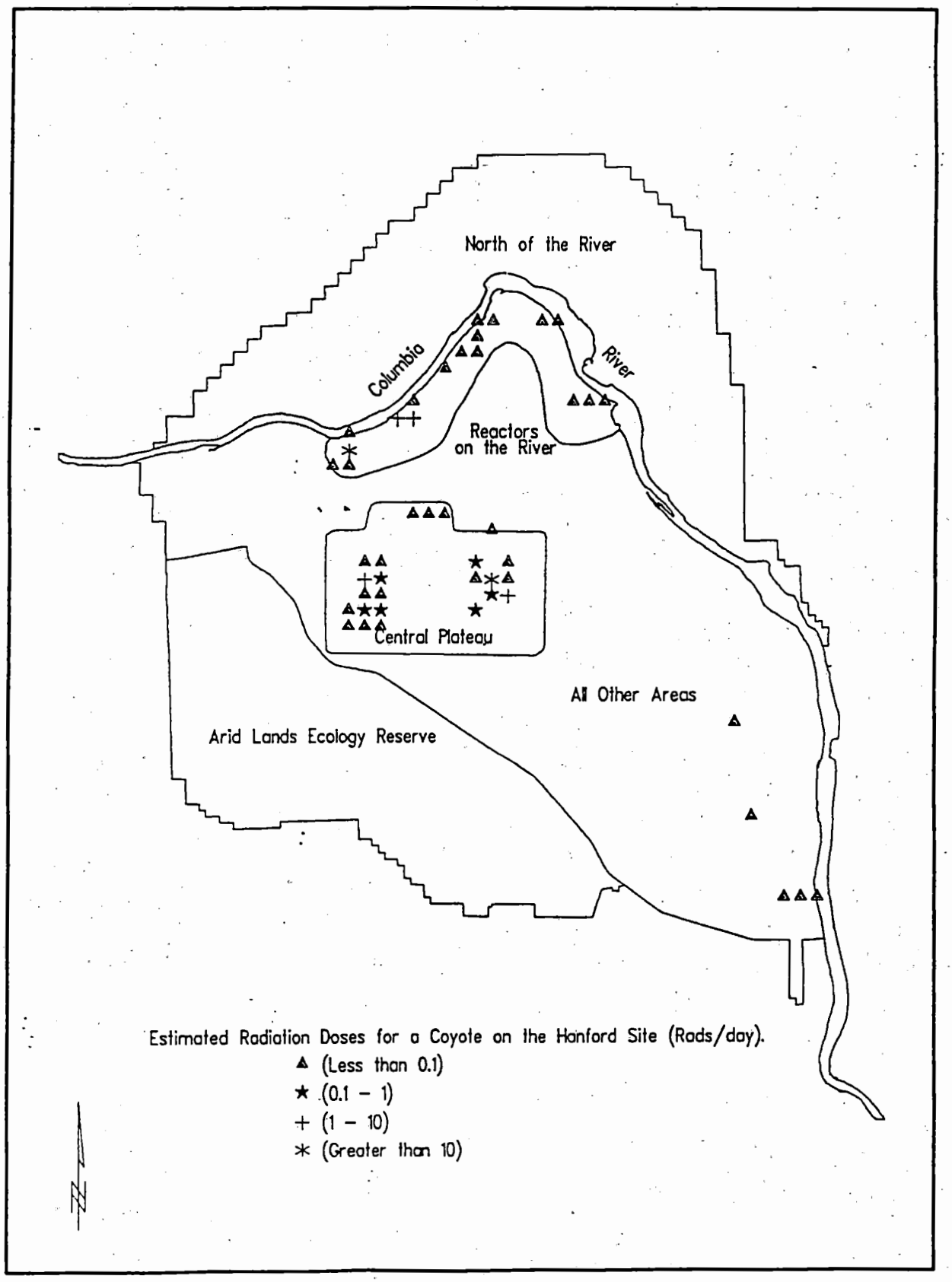

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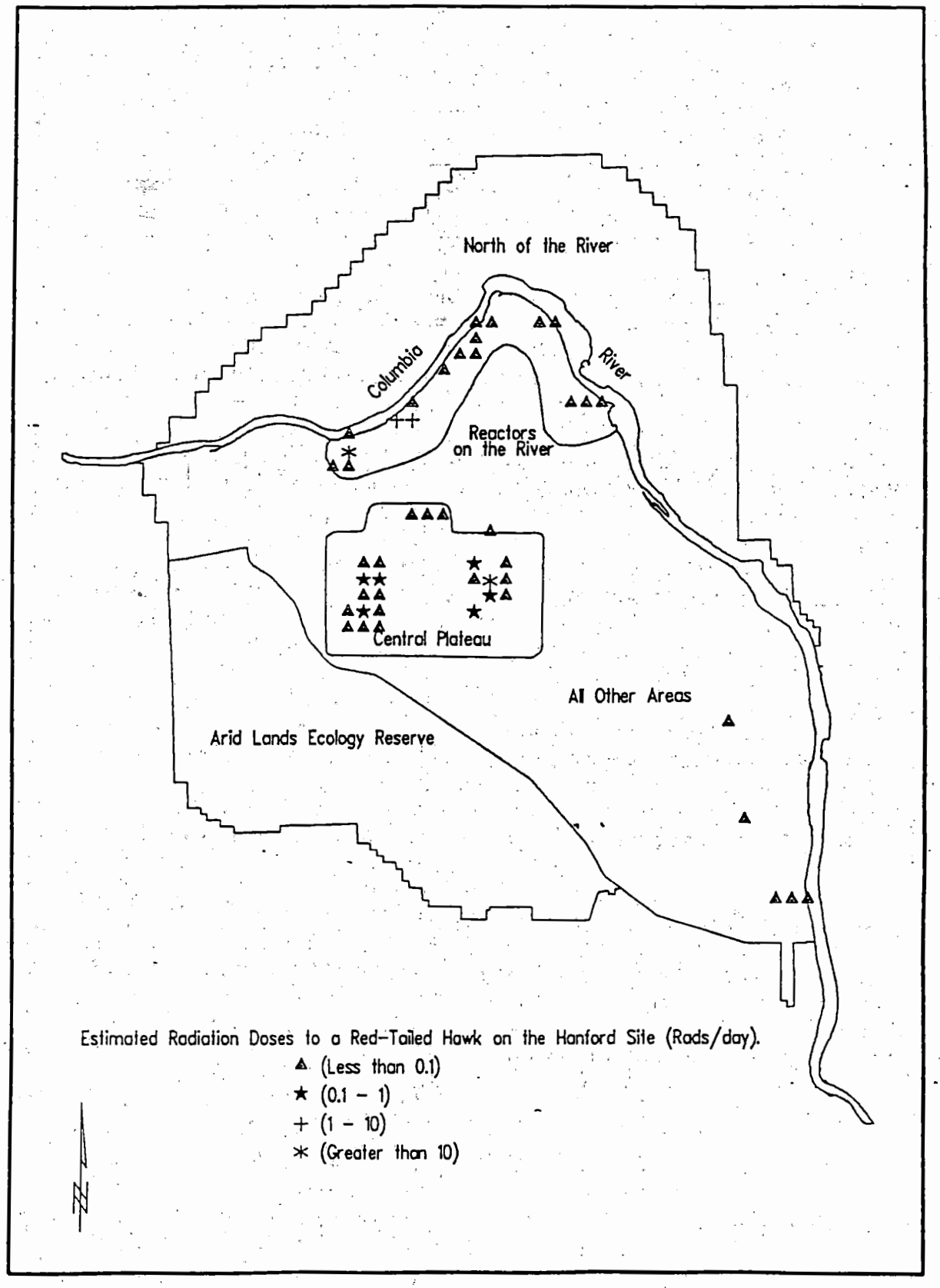
Figure 5-21. Distribution of Estimated Radiation Doses (Rads/day) for a Red-tailed Hawk on the Hanford Site.



Hanford and offsite locations. Fish and wildlife samples collected at the Hanford Site contained small amounts of radioactivity attributed to Hanford operations; however, the concentrations were not sufficient to pose a hazard to the organisms themselves or to humans who might consume them (PNL 1993).

The potentially significant impacts identified in the ecological risk assessment may be reduced by surface decontamination and waste site stabilization activities included in the No-Action Alternative. Continued monitoring would enable detection of potential adverse effects on ecological receptors so that additional corrective measures could be taken to minimize exposures.

5.3.4.6 Ecological Risk, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve excavation and hauling of large volumes of contaminated soil, which could result in airborne suspension and transport of contaminants. Airborne contamination could result in direct exposures of ecological receptors or subsequent uptake through the food chain. These exposures could result in significant short-term impacts, but could be reduced by the mitigation measures for soils (Section 5.3.2), water quality (Section 5.3.3), and air quality (Section 5.3.5). Long-term impacts would be beneficial, because potential adverse exposures to radionuclides and hazardous chemicals would be eliminated by removing and disposing of the contaminated material.

5.3.4.7 Ecological Risk, Restricted Future Land-Use Alternative (R1). This alternative (R1) would involve excavation and hauling of contaminated soils, which could result in short-term increased risks to ecological receptors, as described for the Unrestricted Future Land-Use Alternative. These exposures could result in significant short-term impacts, but could be reduced by the mitigation measures for soils (Section 5.3.2), water quality (Section 5.3.3), and air quality (Section 5.3.5). Remedial activities would reduce long-term risks from exposure, although some wastes would be left in place in the subsurface. The risk from long-term exposures to the remaining contamination would depend on the amount and mobility of contaminants left in place. Continued monitoring would enable detection of potential adverse effects on ecological receptors so that additional corrective measures could be taken to minimize exposures.

5.3.4.8 Ecological Risk, Restricted Future Land-Use Alternative (R2). Remediation to restricted use (R2) would involve leaving wastes in place and installing caps to limit exposures. As with the No-Action Alternative, potentially significant impacts to ecological receptors could occur from long-term exposures to contamination remaining in place. The caps are expected to reduce the potential impacts by limiting exposures. Continued monitoring would enable detection of potential adverse effects on ecological receptors so that additional corrective measures could be taken to minimize exposures.

5.3.4.9 Effects on Biodiversity, No-Action Alternative. The No-Action Alternative is not expected to have significant impacts on biodiversity in the short term. With adequate mitigation, the surface decontamination and waste site stabilization activities would not result in significant population losses of sensitive species. These activities are not likely to affect species diversity in wetland and shrub-steppe plant communities, or affect the distribution of those communities. Current monitoring data indicate that measured exposures to chemical and radiological contaminants on the Hanford Site are below levels that could adversely affect plant and animal species (PNL 1995).

The results of the ecological risk assessment indicate potentially significant impacts from long-term exposures to maximum estimated concentrations of contaminants. Such exposures could result in population losses of some species, which could have indirect food chain effects on the abundance of other species. The potential long-term effects on biodiversity would depend on the

likelihood of continued exposure of sensitive species to high levels of contamination. Continued monitoring would enable detection of potential adverse effects on ecological receptors so that additional corrective measures could be taken to minimize exposures.

5.3.4.10 Effects on Biodiversity, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative could have significant impacts on biodiversity by further reducing shrub-steppe habitat in the Reactors on the River geographic area. Much of the shrub-steppe habitat in the Reactors on the River geographic area has already been modified or lost because of wildfire, past agricultural activities, and industrial development. Further reductions in habitat could result in population losses in species dependent on dense sagebrush. Disturbance and subsequent reclamation of plant communities could reduce species diversity, with indirect effects on community functions, such as forage production, cover, and nutrient cycling. Excavation activities would fragment existing habitats and disrupt the connectivity among different habitats. These impacts would be significant in the short term; long-term impacts to biodiversity could be avoided or reduced through implementation of the mitigation measures previously discussed.

5.3.4.11 Effects on Biodiversity, Restricted Future Land-Use Alternatives (R1 and R2). These alternatives (R1 and R2) would involve levels of disturbance similar to the Unrestricted Future Land-Use Alternative, with similar impacts to biodiversity.

5.3.5 Air Quality

5.3.5.1 Effects on Air Quality, No-Action Alternative. The No-Action Alternative would involve surface decontamination and waste site stabilization activities (see Section 3.3.1). Although these activities would generate fugitive dust and pollutants from equipment exhaust, concentrations of airborne pollutants from the No-Action Alternative would be well below those estimated for the hypothetical excavation site evaluated for the Unrestricted Future Land-Use Alternative (see Section 5.3.5.2). Therefore, the No-Action Alternative is not expected to have significant air quality impacts.

5.3.5.2 Effects on Air Quality, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve complete excavation and removal of contaminated soils and inactive effluent lines, closure of TSD facilities, decommissioning of surplus facilities, and groundwater remediation. Waste site excavation would generate fugitive dust possibly contaminated with radioactive particles. Pollutants also would be generated by combustion of fuel in equipment used for excavation, loading, and hauling. The potential for air quality impacts was evaluated by estimating pollutant concentrations in the air resulting from a hypothetical waste site excavation in the 100-H Area. An excavation rate of 450,000 kg/d (1 million lb/d) was used for estimating purposes. The amounts of pollutants generated at the Hanford Site were estimated using the procedures and assumptions described in Appendix G, and concentrations of pollutants in ambient air downwind from the Hanford Site were projected. The estimated concentrations that workers could be exposed are well within appropriate standards and guidelines (Table 5-16). The same is true for concentrations that the general public could be exposed.

Concentrations in Table 5-16 are consequences of remedial activities at one site. Simultaneous activities at several sites could result in higher concentrations, particularly if the sites happened to be in line and parallel to the wind direction. Potential concentrations were estimated by assuming simultaneous excavation of five sites aligned with the wind direction. The five sites were identical to

Table 5-16. Estimated Concentrations of Airborne Contaminants from Full Excavation in the Reactors on the River Geographic Area.[a]

Type of Air Contaminant	Contaminant Name	Concentration in the Immediate Vicinity[b]	Onsite Occupational Standard or Guideline[c]	Concentration at Nearest Property Line[d]	Offsite Air Quality Standard or Guideline[e]
Fugitive Dust ($\mu g/m^3$)	PM_{10}	780	5,000, 8-h average	1.3	150, 24-h average
Radioisotopes (pCi/m^3)	Sr-90	35	2,000, annual average	0.059	50, annual average
	Cs-137	45	60,000, annual average	0.075	400, annual average
	Pu-239, -240	0.4	3, annual average	0.074	0.02, annual average
	U-238	0.2	300, annual average	0.00025	0.10, annual average
Products of Fuel Combustion ($\mu g/m^3$)	total suspended particulates	72	15,000, 8-h average	0.1	–
	carbon monoxide	470	55,000, 8-h average	0.8	9,000, 8-h average
	nitrogen dioxide	730	9,000, 8-h average	1.2	50, annual average
	sulfur dioxide	98	13,000, 8-h average	0.2	20, annual average

[a]Procedures and assumptions for estimating concentrations of airborne contaminants are discussed in Appendix G. The estimated concentrations of fugitive dust and fuel combustion products do not include background concentrations.

[b]Concentrations immediately downwind from the excavation site are potential concentrations that workers could be exposed.

[c]Occupational standards for fugitive dust and combustion products are PELS listed in 29 CFR 1910. Occupational guidelines for airborne radionuclides are listed in Federal Guidance Report No. 11 (EPA 1988b).

[d]Concentrations at the nearest property line are potential concentrations that the general public could be exposed.

[e]Air quality standards for fugitive dust, CO, and NO_2 are National Ambient Air Quality Standards (40 CFR 50-99). The standard for SO_2 is a Washington State standard. Guidelines for airborne radionuclides are DCGs listed in DOE Order 5400.5 (DOE 1993a).

DCG = Derived Concentration Guideline.
PEL = Permissible Exposure Limit.

the one previously described and were assumed to be spaced 200 m (660 ft) apart. Cumulative concentrations from this arrangement are well below applicable standards and guidelines (Table 5-17). The pollutant concentrations in Tables 5-16 and 5-17 represent short-term impacts that would cease when remediation is concluded.

Remediation for unrestricted use would require transport of contaminated waste to an onsite waste disposal facility. Significant impacts from haul road dust are not expected to occur. Hauling 450,000 kg/d (1 million lb/d) in 10-ton trucks, for example, would require about 50 roundtrips. The resulting traffic count, averaging about 12 trucks per hour, would generate a dust concentration of about 100 $\mu g/m^3$ in the immediate vicinity of the roadway (see Figure 5-5), compared to the 5,000 $\mu g/m^3$ occupational standard.

Table 5-17. Cumulative Impacts of Airborne Contaminants from Simultaneous Excavation of Five Sites in the 100-H Area.[a]

Type of Air Contaminant	Contaminant Name	Concentration in the Immediate Vicinity[b]	Onsite Occupational Standard or Guideline[c]	Concentration at Nearest Property Line[d]	Offsite Air Quality Standard or Guideline[e]
Fugitive Dust ($\mu g/m^3$)	PM_{10}	1,300	5,000, 8-h average	6.1	150, 24-h average
Radioisotopes (pCi/m^3)	Sr-90	59	2,000, annual average	0.28	50, annual average
	Cs-137	76	60,000, annual average	0.0035	400, annual average
	Pu-239, -240	0.7	3, annual average	0.0035	0.02, annual average
	U-238	0.3	300, annual average	0.002	0.10, annual average
Products of Fuel Combustion ($\mu g/m^3$)	total suspended particulates	120	15,000, 8-h average	0.6	–
	carbon monoxide	790	55,000, 8-h average	3.7	9,000, 8-h average
	nitrogen dioxide	1,200	9,000, 8-h average	5.7	50, annual average
	sulfur dioxide	170	13,000, 8-h average	0.8	20, annual average

[a]Procedures and assumptions for estimating concentrations of airborne contaminants are discussed in Appendix G. The five sites are assumed to be 200 m (660 ft) apart and aligned in the direction the wind is blowing. The estimated concentrations of fugitive dust and fuel combustion products do not include background concentrations.

[b]Concentrations immediately downwind from the excavation site are potential concentrations that workers could be exposed.

[c]Occupational standards for fugitive dust and combustion products are PELs listed in 29 CFR 1910. Occupational guidelines for airborne radionuclides are listed in Federal Guidance Report No. 11 (EPA 1988b).

[d]Concentrations at the nearest property line are potential concentrations that the general public could be exposed.

[e]Air quality standards for fugitive dust, CO, and NO_2 are National Ambient Air Quality Standards (40 CFR 50-99). The standard for SO_2 is a Washington State standard. Guidelines for airborne radionuclides are DCGs listed in DOE Order 5400.5 (DOE 1993a).

DCG = Derived Concentration Guideline.
PEL = Permissible Exposure Limit.

Significant air quality impacts are not expected to occur from full excavation at remediation sites in the Reactors on the River geographic area, because the estimated concentrations in Table 5-16 and 5-17 are well below applicable air quality standards. However, these estimates are based on typical meteorological conditions, and could be substantially greater or lower during unusual conditions (e.g., high or low wind speeds, or extreme conditions of atmospheric stability or instability). Furthermore, pollutants other than contaminated dust could be generated. During excavation of a waste site, there would be a potential for short-duration emissions of any waste material the site might contain.

5.3.5.2.1 Potential Mitigation Measures. Mitigation measures, if necessary, would include spraying roads and piles with water or surfactants, a commonly used dust suppression measure that can reduce fugitive emissions by up to 50% (EPA 1985), or temporary enclosure of the area being excavated.

5.3.5.3 Effects on Air Quality, Restricted Future Land-Use Alternative (R1). The Restricted Future Land-Use Alternative (R1) would involve excavation and removal of past-practice waste sites and effluent lines, closure of TSD facilities, decommissioning of surplus facilities, and groundwater remediation, combined with institutional controls. Air quality impacts of waste site excavation under this alternative would be similar to the impacts estimated for full excavation for the Unrestricted Future Land-Use Alternative. No significant impact would be expected.

5.3.5.4 Effects on Air Quality, Restricted Future Land-Use Alternative (R2). Remediation to restricted use (R2) would involve construction of caps over past-practice waste sites, effluent lines, and TSD facilities, and groundwater remediation, combined with institutional controls. Air quality impacts of remediation to restricted use (R2) would be lower than the estimates in Tables 5-16 and 5-17, because less contaminated materials would be disturbed. The hauling of materials from borrow areas for construction of caps would generate similar fugitive dust emissions as estimated for the Unrestricted Future Land-Use Alternative. No significant impact would be expected.

5.3.6 Noise

5.3.6.1 Noise Effects, No-Action Alternative. The No-Action Alternative for the Reactors on the River geographic area would result in no change to existing noise impacts on the surrounding environment. The sound levels in the ambient environment would remain the same as current noise levels.

5.3.6.2 Noise Effects, Unrestricted Future Land-Use Alternative. Remediation to unrestricted use would generate increased noise from heavy truck traffic, and transport and operation of construction equipment. Representative noise levels from remedial activities were estimated for complete excavation of contaminated soils (i.e., remediation to unrestricted use) in the 100-H Area. This area was selected for analysis because of its close proximity to the Wahluke Slope State Wildlife Recreational Area, where high noise levels would be most likely to adversely affect wildlife and recreational users.

To derive typical, cumulative noise levels from remedial activities at the 100-H Area, the Federal Highway Administration's STAMINA traffic noise model was used (DOT 1982). This model predicts noise impacts caused by the operation of motor vehicles at specified receptor locations. The analysis was based on predicted volumes of contaminated soil to be excavated in the 100-H Area, and included the following assumptions: 450,000 kg (1 million lb) of contaminated soil excavated per day, five construction crews working in the 100-H Area, two 11.5-m^3 (15-yd^3) dump trucks operating continuously during the workday for each of the five work sites, one bulldozer per crew, one hydraulic excavator per crew, one grader per crew, one scraper per crew, two front-end loaders per crew, and one medium truck.

The five representative areas where contaminated soil loading activities were assumed to be concentrated are shown as large circles on Figure 5-22. (These circles are not intended to identify specific future work areas, but are intended to provide an appropriate, representative scattering of noise sources across the 100-H Area for noise modeling purposes.) The nearest receptors were assumed to be located radially to the north and east of the 100-H Area (see Figure 5-22).

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Figure 5-22. Representative Noise Sources Across the 100-H Area.

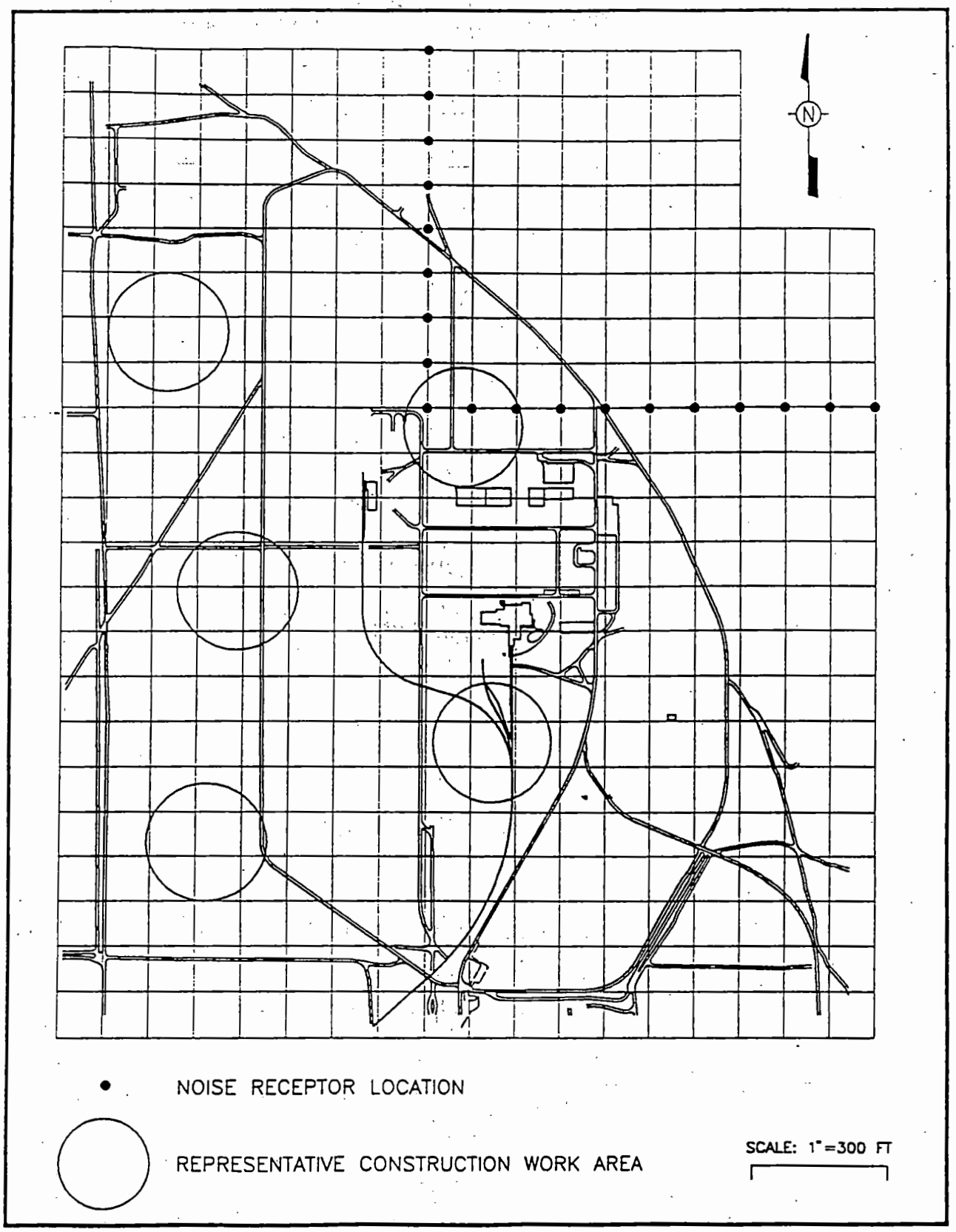

Table 5-18 lists the equivalent noise levels emanating from the 100-H Area (in decibels) predicted by the STAMINA noise model with respect to distance from the Hanford Site. The noise levels shown in Table 5-18 are combined noise impacts resulting from simultaneous construction and excavation activities at all five representative work areas. These noise levels, when compared to the State of Washington noise standards (Table 5-19), indicate that noise violations from remedial activities are not expected.

Table 5-18. Noise Impacts of Full Excavation in the 100-H Area.

Receptor Direction	Distance from 100-H Area m (ft)	Decibels (dBA)
North	At Work Site	59
North	30 (100)	60
North	60 (200)	59
North	90 (300)	58
North	122 (400)	53
North	152 (500)	49
North	183 (600)	47
North	213 (700)	44
North	245 (800)	43
East	At Work Site	59
East	At Work Site	53
East	30 (100)	50
East	60 (200)	48
East	90 (300)	47
East	122 (400)	45
East	152 (500)	44
East	183 (600)	43
East	213 (700)	43
East	245 (800)	42

Table 5-19. Maximum Permissible Noise Levels According to Land Use Classification.

EDNA of Noise Source	EDNA of Receiving Property		
	Class A	Class B	Class C
Class A	55 dBA	57 dBA	60 dBA
Class B	57 dBA	60 dBA	65 dBA
Class C	60 dBA	65 dBA	70 dBA

Class A = residential zones.
Class B = commercial zones.
Class C = industrial zones.
EDNA = Environmental Designation for Noise Abatement.

The construction-related noise could disturb wildlife within hearing or visual distance of remedial activities. This could result in startle behavior by some species and abandonment of nest or den sites. Short-term noise impacts on wildlife are potentially significant, but could be mitigated. These impacts would cease when remedial activities were completed.

Occupational noise exposures within the individual areas may occasionally exceed standards established by the Occupational Safety and Health Administration (OSHA) and the American Conference of Government Industrial Hygienists (ACGIH). Workers exposed to unacceptable noise levels would use appropriate hearing protection during remediation operations.

5.3.6.2.1 ***Potential Mitigation Measures.*** Potential mitigation measures for reducing noise impacts include the following:

- hearing protection for construction and excavation personnel
- monitoring of occupational noise exposure to construction and excavation personnel
- exclusion of all disturbance within an 800-m (0.5-mi) buffer around bald eagle winter roosts from November 15 to March 15.

5.3.6.3 ***Noise Effects, Restricted Future Land-Use Alternatives (R1 and R2).*** Because excavation, construction, and transportation activities associated with these Restricted Future Land-Use Alternatives (R1 and R2) would be less extensive than those associated with the Unrestricted Future Land-Use Alternative, adverse noise impacts also are expected to be lower. Noise impacts under these alternatives are not expected to exceed the levels estimated for the Unrestricted Future Land-Use Alternative, and are not expected to have significant impacts.

5.3.7 Cultural Resources

5.3.7.1 ***Effects on Prehistoric Archaeological Resources, No-Action Alternative.*** The No-Action Alternative could have significant impacts on prehistoric archaeological resources in the Reactors on the River geographic area. The No-Action Alternative would involve scraping surface areas, collection and consolidation of contaminated soil, and site revegetation (see Section 3.3.1). Direct impacts on archaeological resources generally would be limited to sites occurring inside the waste site boundary. One prehistoric site with potential eligibility for listing on the National Register may be disturbed under the No-Action Alternative. Other sites adjacent to direct impact areas also could be disturbed.

5.3.7.1.1 ***Potential Mitigation Measures.*** Potential mitigation measures for archaeological resources include the following.

- Before any ground disturbance activities (e.g., surface soil scraping), consultations would be conducted with the DOE-RL Historic Preservation Officer, the Washington SHPO, and concerned Native American Tribal groups and governments.
- All cultural resources-related work would be conducted in accordance with the *Hanford Cultural Resources Management Plan* (Chatters 1989).

- Whenever possible, avoidance of identified cultural resource areas would serve as the primary form of mitigation.

- Whenever practicable, a full survey of the affected areas would be conducted.

- Surface mapping of all artifact material and data recovery for surface and subsurface materials would be performed only if this action does not pose a potential health risk to field investigators.

- When practicable, an archaeological monitor would be onsite during ground disturbing activities to ensure that construction impacts are limited to the remediation area only. This action would be taken only if it does not pose any potential health risk to the archaeological monitor.

- An interpretive program outlining the history of the Hanford Site would be presented to personnel involved in the remedial activities to foster greater awareness and sensitivity for the cultural resources in the area.

- Remediation and maintenance personnel also would be made aware of the significance of cultural resources in the area, and of the consequences regarding destruction of sites or pedestrian collection of artifact materials.

5.3.7.2 Effects on Prehistoric Archaeological Resources, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would have significant impacts on archaeological resources in the Reactors on the River geographic area. This alternative would involve extensive excavation of contaminated soil, with additional disturbance resulting from constructing temporary access roads, groundwater remediation systems, and other support facilities. One prehistoric campsite with potential National Register eligibility in the 100-K Area could be affected. Three recorded prehistoric occupation areas that are situated within potential trample zones in the 100-N Area also could be affected. These sites represent contributing elements to the Ryegrass Archaeological District that is listed on the National Register. In addition, excavation for the groundwater remediation system could affect at least two recorded prehistoric cultural resources.

5.3.7.2.1 Potential Mitigation Measures. Potential mitigation measures for this alternative would be the same as for the No-Action Alternative.

5.3.7.3 Effects on Prehistoric Archaeological Resources, Restricted Future Land-Use Alternatives (R1 and R2). The Restricted Future Land-Use Alternatives (R1 or R2) would have impacts to prehistoric archaeological resources similar to those described for the Unrestricted Future Land-Use Alternative.

5.3.7.3.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternatives would be the same as for the No-Action Alternative.

5.3.7.4 Effects on Historic Resources, No-Action Alternative. Historic resources of concern potentially affected by the No-Action Alternative include all items and structures within the Reactors on the River geographic area that are over 50 years old, and that reflect the historic settlement and economic development of the area, including materials and structures related to the Manhattan Project and the World War II effort. Items and structures that are representative of the Cold War period also are considered to be of historical significance. In essence, all construction related to the Hanford

Site's defense mission from 1943 to 1990 must be considered for its historical significance. This would include all the reactor areas and their ancillary support structures. Figure 4-20 in Chapter 4.0 shows the location of major historic areas associated with the Hanford Site's former defense mission that could be affected by the No-Action Alternative.

5.3.7.4.1 Potential Mitigation Measures. Current surveillance and maintenance activities attempt to stabilize and maintain the existing structures within the Reactors on the River geographic area, to ensure they are not unduly subjected to weathering and age. Mitigation measures that are currently being implemented include:

- building construction evaluations
- documentation of all historic structures determined to be eligible for the National Register in accordance with the Secretary of the Interior's Guidelines for Architectural and Engineering Documentation
- documentation of all decommissioning work
- monitoring of potentially historic structures for essential repair and maintenance work
- restriction of access to historic sites to authorized personnel.

5.3.7.5 Effects on Historic Resources, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative could have significant impacts on historic resources in the Reactors on the River geographic area. Excavation for the groundwater remediation system would directly affect at least four recorded historic sites. These sites include cement foundations and domestic debris. In addition to the identified sites that would be directly affected by the Unrestricted Future Land-Use Alternative, there are numerous historic archaeological sites within the immediate vicinity of areas that could be disturbed.

5.3.7.5.1 Potential Mitigation Measures. Potential mitigation measures for this alternative would be the same as for the No-Action Alternative.

5.3.7.6 Effects on Historic Resources, Restricted Future Land-Use Alternatives (R1 and R2). The Restricted Future Land-Use Alternatives (R1 or R2) would have impacts to historic resources similar to those described for the Unrestricted Future Land-Use Alternative.

5.3.7.6.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternatives would be the same as for No-Action Alternative.

5.3.7.7 Effects on Areas of Concern to Native Americans, No-Action Alternative. The potential direct and indirect impacts to archaeological resources described in Section 5.3.7.1 would be of concern to Native Americans. In addition, this alternative would continue to require restrictions on access to traditional use areas and sacred sites important to Native Americans in the Reactors on the River geographic area.

5.3.7.8 Effects on Areas of Concern to Native Americans, Unrestricted Future Land-Use Alternative. The potential direct and indirect impacts to archaeological resources described in Section 5.3.7.2 would be of concern to Native Americans. As was discussed in Section 4.6.6, the Reactors on the River geographic area includes a number of areas of importance to Native Americans,

including village locations, fishing and fish processing sites, and areas associated with the origins of the Seven Drums religion. Many of these areas were impacted by construction of Hanford Site facilities during the 1940s and 1950s. Additional impacts to these areas would have cumulative effects on their cultural and historic value to Native Americans. Alteration or destruction of cultural resources important to Native Americans would be a significant impact.

In addition, extensive disturbance under this alternative also could affect culturally important plants and other natural resources important to Native Americans. These impacts, described in Section 5.3.4, could affect future exercise of treaty rights. Any adverse effects on traditional tribal areas could be considered by the tribes to be an abrogation of the 1855 Treaties.

5.3.7.8.1 Potential Mitigation Measures. Potential mitigation measures for addressing Native American concerns include:

- consulting with Native American Tribal governments and organizations to identify project-specific concerns before implementation of project activities
- incorporating recommendations provided by Native American Tribal governments and organizations into project-specific cultural resource mitigation plans for proposed remedial activities
- incorporating recommendations provided by Native American Tribal governments and organizations into revegetation plans for proposed remedial activities
- involving representatives of Native American Tribal governments and organizations in archaeological monitoring during remedial activities.

5.3.7.9 Effects on Areas of Concern to Native Americans, Restricted Future Land-Use Alternatives (R1 and R2). Areas of concern to Native Americans would be similar to those discussed for the Unrestricted Future Land-Use Alternative.

5.3.7.9.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternatives would be the same as for the Unrestricted Future Land-Use Alternative.

5.3.8 Visual and Aesthetic Resources

5.3.8.1 Effects on Visual and Aesthetic Resources, No-Action Alternative. Under the No-Action Alternative, surface decontamination and/or stabilization of waste sites would result in man-made changes to the existing landscape. Potential changes to the surrounding landscape may include surface stabilization through placement of caps of gravel or other earthen material over waste sites, revegetation of sites, and/or weed control. None of these activities is likely to significantly impact the visual and aesthetic resources of the area. Monitoring activities would not result in impacts on visual and aesthetic resources.

5.3.8.2 Effects on Visual and Aesthetic Resources, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve complete excavation and removal of contaminated soils and inactive effluent lines, closure of TSD facilities, decommissioning of surplus facilities, and groundwater remediation. Full excavation of all waste sites in the Reactors on the River geographic area would have short-term adverse impacts on visual and aesthetic resources. The

uncontaminated soils would be stockpiled adjacent to excavation sites, and would contrast visually with the fairly level terrain in the Reactors on the River geographic area. In addition, the work crews and heavy construction equipment would intrude on the surrounding viewscape. Convoys of large, slow-moving haul trucks would detract from the natural setting. Excavation and hauling activities also would generate fugitive dust that could reduce visual clarity and long-range views of landscape features. These impacts could be significant over the short term, although the vantage points available for public viewing are limited to the Columbia River and portions of State Routes 24 and 240. Site reclamation, including reshaping and revegetation, is expected to reduce long-term adverse impacts from full excavation.

Decommissioning of surplus facilities would have a long-term beneficial impact on visual and aesthetic resources in the Reactors on the River geographic area. The removal of structures such as tall stacks and towers would reduce the impact of man-made features on the landscape.

5.3.8.2.1 Potential Mitigation Measures. Potential mitigation measures for visual and aesthetic resources include the following:

- minimizing overall disturbance to extent possible
- controlling fugitive dust (see Section 5.3.5)
- completing remediation in a timely manner
- conducting restoration activities immediately in remediated areas and contemporaneous with ongoing remedial activities in other areas
- restoring remediated areas by reshaping excavations to approximate original conditions and revegetating with native species.

5.3.8.3 Effects on Visual and Aesthetic Resources, Restricted Future Land-Use Alternative (R1). The Restricted Future Land-Use Alternative (R1) would involve excavation and removal of past-practice waste sites and effluent lines, closure of TSD facilities, decommissioning of surplus facilities, and groundwater remediation, combined with institutional controls. Excavation under this alternative would not be as extensive and would enable quicker site reclamation. Short-term adverse impacts would be similar to those discussed for the Unrestricted Future Land-Use Alternative.

5.3.8.3.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative (R1) are the same as for the Unrestricted Future Land-Use Alternative.

5.3.8.4 Effects on Visual and Aesthetic Resources, Restricted Future Land-Use Alternative (R2). Remediation to restricted use (R2) would involve construction of caps over past-practice waste sites, effluent lines, and TSD facilities, and groundwater remediation, combined with institutional controls. The caps could have significant impacts on visual and aesthetic resources, depending on the design used. If the reference caps were used (Appendix E), the size and shape of the caps would be noticeable, with vegetation on the top of the cap contrasting with riprap on the sides. Viewer attention would be focused on the caps, as their rigid geometric design and large size contrast visually with the natural landscape features and flat terrain. In addition, the reference cap design includes placement of large obelisk surface markers with posted warning signs near the caps, which would appear out of place in the landscape. These caps would be noticeable to users of the Columbia River and be visible from certain points along State Routes 24 and 240.

Construction activity associated with cap construction also would result in short-term impacts on the visual and aesthetic resources of the area. Construction equipment, haul trucks, and work crews would intrude on the surrounding viewscape. These activities also would result in the generation of fugitive dust, which could reduce visual clarity and obscure viewsheds.

5.3.8.4.1 Potential Mitigation Measures. Potential mitigation measures would include those described for the Unrestricted Future Land-Use Alternative, as well as the following: using surface markers designed to be compatible with the surrounding landscape and using natural materials in cap construction to minimize contrast with the surrounding landscape.

5.3.9 Human Health Risks

5.3.9.1 Human Health Risks, No-Action Alternative. The No-Action Alternative would involve surface decontamination and/or stabilization of inactive waste sites, environmental monitoring, and security functions (see Section 3.3.1). Potential human exposures to radiological and chemical contaminants would continue to be prevented by engineering and institutional controls, including Hanford Site access restrictions; restrictions on contact with, or proximity to, radioactive and hazardous materials; and restrictions on the use of contaminated groundwater. As long as these controls remain in place, risks to workers and the general public from the Reactors on the River geographic area are expected to remain within acceptable limits. Therefore, the No-Action Alternative, with continued use of engineering and institutional controls, is not expected to have significant impacts on human health.

Consideration of the No-Action Alternative for the Hanford Site requires analysis of potential human health risks in the event that engineering and institutional controls are removed. To assess these health effects, a baseline risk assessment was performed for the Reactors on the River, the Central Plateau, and the All Other Areas geographic areas. Human health risks were calculated for exposures to radioactive materials, carcinogenic chemicals, and noncarcinogenic chemicals. The risk assessment used four exposure scenarios: agricultural, residential, industrial, and recreational. These exposure scenarios, and other assumptions used in the risk assessment, are discussed in Appendix B. The risk assessment results in the Reactors on the River geographic area under the No-Action Alternative are discussed in Section 5.7.3.

The risk assessment performed for the No-Action Alternative also included evaluation of an accident scenario. This scenario involves a range fire that burns a 2.6-km^2 (1-mi^2) area of the Hanford Site, releasing into the atmosphere any radioactive contaminants taken up by plants growing within that area. This type of accident was chosen for the No-Action Alternative because it is a natural occurrence not caused by any specific remedial activity (Appendix B5).

The airborne pathway was the only exposure pathway considered for estimating the impacts of this accident. Radiation doses from the airborne releases were estimated for onsite remediation workers, for a member of the public located at the nearest public access location (NPAL), and for offsite populations. The NPAL for the accident analyses are along the Columbia River, State Route 240, and the roads leading to the Wye Barricade on the Hanford Site.

Table 5-20 lists the maximum estimated radiation doses that would result from the range fire and other accident scenarios for the Reactors on the River future land-use alternatives. The maximum estimated radiation dose to an onsite worker as a result of the range fire is less than 0.1% of the 5,000-mrem/yr annual dose limit for workers. The maximum estimated dose to a member of the

public is less than the standard of 10 mrem for public exposure resulting from routine airborne releases established in DOE Order 5400.5 (DOE 1993a). There are no DOE standards governing exposures caused by accidents.

Table 5-20. Consequences of Accidents During Remediation, Reactors on the River Geographic Area.

Accident Scenario	MEI Doses (mrem)			Maximum Population Dose (person-rem), Population, and Direction
	MEI at 100 m (327 ft)	MEI at the NPAL and Distance	Site Boundary Dose and Distance	
Accidental Dispersion During Groundwater Treatment	620 2.5 E-04[a]	510 at 110 m (360 ft) 2.6 E-04[a]	0.80 at 8,510 m (27,900 ft) 4.0 E-07[a]	0.51 to a population of 97,689 to the west of all the 100 Areas 2.6 E-04[b]
Accidental Dispersion During Excavation	4.6 1.8 E-06[a]	3.9 at 110 m (360 ft) 2.0 E-06[a]	0.10 E-01 at 8,510 m (27,900 ft) 5.0 E-08[a]	5.5 E-02 to a population of 97,689 to the west of all the 100 Areas 2.8 E-05[b]
Range Fire	3.0 1.2 E-06[a]	2.6 at 110 m (360 ft) 1.3 E-06[a]	6.0 E-03 at 8,510 m (27,900 ft) 3.0 E-09[a]	3.4 E-03 to a population of 97,689 to the west of all the 100 Areas 1.7 E-06[b]

[a]Increased probability of this individual contracting a fatal cancer.
[b]Increase in LCFs in this population.
LCF = latent cancer fatality.
MEI = maximally exposed individual.
NPAL = nearest public access location.

5.3.9.2 Human Health Risks, Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve complete excavation and removal of contaminated soils and inactive effluent lines, closure of TSD facilities, decommissioning of surplus facilities, and groundwater remediation. Remedial activities are not expected to result in significant adverse health effects to workers or the general public. Use of good health physics and industrial hygiene practices would ensure that exposures to radioactive and hazardous chemicals remain below applicable regulatory and administrative limits. Site-specific evaluations of potential risk to workers and the public would be performed as part of the CERCLA process. Over the long term, the Unrestricted Future Land-Use Alternative would result in beneficial impacts by reducing cancer risks to levels at or below the target risk range of 10^{-4} to 10^{-6}.

The potential for adverse health effects resulting from accidents during remediation were evaluated using the risk assessment methodology (Appendix B5). In addition to the range fire, which could occur whether the site was remediated or not, two other accident scenarios were considered for the Unrestricted Future Land-Use Alternative. The first is an explosion that disperses a quantity of hazardous and radioactive material into the environment during the excavation of a waste site. The second is the destruction by fire of a filtration unit used to treat contaminated water, and the resultant release of contaminants to the atmosphere.

The **excavation accident scenario** involves the inadvertent ignition of some reactive material in a container encountered during the excavation of a waste site (Appendix B5). The resulting explosion disperses contaminants, which are transported through the air and result in the exposure of workers and the nearby population. The radiation dose to remediation workers would be more than three orders of magnitude below the regulatory limit for radiation workers of 5,000 mrem/yr (see Table 5-20). The estimated radiation doses to a member of the public at the NPAL and to offsite populations are small compared to the allowable annual dose of 10 mrem from airborne sources to a member of the general public (see Table 5-20).

The **groundwater treatment accident scenario** involves a fire that causes the release of radioactive and hazardous contaminants that have accumulated in the filtration unit during the reverse osmosis treatment of groundwater (Appendix B5). Contaminants accumulated on the filter and available for release are assumed to be the result of processing 100,000 L (26,400 gal) of groundwater containing the maximum concentrations of contaminants found in groundwater plumes underlying the area. As with the excavation accident scenario, the impacts at the NPAL and at the Hanford Site boundary would vary according to where the accident occurs. The maximum estimated radiation dose to workers would be less than 20% of the regulatory limit of 5,000 mrem/yr for radiation workers (see Table 5-20). The 0.8-mrem Hanford Site boundary dose is small compared to the allowable annual dose of 10 mrem, and it would not be expected to cause any adverse health effects.

5.3.9.2.1 Potential Mitigation Measures. Potential mitigation measures for the Unrestricted Future Land-Use Alternative are those that are designed to prevent accidents from occurring during remedial activities or to reduce the severity of their impacts once they occur. Appropriate engineering and administrative measures would be applied during routine remedial activities so that the protection of workers, the general public, and the environment is ensured. For remediation and nearby workers, this includes wearing appropriate protective clothing; using respiratory protection, when necessary; and limiting exposures to contaminants in accordance with ALARA guidelines, and good health physics and industrial hygiene practices. For the general public, it involves the use of practices and procedures designed to reduce the transport of radioactive and hazardous materials offsite. These include use of dust suppressants during excavation; use of containment structures, when necessary; and other similar measures to control the spread of these materials.

5.3.9.3 Human Health Risks, Restricted Future Land-Use Alternative (R1). The Restricted Future Land-Use Alternative (R1) would involve excavation and removal of past-practice waste sites and effluent lines, closure of TSD facilities, decommissioning of surplus facilities, and groundwater remediation, combined with institutional controls. As with the Unrestricted Future Land-Use Alternative, use of good health physics and industrial hygiene practices would ensure that exposures to radioactive and hazardous chemicals remain below applicable regulatory and administrative limits. Site-specific evaluations of potential risk to workers and the public would be performed as part of the CERCLA process. Remedial activities are not expected to result in significant adverse health effects to workers or the general public.

Over the long term, the Restricted Future Land-Use Alternative (R1) would result in beneficial impacts by removing some contamination and preventing exposure to remaining contamination by restricting activities. These restrictions would include prohibitions on soil disturbance and restrictions on groundwater use. The combination of excavation and land-use restrictions would reduce cancer risks to levels at or below the target risk range of 10^{-4} to 10^{-6}. Cancer risks could be higher if land-use restrictions are violated.

The accident scenarios described for the Unrestricted Future Land-Use Alternative would be applicable to this alternative. Although the consequences would be the same as for the Unrestricted Future Land-Use Alternative, the excavation accident would be less likely to occur under the Restricted Future Land-Use Alternative (R1), because less material would be excavated and remediation would require less time. Therefore, the overall impacts of the excavation accident, when the probability of occurrence is factored in, would be expected to be lower than for the Unrestricted Future Land-Use Alternative.

The groundwater treatment accident scenario could have the same impacts under the Restricted Future Land-Use Alternative (R1) as for the Unrestricted Future Land-Use Alternative. Therefore, adverse impacts of accidents under the Restricted Future Land-Use Alternative (R1) on human health are considered potentially significant.

5.3.9.3.1 Potential Mitigation Measures. Potential mitigation measures for minimizing human health effects under the Restricted Future Land-Use Alternative (R1) would be the same as for the Unrestricted Future Land-Use Alternative.

5.3.9.4 Human Health Risks, Restricted Future Land-Use Alternative (R2). Remediation to restricted use (R2) would involve construction of caps over past-practice waste sites, effluent lines, and TSD facilities, and groundwater remediation, combined with institutional controls. The Restricted Future Land-Use Alternative (R2) would result in long-term beneficial impacts by preventing human exposures to contamination. The institutional controls would include restrictions on excavation and use of groundwater. The combination of caps and use restrictions would reduce cancer risks to levels at or below the target risk range of 10^{-4} to 10^{-6}. If activity restrictions are violated, cancer risks could be higher, approaching those estimated for the No-Action Alternative.

Because no significant excavation would occur under this alternative, the excavation accident scenario described for the Unrestricted Land-Use Alternative would not apply here. The groundwater treatment accident scenario would have the same impacts under the Restricted Future Land-Use Alternative (R2) as for the Unrestricted Future Land-Use Alternative. Therefore, adverse impacts of accidents under the Restricted Future Land-Use Alternative (R2) on human health are considered potentially significant.

5.3.9.4.1 Potential Mitigation Measures. Potential mitigation measures for minimizing human health effects for the Restricted Future Land-Use Alternative (R2) would be the same as for the Unrestricted Future Land-Use Alternative.

5.3.10 Occupational Impacts

Potential occupational impacts associated with implementing the future land-use alternatives in the Reactors on the River geographic area were estimated by comparing the field labor hours identified in Appendix H for each alternative with the BLS and DOE incident rates (NSC 1993 and EG&G 1993a). The estimates assume that all remediation waste is transported by truck for onsite disposal, as truck transport requires more labor, and thus results in a more conservative analysis. Other assumptions used in this analysis are presented in Appendix I.

5.3.10.1 Occupational Impacts, No-Action Alternative. Labor hour estimates are not available for the No-Action Alternative; therefore, no occupational impacts were estimated, and mitigation measures were not evaluated.

5.3.10.2 Occupational Impacts, Unrestricted Future Land-Use and Restricted Future Land-Use Alternatives. Table 5-21 presents the potential occupational impacts for the Unrestricted Use and Restricted Future Land-Use Alternatives (R1 and R2) for the Reactors on the River geographic area based on BLS incident rates. Total cases include all work-related deaths and illnesses, and those work-related injuries that result in loss of consciousness, restriction of work or motion, transfer to another job, or a requirement for medical attention. Total cases are the sum of lost workday cases and nonfatal cases without lost workdays. Lost workdays are those days that, because of occupational injury or illness, an employee was away from work or limited to restricted work activity. Lost workdays are estimated from lost workday cases.

Table 5-21. Summary of Occupational Injury Impacts per BLS Statistics.

Future Land-Use Alternative (labor hours)	Estimated Total Cases	Estimated Lost Workday Cases	Estimated Nonfatal Cases Without Lost Workdays	Estimated Lost Workdays
Unrestricted (13,500,000)	924	500	423	13,279
Restricted (R1) (9,700,000)	668	358	307	9,486
Restricted (R2) (24,400,000)	1,730	980	749	26,260

Table 5-22 presents the potential occupational impacts based on DOE incident rates. The occupational impacts estimated using DOE incident rates are substantially lower than the impacts estimated using BLS incident rates. DOE incident rates historically have compared favorably to private industry rates. The analysis using DOE incident rates is expected to more accurately reflect potential occupational impacts.

Potential occupational impacts are greatest for remediation to restricted use (R2), achieved by construction of caps over past-practice waste sites, effluent lines, and TSD facilities. This is expected, as cap construction would result in a substantial increase in labor hours caused by transport of cap materials.

5.3.10.2.1 Potential Mitigation Measures. Potential mitigation measures include continued emphasis on safety awareness and worker training.

5.3.11 Volumes, Disturbed Areas, and Costs

The assumptions and methodology used to estimate costs for each future land-use alternative are discussed in Appendix H. Impacts of each future land-use alternative are summarized in Table 5-23.

5.3.11.1 Effects on Volumes, Disturbed Areas, and Costs, No-Action Alternative. The cost of the No-Action Alternative is more than $2.4 billion for 100 years of institutional control (Table 5-24). The cost does not include monitoring of environmental media and external radiation, and is not specific to the Reactors on the River geographic area, but rather applies to the entire Hanford Site.

5.3.11.1.1 Potential Mitigation Measures. Potential mitigation measures include efforts to reduce the costs of institutional controls.

*Table 5-22. Summary of Occupational Injury Impacts per DOE Statistics.**

Future Land-Use Alternatives (labor hours)	Estimated Total Cases	Estimated Lost Workday Cases	Estimated Lost Workdays
Unrestricted (13,5000,000)	233	101	1,560
Restricted (R1) (9,700,000)	167	73	1,122
Restricted (R2) (24,400,000)	421	183	2,824

*Total labor hours does not include decommissioning or groundwater activities.

Table 5-23. Comparison of Waste Volumes and Costs Associated with the Reactors on the River Geographic Area Future Land-Use Alternatives.

Resources Impacted	Alternatives			
	No Action	Unrestricted	Restricted (R1)	Restricted (R2)
Capping Materials LCM[a] ($x\ 10^3$)	0	0	0	18,820
Excavated Volumes BCM[a] ($x\ 10^3$)				
Uncontaminated Soil	0	7,010	5,666	0
Contaminated Soil	0	6,663	4,585	0
Groundwater Treatment Costs in 1994 Dollars (millions)	0	205	205	205
Areas of Disturbance (ha)	87	420	390	373
Project Costs in 1994 Dollars (millions)	2,424[b]	$3,848 (truck haul) $2,824 (rail haul)	$2,090 (truck haul) $2,824 (rail haul)	$4,601 (truck haul) $2,011 (rail haul)

[a]Loose Cubic Meter (LCM) = 1.31 Loose Cubic Yard (LCY)
Bank Cubic Meter (BCM) = 1.31 Bank Cubic Yard (BCY)
ha = 2.47 ac.

[b]Costs for 100 years of institutional control for the Hanford Site. The costs are not broken down by geographic area.

Table 5-24. Cost Summary for the No-Action Alternative.

Activity	Cost ($ millions) (year)	
	Base Year[a]	First 100 Years
Maintenance[b1]		
Surveillance and Maintenance of Surplus Facilities	9.2	923
Waste Site Stabilization[c1]		
Decontamination/Stabilization	2.6	261
Surveillance/Maintenance	3.7	374
Vegetation Management	0.86	86
Safeguards and Security[d2]	7.8	780
Total	24.16	2,424

[a]Subtotal activity cost figures include costs for labor, material, and other services.
[b]*100 D&D Subproject Baseline Summary* (WHC and USACE 1994a).
[c]*RARA/UST Subproject Baseline Summary* (WHC and USACE 1994b).
[d]*Safeguards and Security Program: 1994 Fiscal Year Work Plan* (WHC 1994).
[1]Fiscal Year 1994 Target Costs.
[2]Fiscal Year 1993 Actual Costs.

5.3.11.2 Effects on Volumes, Disturbed Areas, and Costs, Unrestricted Future Land-Use Alternative. Total waste volumes to be excavated under the Unrestricted Future Land-Use Alternative include 5.6 million BCM (7.3 million BCY) of contaminated soil and 3.8 million BCM (5.0 million BCY) of uncontaminated soil. Removal of effluent lines would require excavation of 1.1 million BCM (1.4 million BCY) of contaminated soil and 3.2 million BCM (4.2 million BCM) of uncontaminated soil. The reactor areas that would generate the largest amounts of waste in the Reactors on the River geographic area are 100-DR and 100-K (Table 5-25). The total area disturbed by remedial actions is 420 ha (1,038 ac). Volumes and costs for removing concrete stacks are included in these estimates as waste sites. The cost for total excavation of waste sites, pipelines, and concrete stacks would be about $2.6 billion.

The conceptual groundwater remediation system used for analysis in this EIS is described in Appendix D. The cost for treating groundwater is $204 million.

The cost for decommissioning surplus facilities would be about 1% of the total costs or about $48 million. Decommissioning contaminated and noncontaminated buildings would require disposal of approximately 8,000 LCM (10,000 LCY) of contaminated waste, transport of 13,000 LCM (17,000 LCY) to solid waste landfill, recycling of 30,000 LCM (39,000 LCY) of concrete and steel, and excavation of more than 60,000 LCM (79,000 LCY) of borrow materials.

Two transportation scenarios were analyzed for transporting waste to the ERDF: trucks and rail. The loose volumes to be transported are assumed to be 18% greater than bank volumes. Total labor hours for the truck alternative would be 37 times the labor requirement for the rail transport (Table 5-26). Costs for transportation of waste to the ERDF range from $48 million for rail haul to $1,050 million for truck haul.

The total costs of remedial actions to restore the Reactors on the River geographic area to allow unrestricted uses are approximately $3.8 billion hauled by truck and approximately $2.8 billion hauled by rail (see Table 5-23).

Table 5-25. Waste Volume Breakdown for Waste Sites and Pipelines in the Reactors on the River Geographic Area.

Reactor Area	Noncontaminated Soil (% of Total)	Contaminated Soil (% of Total)	Piping (% of Total)
100-B/C	16	18	11
100-DR	18	23	30
100-F	15	15	9
100-H	9	13	9
100-K	27	26	33
100-N	15	6	8
Total	100	100	100

Table 5-26. Summary of Potential Costs for the Unrestricted Future Land-Use Alternative, Reactors on the River Geographic Area.

Resource	Project Cost in 1994 Dollars (millions)					
	Waste Sites	Pipelines	Groundwater	D&D	Transportation	
					Truck[a]	Rail[b]
Mobilization and Preparatory Work	17	0.4	--	6.7	--	--
Monitoring, Sampling, and Analysis	1,400	360	--	3.0	--	--
Surface Water Collection and Control	0.9	0	--	0	--	--
Decommissioning	0	0	--	28	--	--
Solids Collection and Containment	330	85	--	2.5	--	--
Disposal	0	0	--	3.5	--	--
Site Restoration	240	39	--	3.3	--	--
Demobilization	5.5	0.3	--	0.1	--	--
Total Costs	1,993.4	484.7	205	47.1	1,050	48
Fuel Use (millions) L (gal)	75 (20)	24 (6.3)		3.0 (0.8)	52 (14)	9.1 (2.4)
Labor Hours (millions)	7.9	2.3	0.4	0.4	7.1	0.19

[a]Does not include approximately 100,000 labor hours, 7.6 million L (2 million gal) of fuel, and $23 million in costs for haul road construction.

[b]Does not include approximately $3 million and 1,000 labor hours for rail improvements.

D&D = decommissioning.

5.3.11.2.1 Potential Mitigation Measures. All projects to be undertaken to clean up the Hanford Site would seek to minimize waste production. Existing waste minimization plans for 100 Area projects require a readiness review to address waste minimization before receiving approval to start work. Recycling is a critical component of any waste minimization effort and would be implemented, to the extent possible, for decommissioning waste; however, significant quantities of materials are not recyclable because of a lack of cost-effective decontamination technology. Sensors to monitor contamination as excavation proceeds would prevent excavation of noncontaminated soils. Excavation of waste in combination with technologies such as soil washing would result in reduced disposal requirements.

Continuing emphasis would be placed on the development and implementation of new remedial technologies to reduce the volumes, levels of disturbance, and costs associated with remediating waste sites in the Reactors on the River geographic area. These new technologies may include *in-situ* treatments, which could significantly reduce the volumes of contaminated soils requiring excavation and disposal.

5.3.11.3 Effects on Volumes, Disturbed Areas, and Costs, Restricted Future Land-Use Alternative (R1): The Restricted Future Land-Use Alternative (R1) would involve excavation and removal of past-practice waste sites and effluent lines, closure of TSD facilities, decommissioning of surplus facilities, and groundwater remediation, combined with institutional controls. Waste volumes to be excavated, and the resulting disturbed areas for the Restricted Future Land-Use Alternative (R1), include 2.4 million BCM (3.1 million BCY) of uncontaminated soil and 3.5 million BCM (4.6 million BCY) of contaminated soil (see Table 5-23). Excavation of pipelines would require removal of 1.1 million BCM (1.4 million BCY) of contaminated soil and 3.2 million BCM (4.2 million BCY) of uncontaminated soil. The total area disturbed by remedial actions is 390 ha (964 ac). The costs for excavating waste sites, concrete stacks, and pipelines to a depth of 5 m (15 ft) would be about $1.8 billion, or about 30% less than complete excavation (Table 5-27). The volumes and costs for decommissioning surplus facilities for this alternative were described in detail for the Unrestricted Future Land-Use Alternative.

The cost for groundwater treatment would be about $205 million. Total costs of remedial actions are $2.1 billion hauled to the ERDF by truck and $2.8 billion hauled to the ERDF by rail (Table 5-23).

5.3.11.3.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative (R1) would be the same as for the Unrestricted Future Land-Use Alternative.

5.3.11.4 Effects on Volumes, Disturbed Areas, and Costs, Restricted Future Land-Use Alternative (R2). The Restricted Future Land-Use Alternative (R2) would involve construction of caps over past-practice waste sites, effluent lines, and TSD facilities, and groundwater remediation, combined with institutional controls. The reference cap design used to estimate volumes and costs is described in Appendix E. It is assumed that all cap material is available onsite. The material volumes to be transported by truck or rail to the 100 Areas for cap construction are shown in Table 5-28. Surplus facilities decommissioning volumes and costs, and groundwater remediation cost would be the same as in the Restricted Future Land-Use Alternative (R1). The total area disturbed by remedial actions would be 373 ha (921 ac).

Table 5-27. Summary of Potential Costs for the Restricted Future Land-Use Alternative (R1), Reactors on the River Geographic Area.

Resource	Project Cost in 1994 Dollars (millions)					
	Waste Sites	Pipelines	Groundwater	D&D	Transportation	
					Truck[a]	Rail[b]
Mobilization and Preparatory Work	17	0.4	--	6.7	--	--
Monitoring, Sampling, and Analysis	920	360	--	3.0	--	--
Surface Water Collection and Control	0.8	0	--	0	--	--
Decommissioning	0	0	--	28	--	--
Solids Collection and Containment	210	85	--	2.5	--	--
Disposal	0	0	--	3.5	--	--
Site Restoration	160	39	--	3.3	--	--
Demobilization	5.5	0.3	--	0.1	--	--
Total Costs	1,313.3	484.7	204	47.1	740	34
Fuel Use (millions) L (gal)	45.1 (11.9)	23.8 (6.3)	--	3.0 (0.8)	36 (9.5)	6.4 (1.7)
Labor Hours (millions)	5.2	2.3	0.4	.4	5.0	0.13

[a]Does not include approximately 100,000 labor hours, 7.6 million L (2 million gal) of fuel, and $23 million in costs for haul road construction.

[b]Does not include approximately $3 million and 1,000 labor hours for rail improvements.

D&D = decommissioning.

The total costs of remedial actions (Table 5-29) for the Restricted Future Land-Use Alternative (R2) are $4.6 billion if cap material is hauled to the 100 Areas by truck and $2.0 billion if cap material is hauled by rail.

5.3.11.4.1 Potential Mitigation Measures. More site characterization has the potential to reduce the number and size of waste sites to be remediated. The use of a RCRA Subtitle C cap or a modified RCRA cap, instead of the reference cap described in Appendix E, would reduce the volumes of cap materials required, associated areas of disturbance, and the costs of remedial actions. Minimum technology requirements for a RCRA Subtitle C cap are specified in "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," (40 CFR 264.310). The modified RCRA cap would better suit the conditions at the Hanford Site. The unit cost for a RCRA Subtitle C cap or modified RCRA cap is $51/m^2$ ($5/ft^2$) and $72/m^2$ ($7/ft^2$), respectively. The unit cost for a reference cap is $134/m^2$ ($12/ft^2$) (DOE-RL 1994a).

Table 5-28. Volumes of Capping Materials Required for the Restricted Future Land-Use Alternative (R2), Reactors on the River Geographic Area.

Material	Volume (x 10^3) LCM	(LCY)
Drainage Gravel	845	(1,107)
Gravel	845	(1,107)
Basalt	8,446	(11,064)
Asphalt Base	276	(365)
Contour Fill	1,689	(2,213)
Lower Silt	2,813	(3,685)
Upper Silt	2,813	(3,685)
Sand	422	(553)
Asphalt	669	(876)
Total	18,820	(24,655)

LCM = Loose Cubic Meter.
LCY = Loose Cubic Yard.

Table 5-29. Summary of Potential Costs for the Restricted Future Land-Use Alternative (R2), Reactors on the River Geographic Area.

Resource	Project Cost in 1994 Dollars (millions)					
	Waste Sites	Pipelines	Groundwater	D&D	Transportation	
					Truck[a]	Rail[b]
Mobilization and Preparatory Work	20	2	--	6.7	--	--
Monitoring, Sampling, and Analysis	120	9.2	--	3.0	--	--
Surface Water Collection and Control	1.9	0.1	--	0	--	--
Decommissioning	0	0	--	28	--	--
Solids Collection and Containment	650	53	--	2.5	--	--
Disposal	0	0	--	3.5	--	--
Site Restoration	460	43	--	3.3	--	--
Demobilization	3.9	0.4	--	0.1	--	--
Total Costs	1,255.8	107.7	205	47.1	2,700	140
Fuel Use (millions) L (gal)	53.0 (14.0)	4.2 (1.1)	--	3.0 (0.8)	130 (34)	27 (7.0)
Labor Hours (millions)	4.8	0.4	0.4	0.4	18.4	0.55

[a]Does not include approximately 100,000 labor hours, 7.6 million L (2 million gal) of fuel, and $23 million in costs for haul road construction.

[b]Does not include approximately $3 million and 1,000 labor hours for rail improvements.

D&D = decommissioning.

Continuing emphasis would be placed on the development and implementation of new remedial technologies to reduce the volumes, levels of disturbance, and costs associated with remediating waste sites in the All Other Areas geographic area. These new technologies may include *in-situ* treatments, which could significantly reduce the volumes of contaminated soils requiring excavation and disposal.

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5.4 Central Plateau Geographic Area

The scope of the proposed actions in the Central Plateau geographic area includes the past-practice waste units and TSD facilities listed in Appendix A, and groundwater contaminant plumes that contain radiological and chemical contaminants. Potential impacts of the No-Action and Exclusive Future Land-Use Alternatives are described in the following sections.

5.4.1 Geology

This section describes the impacts of each alternative on the geologic resources in the Central Plateau geographic area. While neither of the alternatives result in direct impacts, the Exclusive Future Land-Use Alternative will deplete quarry and borrow sites. Section 5.10 discusses the irretrievable and irreversible commitment of resources, and additional discussion of quarry and borrow sites is provided in Appendix E.

5.4.1.1 Effects on Geologic Resources, No-Action Alternative. Under the No-Action Alternative, stabilization of waste sites would result in a limited depletion of quarry and borrow sites. Continued restrictions on public access to the Central Plateau geographic area would preclude exploration or exploitation of mineral deposits. There currently are no known mineral leases in this area, and a formal evaluation of the mineral potential of this area has never been prepared. Continuing to exclude geologic resources in the Central Plateau geographic area from development would not be expected to result in significant short- or long-term adverse impacts. Continued environmental monitoring and maintenance activities would have no significant impacts on the geologic resources of the Central Plateau geographic area.

5.4.1.2 Effects on Geologic Resources, Exclusive Future Land-Use Alternative. The Exclusive Future Land-Use Alternative would involve the capping of waste sites. Capping would require approximately 17,500,000 LCM (22,900,000 LCY) of materials and disturbance of approximately 475 ha (1,174 ac), according to Bechtel Hanford, Inc. (BHI) baseline planning documents (BHI 1995), based on installation of modified RCRA caps. This alternative would have an impact on the geologic resources of the quarry and borrow sites (Appendix E), and Section 5.10 discusses this as an irreversible and irretrievable commitment of resources. As in the No-Action Alternative, existing restrictions on public access to the Central Plateau geographic area would continue with no related short- or long-term adverse geologic impacts from these restrictions. In addition, the indefinite restriction on the withdrawal and use of groundwater, and the restriction on soil disturbing activities would have no short- or long-term adverse geologic impacts.

A small number of features relevant to the study of the region's geologic evolution potentially could be destroyed during remediation, but this would result in minimal impacts, since such features occur elsewhere.

5.4.2 Soils

5.4.2.1 Effects on Soils, No-Action Alternative. Approximately 272 ha (680 ac) (combined acreages of soil types) would be disturbed by surface decontamination or stabilization of inactive waste sites under the No-Action Alternative. Potential short-term impacts on soils would be expected, even with implementation of appropriate mitigation measures, which are described under the Exclusive Future

Land-Use Alternative. Continued environmental monitoring and maintenance activities would not have a significant impact on the soils in the Central Plateau geographic area.

5.4.2.2 Effects on Soils, Exclusive Future Land-Use Alternative. Approximately 475 ha (1,174 ac) would be disturbed by remedial activities under this alternative, according to current BHI baseline planning documents (BHI 1995). Potential short-term impacts on soils would include soil compaction and increased potential for erosion. Soil compaction, particularly in Ephrata sandy loam soils, would cause increased runoff during storm events, resulting in less infiltration of water into the soil, and compaction would reduce the amount of loose soil that promotes plant growth. Wind erosion resulting from disturbance of existing vegetation during remediation would be another potentially significant short-term impact, particularly in areas with Quincy sand and Burbank loamy sand. Mitigation measures would reduce but not eliminate these potential impacts.

5.4.2.2.1 Potential Mitigation Measures. Potential mitigation measures for the Exclusive Future Land-Use Alternative would include the following:

- restricting heavy equipment to immediate waste site areas
- using the same or existing transportation routes to minimize damage to undisturbed soil and vegetation
- using silt fences and dust control measures to reduce soil erosion
- reseeding disturbed areas with native vegetation to reduce long-term soil loss from wind and water erosion.

5.4.3 Water Resources

This section describes the effects of each alternative on the water resources of the Central Plateau geographic area, which include groundwater in the Central Plateau and the Hanford Reach. Pumping and treating the groundwater under the Exclusive Future Land-Use Alternative in the Central Plateau geographic area would reduce existing contamination and would reduce the rate of contaminant migration in groundwater.

5.4.3.1 Effects on Groundwater, No-Action Alternative. The No-Action Alternative would involve no treatment of existing groundwater contamination, and would not have significant short-term impacts on groundwater. Over the long term, groundwater contamination would be reduced as contaminants would continue to attenuate and migrate to the Columbia River. Contaminant plumes identified in the Central Plateau geographic area include:

- chromium
- nitrate
- cyanide
- fluoride
- strontium-90
- cesium-137
- tritium
- cobalt-60
- iodine-129

- plutonium
- technetium-99
- uranium
- carbon tetrachloride
- chloroform
- trichloroethylene.

Current restrictions on the use of groundwater in the Central Plateau geographic area would continue until natural attenuation allows use.

Other potential groundwater contaminants are present in the soils above the water table, the area referred to as the vadose zone (DOE-RL 1994b). The effect of any migration from the vadose zone is not expected to be significant under existing conditions. Although natural groundwater recharge rates have not been definitively determined, they are considered to be very low and may be zero (DOE-RL 1993b). This assumption is based on the presence of native plant communities adapted to dry conditions where plants tend to use all available water. Studies conducted elsewhere have found that precipitation does not penetrate below the root zone if annual precipitation is less than 30 cm (12 in.) (Durbin 1978).

Some contaminant migration could occur where vegetation cover is lacking and precipitation is allowed to infiltrate beyond the root zone. Contaminants that are not readily adsorbed to the soil (e.g., nitrate, tritium, and chromium) would be flushed from the vadose zone sooner than the adsorbed contaminants (e.g., strontium-90). Although some more mobile contaminants contained in the soil may continue to migrate downward to the water table, they would be diluted to low concentrations as they mix with the groundwater. In some locations, these contaminants could extend natural attenuation times for groundwater.

5.4.3.1.1 Potential Mitigation Measures. Existing restrictions on groundwater use in the Central Plateau geographic area and other areas would need to be maintained. No other mitigation measures are recommended.

5.4.3.2 Effects on Groundwater, Exclusive Future Land-Use Alternative. Under the Exclusive Future Land-Use Alternative, the reference caps would eliminate any natural infiltration at waste sites. The pump-and-treat system would temporarily draw down the water table and change the direction of groundwater flow in the immediate vicinity of the pump-and-treat systems.

Under this alternative, the use of caps would prevent long-term migration of contaminated vadose zone water beneath waste sites from entering the groundwater, thus greatly reducing the possibility of long-term contamination of groundwater from these sites. The pump-and-treat activities would minimize the movement of groundwater contaminants to downgradient areas.

5.4.3.3 Effects on Surface Water, No-Action Alternative. Under the No-Action Alternative, some contaminant plumes currently located within the Central Plateau geographic area eventually would migrate to the Columbia River. Based on current sampling, it has been demonstrated that tritium and iodine-129 (originating in the Central Plateau) have already reached the Columbia River. Under the No-Action Alternative, it is likely that other contaminants such as technetium-99 and uranium also would reach the river. At the present time, it is not known if the contaminants reaching the river will exist in levels above the DWS. Because this is unknown, the impacts are to be considered significant.

5.4.3.4 Effects on Surface Water, Exclusive Future Land-Use Alternative. No significant physical effects on surface water are expected. Treated water from groundwater remediation would not be discharged to surface waters.

5.4.4 Ecology

This section describes the effects of each alternative on ecological resources in the Central Plateau geographic area. No analysis was made of the effects on the man-made wastewater ponds and ditches as wetlands, because these facilities are included for eventual decontamination and stabilization (WHC and USACE 1994b). Appendix J addresses Floodplains and Wetlands Assessment in accordance with 10 CFR 1022.

5.4.4.1 Habitat Disturbance, No-Action Alternative. Under the No-Action Alternative, 50 ha (125 ac), 0.7% of the shrub-steppe habitat in the Central Plateau geographic area, would be disturbed by surface decontamination and stabilization actions.

5.4.4.2 Habitat Disturbance, Exclusive Future Land-Use Alternative. Under the Exclusive Future Land-Use Alternative, capping of waste sites and pump-and-treat operations in the Central Plateau geographic area would disturb approximately 6% of the shrub-steppe habitat. Short-term effects include loss of bird nesting habitat for certain species (sage sparrows, sage thrasher, and loggerhead shrike) and loss of habitat for small mammals and reptiles. Potential long-term effects include reduction in dense sagebrush.

5.4.4.3 Effects on Species of Concern, No-Action Alternative. Under the No-Action Alternative, there would be some direct mortality to small mammals and reptiles inside the boundaries of waste sites that undergo stabilization. These impacts would not be significant.

5.4.4.4 Effects on Species of Concern, Exclusive Future Land-Use Alternative. No federally listed threatened or endangered species occur in the Central Plateau geographic area. Species of concern that may occur in this area include the ferruginous hawk (federal candidate), golden eagle (state candidate), Swanson's hawk (state candidate), sage sparrow (state candidate), sage thrasher (state candidate), striped whipsnake (state candidate), and possibly the Columbia milk-vetch (state threatened and federal candidate). Potential short-term impacts under the Exclusive Future Land-Use Alternative would include the loss of habitat and prey-base for some species. Potential long-term effects would include some permanent loss of shrub-steppe habitat, although reclamation would reduce this impact. Additional population losses of candidate species could result in their listing as threatened or endangered under the *Endangered Species Act of 1973*.

5.4.4.5 Ecological Risk, No-Action Alternative. The No-Action Alternative could have significant impacts to species as the result of long-term exposures to chemical and radiological contaminants in the Central Plateau geographic area. The potential radiological and nonradiological risks to ecological receptors in the Central Plateau geographic area were evaluated in the ecological risk assessment (Appendix C). Potential doses caused by exposure to certain chemicals and radionuclides were estimated for a generic plant, the Great Basin pocket mouse, the coyote, and the redtailed hawk. All values of the chemical HI for plants and most of these for the mouse were equal to or greater than 1.0 (Table 5-30), indicating a potential for adverse effects. Several estimated radiation doses for the plant, coyote and, hawk were greater than the 0.1 rad/d (Table 5-31) suggested by IAEA (1992) as protective of terrestrial organisms. Figures 5-14 through 5-21 represent the distribution of estimated exposures to ecological receptors.

These results indicate potential adverse effects on ecological receptors exposed to the maximum estimated contaminant concentrations in the Reactors on the River geographic area. The use of the maximum estimated contaminant concentrations represents worst-case conditions. Current monitoring data indicate that measured exposures on the Hanford Site are below levels of concern.

Table 5-30. Hazard Index Summed by Cell, Central Plateau Geographic Area.

Cell ID	Hazard Index			
	Plant	Mouse	Coyote	Hawk
565133	--	--	--	--
566133	--	--	--	--
566134	***2.63 E+02***	***2.62 E+00***	1.22 E-05	1.76 E-05
566135	***1.18 E+03***	***7.96 E+00***	3.65 E-05	5.51 E-05
566136	4.44 E+04	2.13 E+04	9.75 E-02	1.65 E-03
567133	--	--	--	--
567134	1.55 E+03	1.65 E+00	4.46 E-05	1.83 E-03
567135	--	--	--	--
567136	3.92 E+04	6.96 E-04	1.33 E-07	6.38 E-06
567137	--	--	--	--
573134	--	--	--	--
573136	1.33 E+03	***1.28 E+00***	1.22 E-05	3.20 E-04
573137	6.30 E+04	***3.04 E+04***	1.39 E-01	2.35 E-03
574136	--	--	--	--
575135	5.19 E+01	8.02 E-03	1.53 E-06	7.35 E-05
575136	--	--	--	--

Range: 1.33 E-07 to 6.30 E+04.
Bold italics indicates values greater than 1.0; -- indicates no data (see Appendix C).

Recent environmental monitoring data indicate that Hanford operations have resulted in small accumulations of some radionuclides in fish and wildlife; however, the concentrations are insufficient to pose a hazard to fish and wildlife or to humans who might consume them (PNL 1993).

5.4.4.6 Ecological Risk, Exclusive Future Land-Use Alternative. The Exclusive Future Land-Use Alternative is expected to pose short-term adverse impacts to ecological resources. The short-term impacts would result from resuspension of contaminated soil with consequent direct exposure of ecological receptors, but these impacts could be mitigated. The long-term impacts would be beneficial because of reduction in exposure to radionuclides and hazardous chemicals.

5.4.4.7 Effects on Biodiversity, No-Action Alternative. The No-Action Alternative is not expected to have significant impacts on biodiversity in the short or long term.

5.4.4.8 Effects on Biodiversity, Exclusive Future Land-Use Alternative. The Exclusive Future Land-Use Alternative is expected to have the most significant impacts on biodiversity of the Central Plateau geographic area. Disturbance and subsequent reclamation of plant communities could reduce species diversity, with indirect effects on community functions such as forage production, cover, and nutrient cycling. Activities would fragment existing habitats and disrupt the connectivity among different habitats. These impacts are expected to be significant in the short term, but long-term effects on biodiversity could be avoided or reduced through implementation of mitigation measures.

Table 5-31. Estimated Radiation Dose, Total by Cell, Central Plateau Geographic Area.

Cell ID	Estimated Total Dose (rad/d)			
	Plant	Mouse	Coyote	Hawk
565133	1.28 E-02	3.65 E-08	9.10 E-05	4.58 E-05
565134	1.21 E-03	3.06 E-06	3.98 E-03	3.37 E-03
566133	***1.92 E-01***	4.97 E-07	1.03 E-03	5.98 E-04
566134	***9.24 E+00***	4.94 E-04	***6.78 E-01***	***5.48 E-01***
566135	***4.68 E+00***	1.35 E-05	3.55 E-02	1.72 E-02
566136	***1.25 E+01***	4.09 E-04	***1.84 E+00***	***6.18 E-01***
566137	1.71 E-03	5.25 E-09	9.31 E-06	6.10 E-06
567133	***1.88 E-01***	7.97 E-07	2.51 E-03	1.07 E-03
567134	***1.54 E+01***	4.23 E-05	***1.02 E-01***	5.25 E-02
567135	***1.35 E-01***	2.00 E-06	1.03 E-02	3.22 E-03
567136	***1.10 E+02***	2.97 E-04	***5.12 E-01***	***3.43 E-01***
567137	***1.80 E+00***	4.65 E-06	7.30 E-03	5.28 E-03
569140	6.59 E-02	3.13 E-07	6.78 E-04	3.80 E-04
570140	4.21 E-02	2.00 E-07	4.32 E-04	2.42 E-04
571140	4.21 E-02	2.00 E-07	4.32 E-04	2.42 E-04
573134	***3.66 E+01***	1.32 E-04	***3.68 E-01***	***1.71 E-01***
573136	***2.15 E+00***	1.47 E-05	2.99 E-02	1.75 E-02
573137	***7.73 E+01***	2.34 E-04	***4.12 E-01***	***2.71 E-01***
574135	***1.25 E-01***	2.53 E-04	***3.29 E-01***	***2.78 E-01***
574136	***6.23 E+03***	1.34 E-02	***1.74 E+01***	***1.47 E+01***
574139	2.15 E-02	7.33 E-07	1.03 E-03	8.15 E-04
575135	***1.09 E+02***	7.28 E-04	***1.37 E+00***	***8.56 E-01***
575136	***1.01 E-01***	7.83 E-07	2.28 E-03	1.03 E-03
575137	6.18 E-05	1.67 E-10	2.72 E-07	1.91 E-07

Range: 1.67 E-10 to 6.23 E+03.
Bold italics indicates values greater than 0.1.

5.4.4.9 Potential Mitigation Measures. Potential mitigation measures for ecological resources under the No-Action and Exclusive Future Land-Use Alternatives include the following:

- limiting areas to be disturbed to immediate waste site area
- using established transportation routes to minimize damage to undisturbed soil and vegetation
- using silt fences and dust control measures to reduce soil erosion
- revegetating all disturbed areas with native species to reduce long-term soil loss from wind and water erosion
- avoiding disturbance of known nesting and foraging areas for species such as the loggerhead shrike from March 1 to September 30, the primary nesting season
- continuing ecological monitoring.

5.4.5 Air Quality

*5.4.5.1 **Effects on Air Quality, No-Action Alternative.*** Generation of airborne pollutants under the No-Action Alternative would not exceed the quantities presently generated under Hanford operations. No significant impacts are expected from implementation of the No-Action Alternative in the Central Plateau geographic area, because present Hanford operations meet air quality standards (PNL 1995).

*5.4.5.2 **Effects on Air Quality, Exclusive Future Land-Use Alternative.*** Capping of waste sites would generate fugitive dust, possibly contaminated with radioactive particles. Airborne pollutants also would be released in exhaust from equipment used for excavation, loading, and hauling. Generation of airborne pollutants, especially particulates, would be greater than is currently experienced on the Hanford Site. Stringent engineering practices and mitigation measures, however, are expected to maintain airborne particulates at levels similar to quantities presently generated under Hanford operations. No significant impacts are expected from implementation of the Exclusive Future Land-Use Alternative in the Central Plateau geographic area, because present Hanford operations meet air quality standards (PNL 1995).

Transportation of contaminated waste for disposal would not result in significant impacts from haul road dust (see Section 5.2.5.2).

*5.4.5.2.1 **Potential Mitigation Measures.*** Potential mitigation measure to reduce air quality impacts include the use of dust suppression measures, covering haul trucks, and use of temporary enclosures.

5.4.6 Noise

*5.4.6.1 **Noise Effects, No-Action Alternative.*** The noise analysis for this EIS includes potential noise sources that would be produced by remedial activities and their potential impact on nearby workers, and on downwind residential areas and wildlife. The predominant source of noise would be heavy trucks and construction equipment. The conservative analysis for the Central Plateau geographic area is based on a scenario at the 100-H Area in the Reactors on the River geographic area (see Section 5.3.6). Under the No-Action Alternative for this area, there would be little remediation and the expected noise impacts would not be significant.

*5.4.6.2 **Noise Effects, Exclusive Future Land-Use Alternative.*** The Exclusive Future Land-Use Alternative involves the capping of waste sites and groundwater remediation in the Central Plateau geographic area. Noise impacts of construction and transportation activities are not predicted to violate State of Washington noise standards. Construction-related noise could disturb wildlife within hearing or visual distance of remediation activities. Short-term noise impacts would cease when remediation was completed.

*5.4.6.2.1 **Potential Mitigation Measures.*** Use of hearing protection devices and monitoring of occupational noise are potential mitigation measures for noise impacts under this alternative.

5.4.7 Cultural Resources

5.4.7.1 Effects on Prehistoric and Historic Resources, No-Action Alternative. Impacts to prehistoric and historic resources would be limited to sites that occur within a waste site boundary. Recorded prehistoric resources within the Central Plateau geographic area that could be affected include one rock cairn, and a multicomponent site composed of prehistoric lithic scatter and an historic dump site. Recorded historic resources in the Central Plateau geographic area that could be affected include a portion of the White Bluffs Road, seven historic trash and debris scatters, and one multicomponent site. In addition, numerous historic isolates have been recorded in the Central Plateau geographic area, and these could be affected.

5.4.7.1.1 Potential Mitigation Measures. Potential mitigation measures for the No-Action Alternative include the following:

- Conducting a survey of the affected areas, whenever practicable
- Before any ground disturbance activities, conducting consultations with the DOE-RL Historic Preservation Officer, the Hanford Cultural Resource Laboratory, the Washington SHPO, and concerned Native American Tribal groups and governments
- Conducting all cultural resources-related work in accordance with the *Hanford Cultural Resources Management Plan* (Chatters 1989)
- Avoiding cultural resource areas identified during project planning
- An archaeological monitor would be onsite during ground disturbing activities, when practicable
- An interpretive training program outlining the history of the Hanford Site would be presented to personnel involved in the remedial activities.

5.4.7.2 Effects on Prehistoric and Historic Resources, Exclusive Future Land-Use Alternative. Potential impacts of this alternative would result from capping of waste sites and pump-and-treat operations. Because of the greater area of disturbance under this alternative, greater potential impact on prehistoric and historic resources would be expected. These impacts would be potentially significant, but could be mitigated.

5.4.7.3 Effects on Areas of Concern to Native Americans, No-Action Alternative. Potential direct and indirect impacts on Native American archaeological sites under the No-Action Alternative would be an issue of concern to Native Americans, particularly if areas of traditional cultural uses (e.g., traditional burial areas and areas of religious use) are affected. This alternative would continue restrictions on the use of traditional hunting and gathering sites, and cultural properties.

5.4.7.3.1 Potential Mitigation Measures. Mitigation measures to address issues of concern to Native Americans include:

- Consultation with Native American Tribal governments/groups with regard to the potential impacts on areas that might concern them before implementation of project activities

- Incorporation of recommendations provided by Native American Tribal governments/groups into project-specific cultural resource mitigation plans for proposed remedial activities

- Incorporating recommendations provided by Native American Tribal governments and organizations into revegetation plans for proposed remedial activities

- Involving representatives of Native American Tribal governments and organizations in archaeological monitoring during remedial activities.

5.4.7.4 Effects on Areas of Concern to Native Americans, Exclusive Future Land-Use Alternative. Potential direct and indirect impacts on Native American archaeological sites under the Exclusive Future Land-Use Alternative would be an issue of concern to Native Americans, particularly if areas of traditional cultural uses (e.g., traditional burial areas or areas of religious use) are affected. This alternative would continue restrictions on the use of traditional hunting and gathering sites, and cultural properties.

Remediation under this alternative would eventually allow some Native American uses of the Central Plateau geographic area. As described in Section 3.2.4.2, the buffer zone established around waste sites in this area would decrease in size as remediation reduces risks. As the buffer zone shrinks, these lands would no longer be classified as exclusive use.

5.4.7.4.1 Potential Mitigation Measures. Potential mitigation measures for the Exclusive Future Land-Use Alternative are the same as for the No-Action Alternative.

5.4.8 Visual and Aesthetic Resources

5.4.8.1 Effects on Visual and Aesthetic Resources, No-Action Alternative. Continued environmental monitoring and maintenance activities, and stabilization of waste sites would have no significant impact on visual and aesthetic resources.

5.4.8.2 Effects on Visual and Aesthetic Resources, Exclusive Future Land-Use Alternative. Under the Exclusive Future Land-Use Alternative, capping of waste sites and pump-and-treat operations would result in short-term impacts on visual and aesthetic resources in the Central Plateau geographic area. Short- and long-term visual impacts would result from construction.

The construction of caps on waste sites in the Central Plateau geographic area would permanently alter the landscape, and would be a significant impact. The size and shape of the caps would be noticeable on the flat plateau, where there is minimal topographic relief. Viewer attention would be focused on the caps, as their rigid geometric design and large size would contrast with the natural landscape.

5.4.8.2.1 Potential Mitigation Measures. Potential mitigation measures include contouring and revegetating capped sites, and the use of dust suppressing measures.

5.4.9 Human Health Risks

5.4.9.1 Human Health Risks, No-Action Alternative. Under the No-Action Alternative, the activities would be limited to monitoring of environmental media, maintaining and stabilizing waste sites and facilities, and security functions. Potential human exposures to radiological and chemical contaminants would continue to be prevented by engineering and institutional controls, including site access restrictions; restrictions on contact with, or in proximity to, radioactive and hazardous materials; and restrictions on the withdrawal and use of groundwater. As long as these controls remain in place, risks to workers and the general public from contaminants in the Central Plateau geographic area are expected to remain within acceptable limits. Therefore, the No-Action Alternative, with continued use of engineering and institutional controls, is not expected to have significant impacts on human health.

The removal of institutional controls in the Central Plateau geographic area has the potential to result in significant human health risks. A baseline risk assessment was performed to assess the potential human health risks associated with loss of institutional controls under the No-Action Alternative. Human health risks were calculated for exposures to radioactive materials, carcinogenic chemicals, and noncarcinogenic chemicals using the industrial exposure scenario. This exposure scenario and other assumptions used in the risk assessment are discussed in Appendix B. The risk assessment results for the Central Plateau geographic area are discussed in Section 5.7.3.

Table 5-32 presents the consequences of a range fire occurring in the Central Plateau geographic area that releases contaminants taken up by plants growing within the area. The assumptions used in this accident scenario are similar to those described for the Reactors on the River geographic area (Section 5.3.9.1). The maximum estimated radiation dose to an onsite worker for this scenario is less than 0.1% of the 5,000-mrem/yr annual dose limit for workers (see Table 5-32).

5.4.9.2 Human Health Risks, Exclusive Future Land-Use Alternative. The Exclusive Future Land-Use Alternative would be achieved through a combination of institutional controls, capping of contaminated areas, and groundwater remediation. The DOE would maintain institutional control of the Central Plateau geographic area, and would continue to use the area for waste management activities. Withdrawal and use of groundwater in the Central Plateau geographic area would be controlled for an indefinite period.

Over the long term, the Exclusive Future Land-Use Alternative would result in beneficial impacts on human health by removing some contamination and preventing exposure to remaining contamination by restricting activities. These restrictions would include prohibitions on soil disturbance and restrictions on groundwater use for an indefinite period. The combination of capping wastes, groundwater remediation, and use restrictions would reduce cancer risks to levels at or below the target risk range of 10^{-4} to 10^{-6}. Cancer risks could be higher if activity restrictions are violated.

Table 5-32. Consequences of Accidents During Remediation, Central Plateau Geographic Area.

Accident Scenario	MEI Doses (mrem)			Maximum Population Dose (person-rem), Population, and Direction
	MEI at 100 m (327 ft)	MEI at the NPAL and Distance	Site Boundary Dose and Distance	
Groundwater Treatment	280 *1.1 E-04*[a]	0.6 at 3,920 m (12,860 ft) *3.0 E-07*[a]	0.2 at 11,720 m (38,400 ft) *1.0 E-07*[a]	0.49 to a population of 114,734 to the southeast of the Central Plateau *2.5 E-04*[b]
Range Fire	1.4 *5.6 E-07*[a]	0.003 at 3,920 m (12,860 ft) *1.5 E-09*[a]	0.0015 at 11,720 m (38,400 ft) *7.5 E-10*[a]	0.0033 to a population of 114,734 to the southeast of the Central Plateau *1.7 E-06*[b]

[a]Increased probability of this individual contracting a fatal cancer.
[b]Increase in LCFs in this population.
LCF = latent cancer fatality.
MEI = maximally exposed individual.
NPAL = nearest public access location.

The potential for adverse health effects resulting from accidents during remediation were evaluated using risk assessment methodology (Appendix B5). In addition to the range fire, an accident involving a fire during groundwater treatment was evaluated. This scenario is described in Section 5.3.9.2 and Appendix B5.

For the groundwater treatment accident, the estimated maximum radiation dose to remediation workers would be 6% of the regulatory limit for radiation workers of 5,000 mrem/yr. The estimated doses at the NPAL and site boundary (see Table 5-32) are less than 10% of the 10 mrem limit. Therefore, adverse impacts of the Exclusive Future Land-Use Alternative on human health are not considered potentially significant.

5.4.9.2.1 Potential Mitigation Measures. Potential mitigation measures for the Exclusive Future Land-Use Alternative are those that are designed to prevent accidents during remedial activities or to reduce the severity of their impacts once they occur. Appropriate engineering and administrative measures would be applied during routine remedial activities, so that the protection of workers, the general public, and the environment is ensured. For remediation and nearby workers, mitigation involves wearing appropriate protective clothing; using respiratory protection, when necessary; and limiting exposures to contaminants in accordance with ALARA guidelines, and good health physics and industrial hygiene practices. For the general public, mitigation involves the use of practices and procedures designed to reduce the transport of radioactive and hazardous materials offsite. These practices include the use of dust suppressants during surface disturbing activities; use of containment structures, when necessary; and other similar measures to control the spread of contaminants.

5.4.10 Occupational Impacts

This section estimates potential occupational impacts associated with the remediation of the Central Plateau geographic area. Potential occupational impacts were estimated using the method described in Appendix I. The occupational impacts are estimated by comparing the field labor hours identified in Appendix H for each land-use alternative with BLS and DOE incident rates (NSC 1993; EG&G 1993).

5.4.10.1 Occupational Impacts, No-Action Alternative. Labor hour estimates are not available for the No-Action Alternative; therefore, no occupational impacts were estimated, and mitigation measures were not evaluated.

5.4.10.2 Occupational Impacts, Exclusive Future Land-Use Alternatives. This section describes the potential occupational impacts associated with remediation of the Central Plateau geographic area for exclusive use. A discussion of potential mitigation measures also is included.

Table 5-33 presents the potential occupational impacts for the Exclusive Future Land-Use Alternative for the Central Plateau geographic area based on BLS incident rates. Total cases include all work-related deaths and illnesses, and those work-related injuries that result in loss of consciousness, restriction of work or motion, transfer to another job, or a requirement for medical attention. It is the sum of lost workday cases and nonfatal cases without lost workdays. Lost workdays are those days that, because of occupational injury or illness, an employee was away from work or limited to restricted work activity. Lost workdays are attributable to lost workday cases.

Table 5-33. Summary of Occupational Impacts per BLS Statistics.

Remediation Alternative (labor hours)	Estimated Total Cases	Estimated Lost Workday Cases	Estimated Nonfatal Cases Without Lost Workdays	Estimated Lost Workdays
Exclusive (8,355,250)	579	319	260	8,484

Table 5-34 presents the potential occupational impacts based on DOE incident rates. The occupational impacts estimated using DOE incident rates are substantially lower than the impacts estimated using BLS incident rates. DOE incident rates historically have compared favorably to private industry rates. The analysis using DOE incident rates is expected to more accurately reflect potential occupational impacts.

5.4.10.2.1 Potential Mitigation Measures. Potential mitigation measures include continued emphasis on safety awareness and worker training.

5.4.11 Volumes, Disturbed Areas, and Costs

This section describes the volumes of excavated soils, waste, and materials; areas of disturbance; and costs of implementing the No-Action and Exclusive Future Land-Use Alternatives for the Central Plateau geographic area. The assumptions and methodology used are described in Appendix H. Impacts of each alternative are summarized in Table 5-35.

5.4.11.1 Effects on Volumes, Disturbed Areas, and Costs, No-Action Alternative. The No-Action Alternative involves moving large quantities of surface soils to consolidate the contamination within original waste site boundaries and stabilize the sites with clean fill dirt. Some backfill may be required, but minimal volumes would be excavated. The total area disturbed would be 280 ha (692 ac).

The costs of the No-Action Alternative have not been determined for each geographic area, but they are summarized for the Hanford Site in Table 5-24. The cost is more than $2.4 billion for 100 years of institutional controls. These costs are not specific to the Central Plateau geographic area, but rather apply to the entire Hanford Site.

5.4.11.1.1 Potential Mitigation Measures. Potential mitigation measures include efforts to reduce the costs of institutional controls.

Table 5-34. Summary of Occupational Impacts per DOE Statistics.

Remediation Alternative (labor hours)	Estimated Total Cases	Estimated Lost Workday Cases	Estimated Lost Workdays
Exclusive (8,355,250)	144	63	966

Table 5-35. Comparison of Volumes, Disturbed Areas, and Costs Associated with the Central Plateau Geographic Area Future Land-Use Alternatives.

Resources	Alternatives	
	No Action	Exclusive
Capping Materials LCM[a,b] (x 10^6)	0	17.5
Groundwater Treatment Costs in 1995 Dollars (millions)	0	411
Areas of Disturbance (ha)	280	475
Project Cost in 1995 Dollars (millions)[b]	2,424[c]	1,514

[a]Loose Cubic Meter (LCM) = 1.31 Loose Cubic Yard (LCY)
Bank Cubic Meters (BCM) = 1.31 Bank Cubic Yards (BCY)
ha = 2.47 ac.
[b]Values represent installation of Modified RCRA caps.
[c]Cost for 100 years of institutional control for the Hanford Site. The costs are not broken down by geographic area.

5.4.11.2 Effects on Volumes, Disturbed Areas, and Costs, Exclusive Future Land-Use Alternative. The total area disturbed by remedial actions is 475 ha (1,174 ac). The costs of remedial actions are approximately $1.514 billion.

5.4.11.2.1 Potential Mitigation Measures. More site characterization has the potential to reduce the number and size of waste sites to be remediated. The development of additional remedial technologies may provide cost savings opportunities in the future.

Continuing emphasis would be placed on the development and implementation of new remedial technologies to reduce the volumes, levels of disturbance, and costs associated with remediating waste sites in the All Other Areas geographic area. These new technologies may include *in-situ* treatments, which could significantly reduce the volumes of contaminated soils requiring excavation and disposal.

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All Other Areas

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5.5 All Other Areas Geographic Area

The scope of proposed actions in the All Other Areas geographic area includes numerous waste sites, TSD units, and groundwater plumes containing nitrate, tritium, uranium, iodine-129, trichloroethylene, perchloroethylene, and 1,2-dichloroethylene. Potential impacts of the No-Action and future land-use alternatives for this area are discussed in the following sections.

5.5.1 Geology

5.5.1.1 Effects on Geologic Resources, No-Action Alternative. Under the No-Action Alternative, past-practice waste sites and TSD facilities would be left in place, requiring restrictions on public access to portions of the All Other Areas geographic area for exploration or exploitation of mineral deposits. Because such access restrictions currently are in force, this alternative would not involve a new impact. Continuation of the existing access restrictions is not expected to result in short- or long-term adverse impacts, because the primary mineral resources in the area (sand, gravel, and basalt) are readily available in uncontaminated portions of the All Other Areas geographic area and in the region. Monitoring of environmental media would have no significant impact on the geologic resources of this area.

5.5.1.2 Effects on Geologic Resources, Restricted Future Land-Use Alternative (R1). The Restricted Future Land-Use Alternative (R1) would involve excavation and removal of contaminated soils at past-practice waste sites, closure of TSD facilities, and the use of engineering and institutional controls. The extent of excavation would vary, depending on the extent of contamination present and the desired remediation level. The desired remediation levels for waste sites in the All Other Areas geographic area would be determined through the CERCLA process using the recreational and industrial exposure scenarios.

Although the extent of excavation would be determined through the CERCLA process, as described above, it was necessary for this analysis to make assumptions on the extent of excavation to estimate excavation volumes. For purposes of estimating excavation volumes, the maximum excavation depth was assumed to be 4.6 m (15 ft) below the surface for the Restricted Future Land-Use Alternative (R1). This value, which is based on the State of Washington's *Model Toxics Control Act of 1989*, was combined with WIDS data to calculate volumes to be excavated under this alternative. The models used to calculate volumes are described in Appendix H.

Estimated volumes to be excavated for the Restricted Future Land-Use Alternative (R1) include 1.6 million BCM (2.1 million BCY) of contaminated soil and 1.6 million BCM (2.1 million BCY) of uncontaminated soil. Because some contamination would be left in place, this alternative would involve the long-term continuation of existing restrictions on public access to sand, gravel, and basalt resources. As in the No-Action Alternative, such access restrictions would not be expected to have significant effects on the commercial development of geologic resources.

Features relevant to the study of the region's glacial flood events are found in the All Other Areas geographic area. A small number of these features potentially could be destroyed during remediation. This would cause minimal adverse impact, because such features also occur in uncontaminated portions of this area, and elsewhere within the Hanford Site, and would continue to be available for study.

5.5.1.3 Effects on Geologic Resources, Restricted Future Land-Use Alternative (R2). The Restricted Future Land-Use Alternative (R2) would involve constructing caps over past-practice waste sites and TSD facilities. Estimated volumes of cap materials used for this alternative are presented in Section 5.5.11. This alternative would result in significant depletion of the geologic resources of quarry and borrow sites. The locations of these sites are discussed in Appendix E. The impacts on geologic resources are summarized in Section 5.10 as irreversible and irretrievable commitments of resources.

Because contamination would be left in place, this alternative would involve the long-term continuation of existing restrictions on public access to sand, gravel, and basalt resources. As in the No-Action Alternative, such access restrictions would not be expected to have significant effects on the commercial development of geologic resources. This alternative would have the same minimal impacts on natural geologic features as for the Restricted Future Land-Use Alternative (R1).

5.5.1.3.1 Potential Mitigation Measures. Mitigation measures to reduce depletion of borrow sites include the use of RCRA C or Modified RCRA caps as alternatives to the reference cap. The reference cap is described in Appendix E.

5.5.2 Soils

The potential impacts of the alternatives on soils in the All Other Areas geographic area are summarized in Table 5-36.

5.5.2.1 Effects on Soils, No-Action Alternative. Under the No-Action Alternative, potential impacts on soils primarily would be related to surface decontamination and/or stabilization of past-practice waste sites and TSD facilities. Approximately 45 ha (114 ac) would be disturbed under the No-Action Alternative (see Table 5-36). Potential short-term impacts on soils under this alternative would include some soil compaction and an added potential for wind erosion. Long-term impacts would not be significant, if appropriate mitigation measures were implemented. Environmental monitoring and maintenance activities are not expected to impact soils.

5.5.2.1.1 Potential Mitigation Measures. Potential mitigation measures for soils include the following: using silt fences and dust control measures to reduce soil erosion; and reseeding disturbed areas with native vegetation to reduce long-term soil loss from wind and water erosion.

5.5.2.2 Effects on Soils, Restricted Future Land-Use Alternative (R1). Remediation to restricted use (R1) would have potentially significant impacts on soils in the All Other Areas geographic area. Remedial activities affecting soils include excavating, loading, and hauling contaminated soil from past-practice waste sites and TSD facilities; constructing groundwater remediation systems; and restoring sites. The Restricted Future Land-Use Alternative (R1) would disturb approximately 301 ha (753 ac) of soils in this areas (see Table 5-36).

*Table 5-36. Soils Disturbed under the All Other Areas Geographic Area Future Land-Use Alternatives.**

Soil Types	No Action ha (ac)	Restricted	
		R1 ha (ac)	R2 ha (ac)
Quincy sand	17 (42)	90 (225)	135 (334)
Burbank loamy sand	10 (26)	70 (176)	90 (222)
Ephrata sandy loam	14 (36)	44 (110)	54 (133)
Kiona silt loam	4 (10)	2 (4)	4 (9)
Hezel sand	0	3 (7)	3 (7)
Dune sand	0	18 (45)	18 (45)
Esquatzel silt loam	<0.4 (<1)	1 (3)	2 (6)
Warden silt loam	0	73 (183)	74 (183)
Total	45 (114)	301 (753)	380 (939)

*Areal impact information generated from the GIS; includes area disturbed for partial excavation, cap construction, trample zones, effluent lines, haul roads, and wells.

The use of heavy equipment, such as scrapers and trucks, could be expected to compact soils at waste sites caused by repeated travel over the same area. Soil compaction would cause increased runoff during storm events, resulting in less infiltration of water into the soil. Compaction also would inhibit plant growth. Soil types in the All Other Areas geographic area most susceptible to soil compaction are Ephrata sandy loam, Esquatzel silt loam, and Warden silt loam (Table 5-37).

Soil disturbance during remediation activities also would increase soil erosion. The use of heavy equipment, particularly in undisturbed shrub-steppe habitat adjacent to waste sites, would crush or scrape off existing vegetation such as sagebrush, reducing the ability of soils to resist erosion. Soil types in the All Other Areas geographic area most susceptible to wind erosion are Quincy sand, Burbank loamy sand, and Hezel sand (see Table 5-37). None of these soils are highly susceptible to water erosion. Mitigation measures would reduce but not eliminate all potential impacts associated with this alternative.

5.5.2.2.1 Potential Mitigation Measures. Mitigation measures under this alternative would be similar to those for the No-Action Alternative, but applied on a larger scale. These would include:

- limiting the use of heavy equipment to immediate waste site areas
- using existing travel routes, whenever possible, to minimize damage to undisturbed soil and vegetation
- using erosion control measures such as silt fences and dust control to reduce soil erosion
- replanting remediated waste sites and temporary access roads with native vegetation to reduce long-term soil loss from wind and water erosion.

Table 5-37. Compaction and Erosion Hazard Potential for Affected Soils in the All Other Areas Geographic Area.

Soil Type	Compaction Hazard[a]	Erodibility Class[b]	
		Wind	Water
Quincy sand	Slight	High	Not High
Burbank loamy sand	Slight	High	Not High
Ephrata sandy loam	Severe	NA	NA
Kiona silt loam	Moderate	Not High	Not High
Dune sand	Slight	Not High	Not High
Esquatzel silt loam	Severe	Not High	Not High
Hezel	Slight	High	Not High
Warden silt loam	Severe	Not High	Not High

[a]Brincken (1994).
[b]Bolick (1994).
NA = Erosion class not available for Ephrata sandy loam.

5.5.2.3 Effects on Soils, Restricted Future Land-Use Alternative (R2). Remediation to restricted use (R2) would have potentially significant impacts on soils in the All Other Areas geographic area. Activities that would occur include placing caps over past-practice waste sites and closure of TSD facilities, constructing groundwater remediation systems, and restoring sites. Remediation activities would disturb approximately 380 ha (939 ac) of soils (see Table 5-36), and would increase soil compaction and erosion, as described for the Restricted Future Land-Use Alternative (R1). Mitigation measures would reduce but not eliminate the potential impacts associated with the Restricted Future Land-Use Alternative (R2).

5.5.2.3.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative (R2) are the same as for the Restricted Future Land-Use Alternative (R1).

5.5.3 Water Resources

5.5.3.1 Effects on Hydrology, No-Action Alternative. The No-Action Alternative would have no impacts on the volume or rate of groundwater movement in the All Other Areas geographic area, because groundwater would not be removed or altered as a result of this alternative. The No-Action Alternative would have no impacts on the flow of the Columbia River. Normal discharge of groundwater from the area would continue to augment river flows.

5.5.3.2 Effects on Hydrology, Restricted Future Land-Use Alternative (R1).

5.5.3.2.1 Groundwater. Groundwater remediation under this alternative could cause localized drawdown of the water table and temporary changes in direction of groundwater flow near the extraction wells. These effects would not have significant impacts on the use of groundwater, as groundwater use during remediation activities would continue to be restricted.

5.5.3.2.2 Surface Water. Groundwater remediation under this alternative is not expected to have adverse effects on the Columbia River, Yakima River, or Cold Creek. Although groundwater treatment could result in diminished groundwater flow to the Columbia River, treated groundwater would be reinjected or discharged to the river. The potential effects on Columbia River flows are not considered significant, given the high flow rates in the river.

5.5.3.3 Effects on Hydrology, Restricted Future Land-Use Alternative (R2). Groundwater remediation under this alternative would have effects on hydrology similar to those described for the Restricted Future Land-Use Alternative (R1). The construction of caps over past-practice waste sites would eliminate natural infiltration from these areas to groundwater. This is not expected to be a significant impact, as infiltration is not considered a significant source of groundwater recharge under natural conditions (DOE-RL 1993b).

5.5.3.4 Effects on Water Quality, No-Action Alternative.

5.5.3.4.1 Groundwater. The No-Action Alternative would involve no treatment of existing groundwater contamination, and would not have significant short-term impacts on groundwater. Contaminant plumes recognized in the All Other Areas geographic area include trichloroethylene, 1,2-dichloroethylene, and uranium in the 300 Area; trichloroethylene and perchloroethylene at the Solid Waste Landfill; and the large nitrate, iodine-129, and tritium plumes between the Central Plateau geographic area and the Columbia River. Low concentrations and isolated occurrences of other contaminants have been detected. Contaminant concentrations in some plumes exceed EPA DWSs, requiring long-term restrictions on withdrawal and use of groundwater.

5.5.3.4.2 Surface Water. The No-Action Alternative is not expected to degrade Columbia River water quality in the short or long term. Surface decontamination and stabilization of past-practice waste sites and TSD facilities could result in increased runoff and soil erosion, as described in Section 5.5.2.1. The mitigation measures described in that section for soils would minimize the potential adverse effects on water quality in the Columbia River.

Contaminants present in the groundwater would continue to migrate to the Columbia River under the No-Action Alternative. Existing groundwater discharges have contributed to radionuclide concentrations in the Columbia River. Tritium has been identified at elevated levels at the Richland Pumphouse relative to Priest Rapids Dam, indicating an influence from Hanford operations (PNL 1995). However, the radionuclide concentrations in the river water are well below applicable DWSs. Since surface water quality is not expected to deteriorate, downstream surface water supplies for municipal and other uses should not be affected.

5.5.3.4.2.1 Potential Mitigation Measures. Implementation of the No-Action Alternative would require maintaining existing restrictions on groundwater use in the All Other Areas geographic area for the indefinite future.

5.5.3.5 Effects on Water Quality, Restricted Future Land-Use Alternative (R1).

5.5.3.5.1 Groundwater. Groundwater remediation under the Restricted Future Land-Use Alternative (R1) would reduce radionuclide and hazardous chemical concentrations in the groundwater. Groundwater remediation would not have significant adverse impacts on groundwater quality and would have beneficial impacts over the long term. Some potential for future groundwater

contamination would remain, as contaminated soil would remain at some remediated waste sites. Water percolating through the vadose zone could transport some of the remaining contaminants to groundwater. The reestablishment of vegetation in remediated areas would increase evapotranspiration and reduce the potential for contaminant transport in the vadose zone.

5.5.3.5.2 Surface Water. Groundwater remediation could reduce the rate of groundwater movement toward the Columbia River, because pumping wells would reduce the hydraulic head gradient toward the river. Eventually, the groundwater contaminant concentrations would be reduced below remediation standards, so the pumping could be discontinued and groundwater allowed to discharge freely to the river.

Should treated groundwater be discharged to the Columbia River, the treated effluent may not have the same composition as normal groundwater because of the chemical effects of the treatment. This discharge would be governed by applicable laws and regulations (CWA), and would not significantly affect water quality in the Columbia River. Application of mitigation measures to control erosion described in Section 5.5.2.2 would minimize impacts to Columbia River water quality during waste site excavation.

5.5.3.6 Effects on Water Quality, Restricted Future Land-Use Alternative (R2).

5.5.3.6.1 Groundwater. Groundwater remediation under this alternative would have effects on groundwater quality similar to those described for the Restricted Future Land-Use Alternative (R1). The caps would prevent precipitation from percolating into the vadose zone and transporting contaminants to groundwater. Groundwater remediation would not have significant adverse impacts on groundwater quality, and would have beneficial impacts over the long term.

5.5.3.6.2 Surface Water. Remediation to restricted use (R2) would not have significant impacts on the water quality of the Columbia River. Caps installed over waste sites would prevent precipitation from percolating into the vadose zone and transporting contaminants to groundwater and to the Columbia River. Application of the mitigation measures for controlling erosion described in Section 5.5.2.2 would minimize impacts to Columbia River water quality during construction of waste site caps.

5.5.3.7 Effects on Floodplains, No-Action Alternative. The No-Action Alternative would not have significant impacts on floodplains. Stabilization of waste sites under the No-Action Alternative would not affect the 100-year floodplains of the Yakima River or Cold Creek. These activities would affect less than 1 ha (2.5 ac) of the Columbia River floodplain (Figure 5-23), which represents less than 1/10 of 1% of the total Columbia River floodplain on the Hanford Site. Floodplains and wetlands impacts are discussed further in the Floodplain/Wetlands Assessment (Appendix J), performed in accordance with 10 CFR 1022.

5.5.3.8 Effects on Floodplains, Restricted Future Land-Use Alternative (R1). Excavation of contaminated soils under the Restricted Future Land-Use Alternative (R1) would not have significant impacts on 100-year floodplains. No disturbance would occur within the Yakima River floodplain. Approximately 10 ha (25 ac) of the Columbia River floodplain and approximately 1 ha (2.5 ac) of the Cold Creek floodplain would be disturbed (Figure 5-24). These acreages represent less than 2% of the Columbia River floodplain and less than 1% of the Cold Creek floodplain in the All Other Areas geographic area. The acreages represent less than 1% of the total floodplains within the Hanford Site. Floodplains and wetlands impacts are addressed in the Floodplain/Wetlands Assessment (Appendix J) in accordance with 10 CFR 1022.

5.5.3.9 Effects on Floodplains, Restricted Future Land-Use Alternative (R2). Construction of caps over past-practice waste sites and TSD facilities under the Restricted Future Land-Use Alternative (R2) would not have significant impacts on floodplains. No disturbance would occur within the Yakima River floodplain. Approximately 7 ha (17 ac) of the Columbia River floodplain and approximately 3 ha (7 ac) of the Cold Creek floodplain would be disturbed (Figure 5-25). These acreages represent less than 2% of the Columbia River floodplain and less than 1/10 of 1% of the Cold Creek floodplain in the All Other Areas geographic area. The acreages represent less than 1% of the total floodplains within the Hanford Site. Floodplains and wetlands impacts are addressed in the Floodplain/Wetlands Assessment (Appendix J), which was performed in accordance with 10 CFR 1022.

5.5.4 Ecology

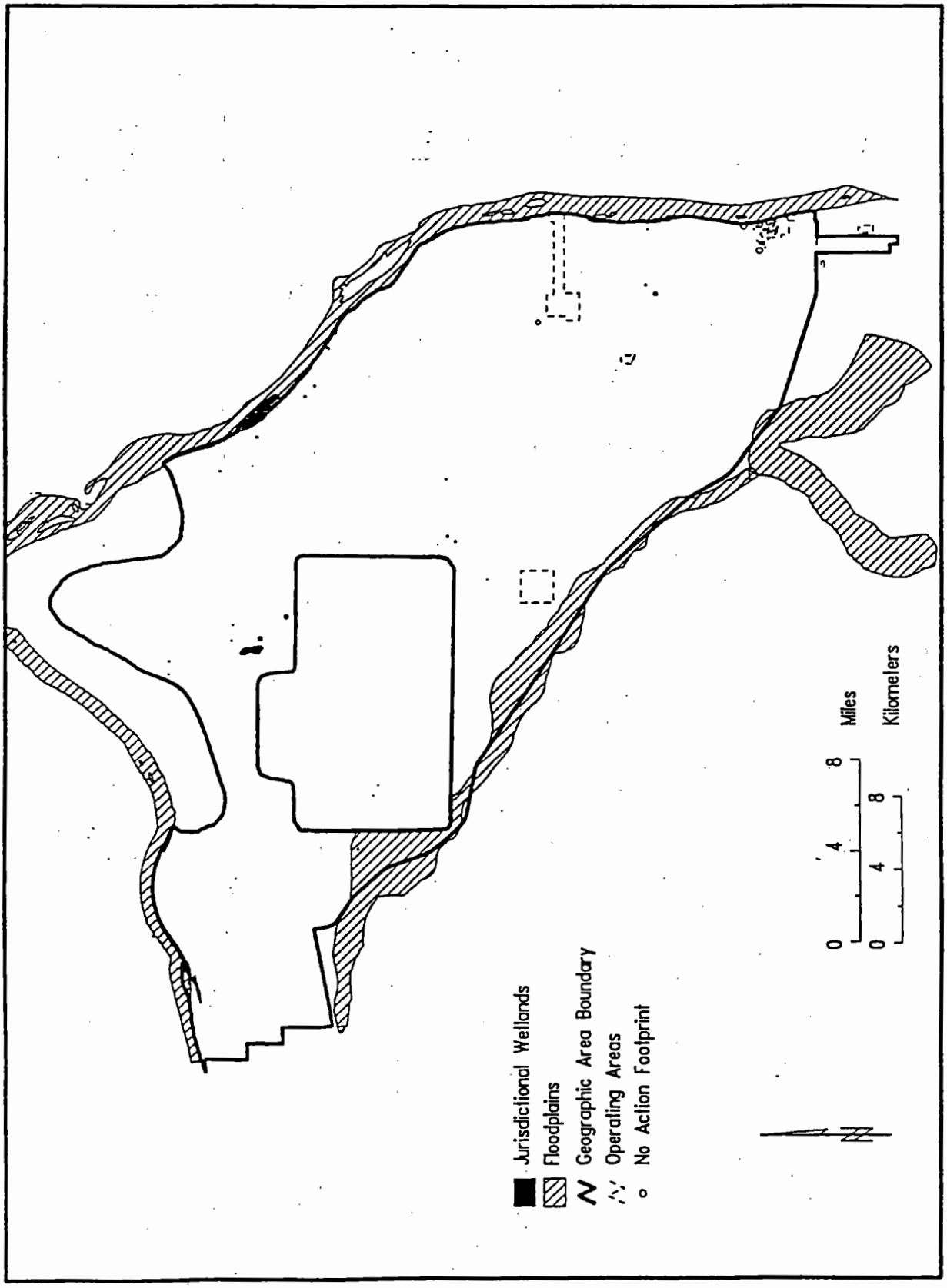
The levels of habitat disturbance associated with each alternative are summarized in Table 5-38.

5.5.4.1 Habitat Disturbance, No-Action Alternative. The No-Action Alternative would involve surface decontamination and stabilization of waste sites, and continuation of current environmental monitoring and maintenance activities. Implementation of the No-Action Alternative would disturb 5 ha (12 ac) of shrub-steppe habitat, which is approximately 0.3% of the shrub-steppe in the All Other Areas geographic area (see Table 5-38). Potential impacts of waste site stabilization would include direct mortality of some species of wildlife from soil scraping and consolidation. Wildlife losses would be limited to small mammals and reptiles, with small home ranges occurring inside waste site boundaries. These impacts would not be considered significant. Surface decontamination and waste site stabilization would not affect wetlands in the All Other Areas geographic area.

Environmental monitoring and maintenance activities are not expected to have any impacts on habitats.

5.5.4.2 Habitat Disturbance, Restricted Future Land-Use Alternative (R1). The Restricted Future Land-Use Alternative (R1) would involve excavating, loading, and hauling contaminated soil from past-practice waste sites and TSD facilities; constructing groundwater remediation systems; and restoring sites. Implementation of the Restricted Future Land-Use Alternative (R1) would result in destruction of 115 ha (287 ac) or 0.7% of the shrub-steppe habitat in the areas (Figure 5-26 and Table 5-38). Disturbance of these areas would lead to loss of nesting habitat for birds such as the sage sparrow, sage thrasher, and loggerhead shrike. Small mammals such as ground squirrels, and reptiles such as snakes and lizards, would be subjected to habitat fragmentation, displacement, or mortality. Noise and increased vehicle use in these areas would disturb wildlife within hearing or visual distance of remedial activities. This could result in startle behavior by some species and abandonment of nest or den sites.

Figure 5-23. 100-Year Floodplain and Wetland Areas Impacted under the All Other Areas No-Action Alternative.



9613470.0485

Figure 5-24. 100-Year Floodplain and Wetland Areas Impacted under the All Other Areas Restricted Future Land-Use Alternative (R1).

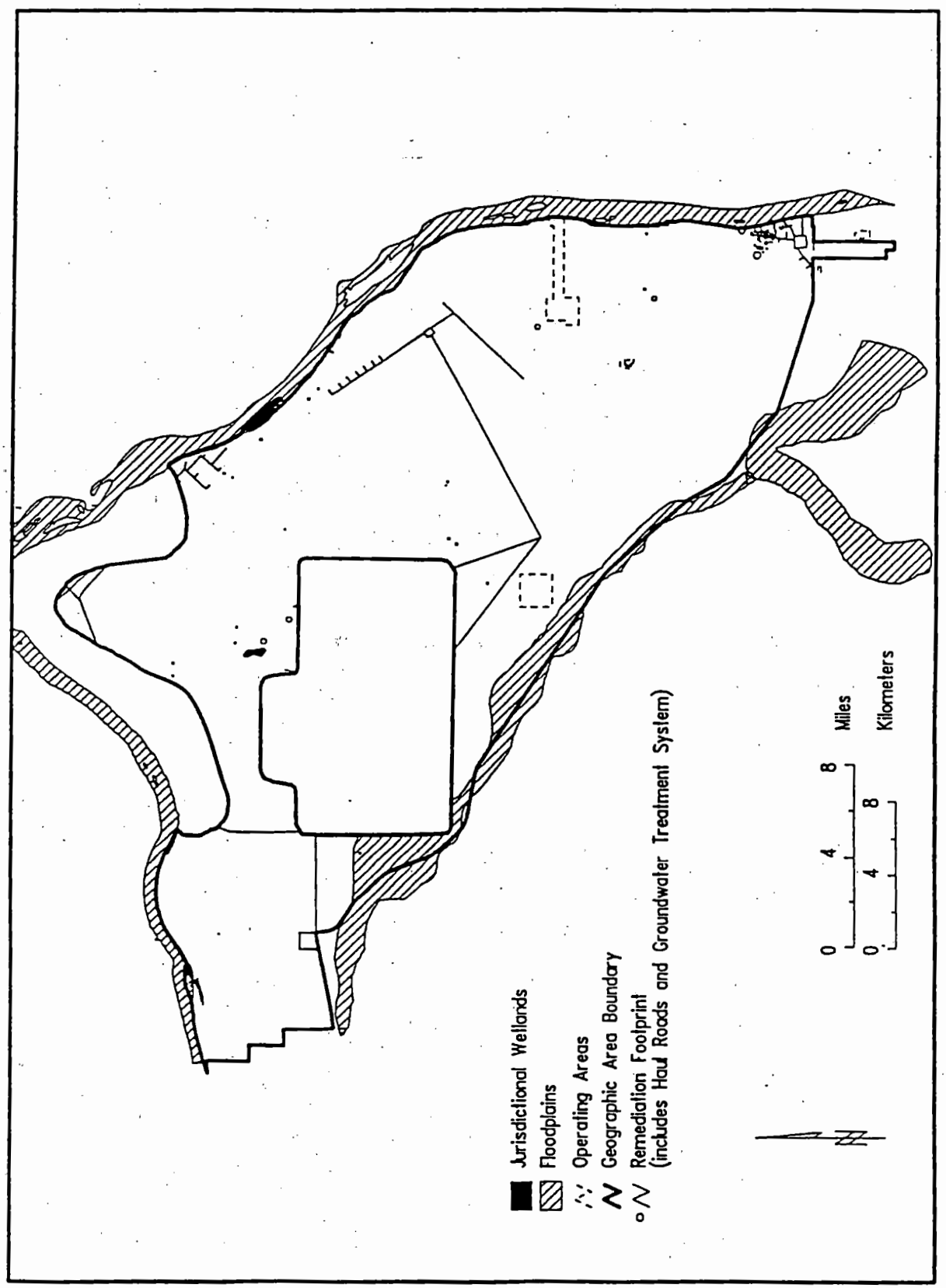


Figure 5-25. 100-Year Floodplain and Wetland Areas Impacted under the All Other Areas Restricted Future Land-Use Alternative (R2).

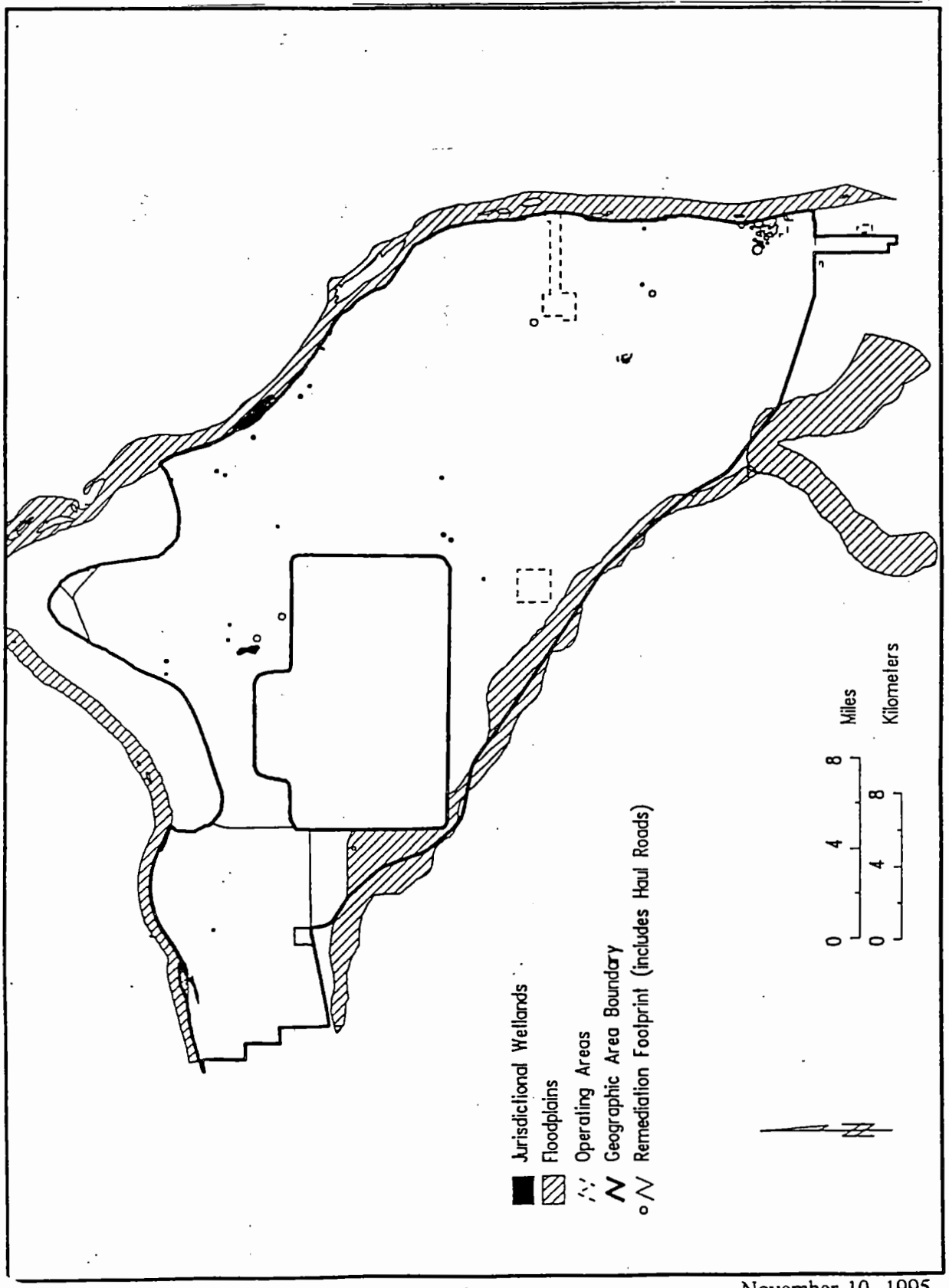


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Figure 5-26. Restricted Future Land-Use Alternative (R1) Impact on Shrub-Steppe Habitat, All Other Areas Geographic Area.

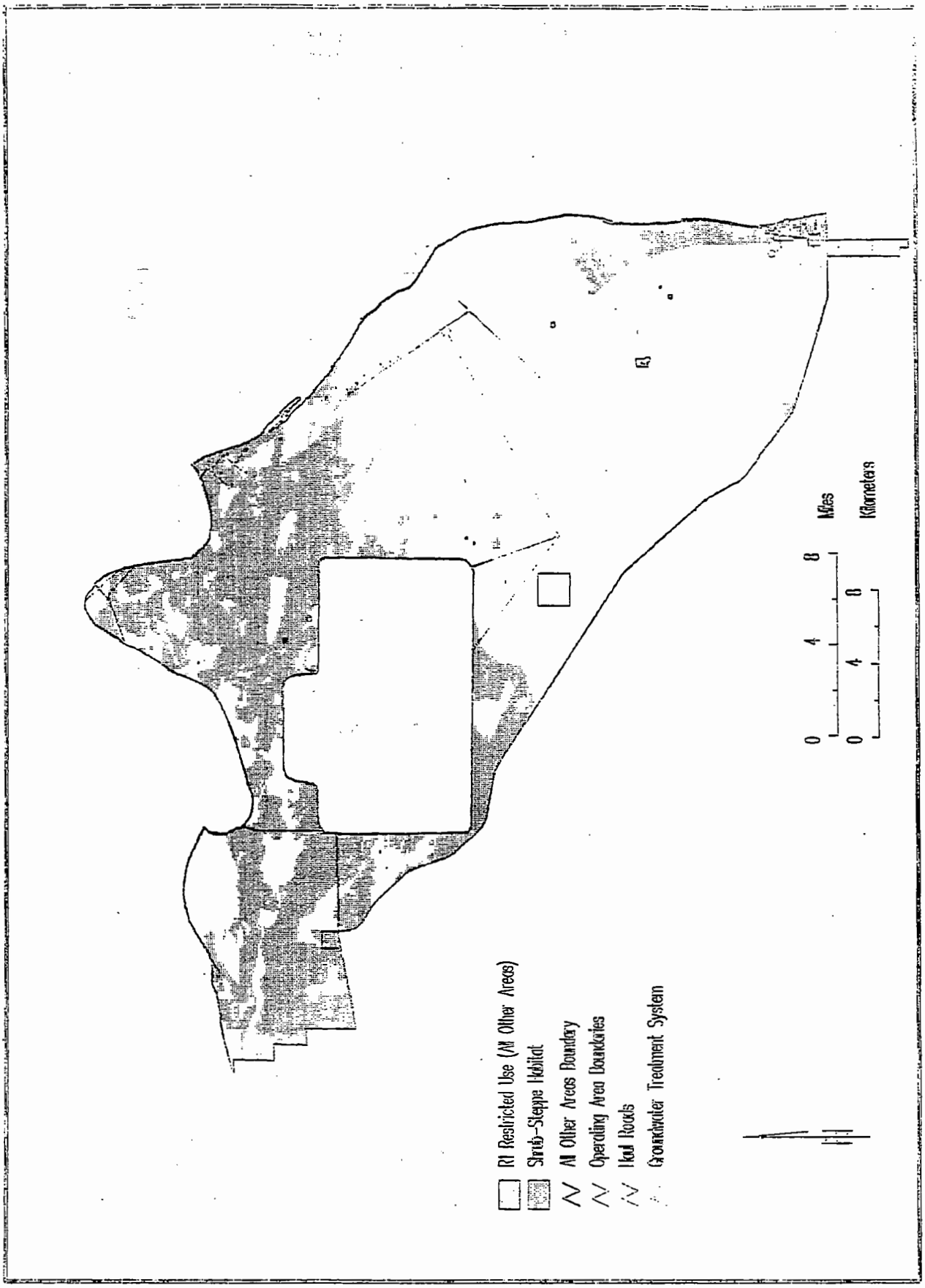


Figure 5-46. Restricted Use Alternative (R1) impact on shrub-steppe, All Other Areas.

Table 5-38. Comparison of Ecological Impacts under the All Other Areas Geographic Area Future Land-Use Alternatives.[a]

Resources Impacted	No Action	Alternatives	
		Restricted (R1)	Restricted (R2)
Shrub-steppe Habitat	5 ha (12 ac)	115 ha (287 ac)	134 ha (329 ac)
Species of Concern[b]	0	2	1
Wetlands[c]	0	0	0

[a]Areal impact information generated from the GIS; includes potential disturbance associated with excavation, cap construction, trample zones, effluent lines, haul roads, and wells.

[b]Includes Swainson's hawk and loggerhead shrike habitat within zone of disturbance.

[c]National Wetlands Inventory Data.

The disturbance associated with the Restricted Future Land-Use Alternative (R1) would have cumulative impacts on shrub-steppe habitat on the Hanford Site, further reducing habitat for species dependent on dense sagebrush. Disturbance of large areas, even if revegetated, would create conditions favorable to introduce species such as noxious weeds that pioneer quickly on newly disturbed soil. These weed species would compete for available soil moisture and would make establishment of desirable native plants difficult. Restoration efforts would reduce impacts on some habitats, but would not fully replace plant communities that have developed over long time periods. The impacts to shrub-steppe habitat would not be significant.

5.5.4.3 Habitat Disturbance, Restricted Future Land-Use Alternative (R2). The Restricted Future Land-Use Alternative (R2) would involve constructing caps over past-practice waste sites and TSD facilities, constructing perimeter roads around caps, constructing groundwater remediation systems, and restoring sites. Implementation of the Restricted Future Land-Use Alternative (R2) would result in the destruction of 134 ha (329 ac) or 0.8% of the shrub-steppe habitat in the All Other Areas geographic area (Figure 5-27 and see Table 5-38). This alternative would not have significant impacts similar to those described for the Restricted Future Land-Use Alternative (R1). Potential impacts would include loss of habitat for song birds, habitat fragmentation, displacement or mortality of small mammals and reptiles, and abandonment of nest or den sites for other species. This alternative would not have cumulative effects on remaining shrub-steppe habitat.

5.5.4.4 Effects on Species of Concern, No-Action Alternative. The No-Action Alternative would not have significant impacts on species of concern in the All Other Areas geographic area.

5.5.4.5 Effects on Species of Concern, Restricted Future Land-Use Alternative (R1). The Restricted Future Land-Use Alternative (R1) potentially would have significant impacts on species of concern in the All Other Areas geographic area. The remedial activities could have short-term impacts on the Swainson's hawk, including physiological stress, if repeatedly flushed from nest sites, and possible nest abandonment, if disturbed during critical nesting periods. Loggerhead shrikes nest in sagebrush and trees on the Hanford Site, and are likely to nest in the All Other Areas geographic area where suitable habitat exists. Potential short-term impacts on the loggerhead shrike include nest desertion, loss of shrub-steppe habitat, and loss of prey base through habitat alteration (Fitzner et al. 1994).

Plant species of concern that may occur in the All Other Areas geographic area include the Columbia yellowcress and northern wormwood (state endangered and federal candidates). Remedial activities potentially could affect both of these plant species, if the activities are implemented in potential habitat.

Long-term impacts on species of concern could involve permanent loss of habitat, resulting in population decline and possible listing of candidate species as a federal threatened or endangered species under the *Endangered Species Act of 1973*. Reclamation would reduce impacts on some habitat, but would not fully replace diverse plant communities that have developed over long periods of time.

5.5.4.6 Effects on Species of Concern, Restricted Future Land-Use Alternative (R2). The Restricted Future Land-Use Alternative (R2) potentially would have significant impacts on the loggerhead shrike. Potential short-term impacts on the loggerhead shrike include nest desertion, loss of shrub-steppe habitat, and loss of prey base through habitat alteration (Fitzner et al. 1994).

Remedial activities potentially could affect populations of the Columbia yellowcress and northern wormwood, if the activities are implemented in potential habitat. Over the long term, the additional habitat losses could result in potential population decline and possible listing as threatened or endangered species under the *Endangered Species Act of 1973*.

5.5.4.7 Ecological Risk, No-Action Alternative. Existing radiological contamination in the All Other Areas geographic area is not expected to pose unacceptable risks to species or their habitats in the short or long term under the No-Action Alternative. Recent environmental monitoring efforts have found no significant differences in radionuclide concentrations in vegetation samples collected at Hanford Site and offsite locations. Other data indicate that Hanford operations have resulted in small accumulations of some radionuclides in fish and wildlife. However, the concentrations of radionuclides were not sufficient to pose a hazard to the organisms themselves or to humans who might consume them (PNL 1993).

An ecological risk assessment (Appendix C) was performed to evaluate the effects of potential long-term exposures to chemicals and radionuclides in the All Other Areas geographic area. The receptors evaluated in the ecological risk assessment included a generic plant, the Great Basin pocket mouse, the coyote, and the red-tailed hawk. No estimated radiation doses for ecological receptors in the All Other Areas geographic area were greater than the 0.1 rad/d benchmark suggested by IAEA (1992) as protective of terrestrial organisms (Table 5-39). The distribution of potential chemical and radionuclide exposures for the entire Hanford Site is shown on Figures 5-14 through 5-21.

The chemical HI for ecological receptors in the All Other Areas geographic area ranged from 1.87×10^{-7} to 1.55×10^{3} (Table 5-40). The single value for plants, and one of those for the mouse, was greater than 1.0, indicating a potential for adverse effects. However, chemical data were available for only two grid cells in the area. The limited data available for chemicals in the All Other Areas geographic area do not allow any conclusions about potential chemical hazards to ecological receptors. Continued monitoring and waste site stabilization included in the No-Action Alternative could mitigate the potential for any adverse effects.

Figure 5-27. Restricted Future Land-Use Alternative (R2) Impact on Shrub-Steppe Habitat, All Other Areas Geographic Area.

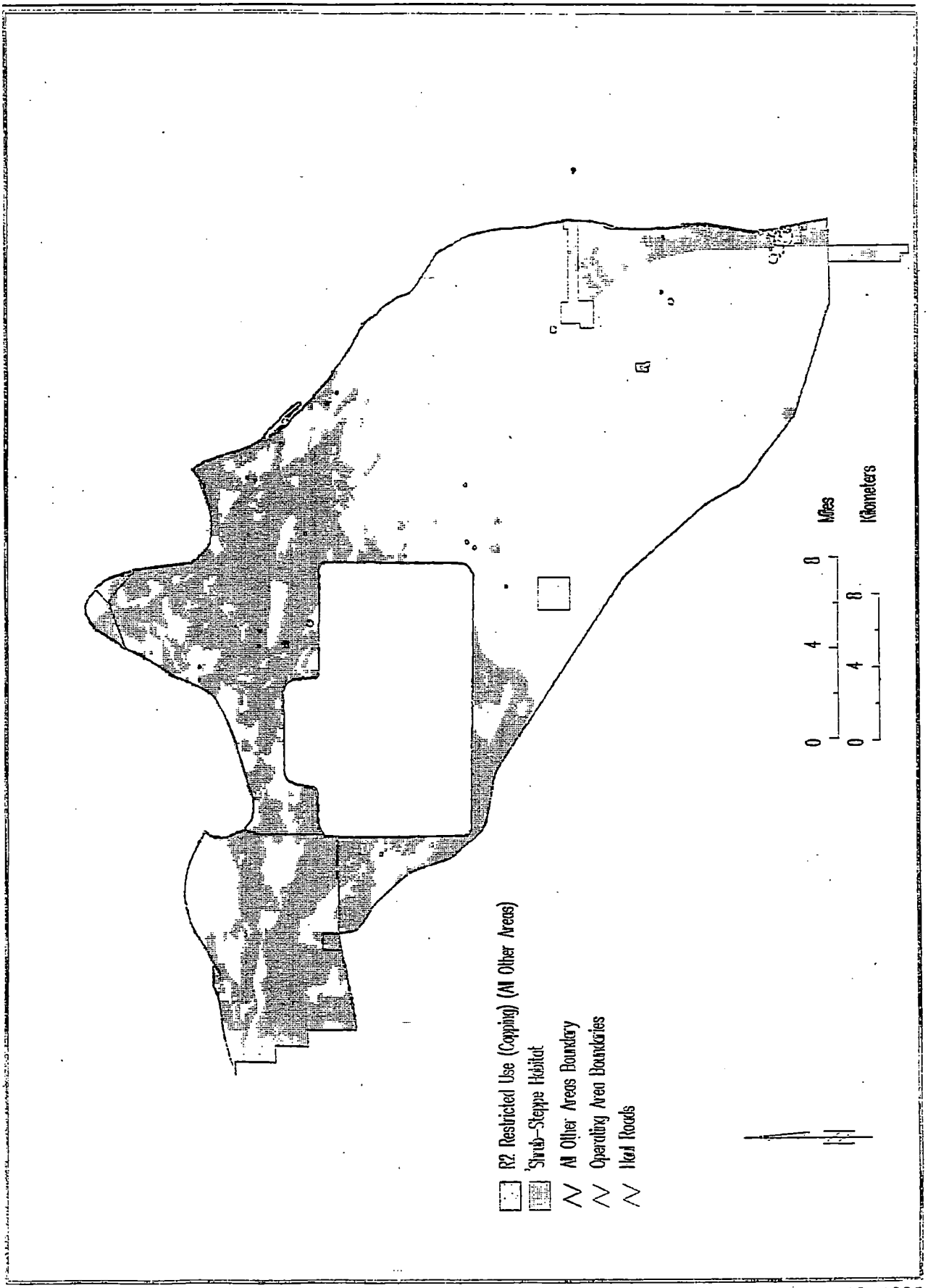


Table 5-39. Estimated Radiation Dose, Total by Cell, All Other Areas Geographic Area.

Cell ID	Estimated Total Dose (rad/d)			
	Plant	Mouse	Coyote	Hawk
589127	2.62 E-05	1.70 E-09	1.46 E-05	3.46 E-06
590121	1.53 E-05	8.44 E-10	7.22 E-06	1.71 E-06
592116	5.18 E-03	6.82 E-08	8.86 E-05	7.50 E-05
593116	1.95 E-05	1.05 E-11	1.37 E-08	1.15 E-08
594116	4.02 E-03	3.35 E-07	9.68 E-04	4.39 E-04

Range: 1.05 E-11 to 5.18 E-03.

Table 5-40. Hazard Index Summed by Cell, All Other Areas Geographic Area.

Cell ID	Hazard Index			
	Plant	Mouse	Coyote	Hawk
591122	--	0.211	9.68 E-07	1.87 E-07
594115	***71.6***	***1.55 E+03***	4.42 E-02	4.97 E-02

Range: 1.87 E-07 to 1.55 E+03.
Bold italics indicates greater than 1.0; -- indicates no data (see Appendix C).

5.5.4.8 Ecological Risk, Restricted Future Land-Use Alternative (R1). The Restricted Future Land-Use Alternative (R1) could result in increased short-term risk to ecological receptors as a result of airborne suspension and transport of contaminated soil. Airborne contamination could result in direct exposures of ecological receptors or subsequent uptake through the food chain. These exposures could result in significant short-term impacts, but could be reduced by implementation of mitigation measures for soils (Section 5.5.2), water quality (Section 5.5.3), and air quality (Section 5.5.5). Over the long term, potential adverse exposures to radionuclides and hazardous chemicals would be reduced by removing and disposing of much of the contaminated material.

5.5.4.9 Ecological Risk, Restricted Future Land-Use Alternative (R2). The Restricted Future Land-Use Alternative (R2) is less likely to increase short-term risks to ecological receptors, because less contaminated soil would be disturbed than under the Restricted Future Land-Use Alternative (R1). Over the long term, the caps are expected to reduce the potential ecological risks by limiting exposures. Some potential for exposure would remain because the contamination would remain in place under the caps. Continued monitoring would enable detection of potential adverse effects on ecological receptors so that additional corrective measures could be taken to minimize exposures.

5.5.4.10 Effects on Biodiversity, No-Action Alternative. The No-Action Alternative is not expected to have significant impacts on biodiversity in the short term. With adequate mitigation, the surface decontamination and waste site stabilization activities would not result in significant population losses of sensitive species. These activities are not likely to affect species diversity in shrub-steppe plant communities or affect the distribution of those communities. Monitoring data indicate that measured

exposures to chemical and radiological contaminants on the Hanford Site are below levels that could adversely affect plant and animal species (PNL 1995).

The potential long-term effects on biodiversity would depend on the likelihood of continued exposure of sensitive species to contamination. Such exposures could result in population losses of some species, which could have indirect food chain effects on the abundance of other species. Continued monitoring would enable detection of potential adverse effects on ecological receptors so that additional corrective measures could be taken to minimize exposures.

5.5.4.10.1 Potential Mitigation Measures. Potential mitigation measures for the No-Action Alternative include the following:

- restrict waste site stabilization activities to the immediate waste site area and avoid disturbing shrub-steppe habitat, whenever possible
- revegetate decontaminated and stabilized areas to provide habitat for small mammals and reptiles, and to reduce additional habitat loss from soil erosion
- continue monitoring wildlife and vegetation for potential adverse exposures to hazardous chemicals and radionuclides.

5.5.4.11 Effects on Biodiversity, Restricted Future Land-Use Alternative (R1). The Restricted Future Land-Use Alternative (R1) could have significant impacts on biodiversity by further reducing shrub-steppe habitat in the All Other Areas geographic area. Much of the shrub-steppe habitat on the Hanford Site has already been modified or lost due to wildfire, past agriculture practices, or industrial development. Further reductions in habitat could result in population losses in species dependent on dense sagebrush, such as the loggerhead shrike. Disturbance and subsequent reclamation of plant communities could reduce species diversity, with indirect effects on community functions, such as forage production, cover, and nutrient cycling. Excavation activities would fragment existing habitats and disrupt the connectivity among different habitats. These impacts are expected to be significant in the short term; long-term impacts to biodiversity could be avoided or reduced through implementation of mitigation measures.

5.5.4.11.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative (R1) include the following:

- Minimize the amount of area disturbed during remediation by restricting disturbance to an area not exceeding the trample zone around each waste site
- Revegetate all disturbed areas with a mixture of native vegetation including shrubs, grasses, and forbs
- Initiate contemporaneous reclamation to help offset habitat loss in the short term, limit the spread of noxious weeds, and reduce the time required to rehabilitate disturbed areas
- Limit unnecessary offroad travel during remediation in undisturbed habitat to avoid additional damage to shrub-steppe
- Use existing travel routes for transport of workers, supplies, etc., whenever possible, to concentrate traffic and associated noise in specific areas

- Use silt fences to control wind and waterborne runoff, spray water on dry areas during excavation, and cover any contaminated areas not being worked at a given time

- Provide compensatory mitigation of shrub-steppe habitat in other suitable locations onsite in cases where shrub-steppe cannot be restored or developed in remediation areas

- Swainson's hawk: exclude human activity within a 250-m (807-ft) buffer around active nests from April to September

- Loggerhead shrike: avoid disturbing habitat known to contain nests and foraging areas from March 1 to September 30

- Avoid modification or destruction of shrub-steppe habitat (Fitzner et al. 1994)

- Plant species of concern.

*5.5.4.12 **Effects on Biodiversity, Restricted Future Land-Use Alternative (R2).*** The Restricted Future Land-Use Alternative (R2) would involve levels of disturbance similar to the Restricted Future Land-Use Alternative (R1), with similar impacts to biodiversity.

*5.5.4.12.1 **Potential Mitigation Measures.*** Potential mitigation measures for the Restricted Future Land-Use Alternative (R2) are the same as for the Restricted Future Land-Use Alternative (R1).

5.5.5 Air Quality

*5.5.5.1 **Effects on Air Quality, No-Action Alternative.*** The No-Action Alternative would involve surface decontamination and stabilization of past-practice waste sites and TSD facilities. These activities would not have significant air quality impacts. Concentrations of airborne pollutants from the No-Action Alternative would be well below those estimated for the hypothetical excavation site evaluated under the Restricted Future Land-Use Alternative (R1) (Section 5.5.5.2). Environmental monitoring and maintenance activities would not generate amounts of airborne pollutants exceeding the amounts currently generated on the Hanford Site.

*5.5.5.1.1 **Potential Mitigation Measures.*** Potential mitigation measures would include watering areas or other methods of dust suppression where soil is disturbed to reduce potential short-term dust generation and revegetation of exposed areas to minimize long-term dust generation.

*5.5.5.2 **Effects on Air Quality, Restricted Future Land-Use Alternative (R1).*** The Restricted Future Land-Use Alternative (R1) would include excavating, loading, and hauling contaminated soil from past-practice waste sites and TSD facilities; constructing groundwater remediation systems; and restoring sites. Waste site excavation would generate fugitive dust, possibly contaminated with radioactive particles. Pollutants also would be generated by combustion of fuel in equipment used for excavation, loading, and hauling. The potential for air quality impacts was evaluated by estimating pollutant concentrations in the air resulting from a hypothetical waste site excavation in the 300 Area. An excavation rate of 450,000 kg/d (1 million lb/d) was used for estimating purposes. The amounts of pollutants generated at the waste site, and concentrations of pollutants downwind from the waste site, were estimated using the procedures and assumptions described in Appendix G. The estimated

concentrations that workers could be exposed are within appropriate standards (Table 5-41), indicating that impacts to workers would not be significant.

The results presented in Table 5-41 indicate that remedial activities could have significant short-term air quality impacts to members of the public located offsite. Estimated concentrations of airborne radionuclides that the general public could be exposed are at or somewhat above guideline concentrations. These short-term impacts would cease when remediation was completed.

Table 5-41. Estimated Concentrations of Airborne Contaminants from Excavation at the 300 Area.[a]

Type of Air Contaminant	Contaminant Name	Concentration in the Immediate Vicinity[b]	Onsite Occupational Standard or Guideline[c]	Concentration at Nearest Property Line[d]	Offsite Air Quality Standard or Guideline[e]
Fugitive Dust ($\mu g/m^3$)	PM_{10}	780	5,000, 8-hr average	43	150, 24-hr average
Radioisotopes (pCi/m^3)	Sr-90	82	2,000, annual average	4.6	50, annual average
	Cs-137	82	60,000, annual average	4.6	400, annual average
	Pu-239, -240	0.3	3, annual average	0.02	0.02, annual average
	U-238	2.9	300, annual average	0.16	0.10, annual average
Products of Fuel Combustion ($\mu g/m^3$)	total suspended particulates	72	15,000, 8-hr average	3.9	–
	carbon monoxide	420	55,000, 8-hr average	26	9,000, 8-hr average
	nitrogen dioxide	730	9,000, 8-hr average	40	50, annual average
	sulfur dioxide	98	13,000, 8-hr average	5.4	20, annual average

[a]Procedures and assumptions for estimating concentrations of airborne contaminants are discussed in Appendix G. The estimated concentrations of fugitive dust and fuel combustion products do not include background concentrations.

[b]Concentrations immediately downwind from the excavation site are potential concentrations that workers could be exposed.

[c]Occupational standards for fugitive dust and combustion products are PELs listed in 29 CFR 1910. Occupational guidelines for airborne radionuclides are listed in Federal Guidance Report No. 11 (EPA 1988b).

[d]Concentrations at the nearest property line are potential concentrations that the general public could be exposed.

[e]Air quality standards for fugitive dust, CO, and NO_2 are National Ambient Air Quality Standards (40 CFR 50-99). The standard for SO_2 is a Washington State standard. Guidelines for airborne radionuclides are DCGs listed in DOE Order 5400.5 (DOE 1993a).

DCG = Derived Concentration Guidelines.
PEL = Permissible Exposure Limits.

Several factors lend conservatism to this analysis. For example, the estimated downwind concentrations of uranium-238 in Table 5-41 were based on the highest known concentration of uranium-238 in any waste site in the 300/400 Areas. Furthermore, these concentrations would be produced only during brief periods when pockets of highly contaminated waste materials would be excavated, whereas the guideline concentrations used for comparison are annual averages. Variations

in wind direction during the year also would affect the annual average concentration at a receptor location.

Concentrations in Table 5-41 are consequences of remedial activities at one site. Simultaneous activities at several sites would result in higher concentrations, particularly if the sites happened to be in line and parallel to the wind direction. Estimates of potential cumulative concentrations were made by assuming simultaneous excavation of five sites aligned with the wind direction. The five sites were identical to the one previously described, and were assumed to be spaced 200 m (660 ft) apart. With this arrangement, cumulative concentrations of airborne radionuclides would be greater than applicable guideline concentrations for exposed members of the public (Table 5-42). The results presented in Tables 5-41 and 5-42, while conservative, indicate that mitigation measures would be required to reduce potential adverse health effects. As was discussed in Section 5.3.5.2, hauling of waste to an onsite disposal facility would generate fugitive dust at levels below applicable standards.

5.5.5.2.1 Potential Mitigation Measures. Potential mitigation measures for reducing potential air quality impacts include spraying excavation sites with water or surfactants for dust suppression, which could reduce fugitive emissions by up to 50% (EPA 1985). Temporary enclosures could be constructed over the excavation sites to contain airborne contaminants. Some remediation may require remote operations. Monitoring of air quality adjacent to and downwind from excavation activities would be performed to evaluate the effectiveness of mitigation measures.

5.5.5.3 Effects on Air Quality, Restricted Future Land-Use Alternative (R2). The Restricted Future Land-Use Alternative (R2) would include placing caps over past-practice waste sites and TSD facilities, constructing groundwater remediation systems, and restoring sites. Airborne pollutants produced by this alternative would include dust and emissions from construction equipment. Air quality impacts of remediation to restricted use (R2) would be lower than the estimates in Tables 5-41 and 5-42, because less contaminated materials would be disturbed.

The hauling of materials from borrow areas for construction of caps would generate similar fugitive dust emissions as estimated for the Restricted Future Land-Use Alternative (R1). No significant impact would be expected.

5.5.5.3.1 Potential Mitigation Measures. Potential mitigation measures for this alternative are the same as those for the Restricted Future Land-Use Alternative (R1).

5.5.6 Noise

5.5.6.1 Noise Effects, No-Action Alternative. Under the No-Action Alternative, little or no change would occur in noise impacts on the surrounding environment. The sound levels in the ambient environment would remain essentially the same as current noise levels.

5.5.6.2 Noise Effects, Restricted Future Land-Use Alternative (R1). This alternative involves excavating, loading, and hauling contaminated soil from past-practice waste sites and TSD facilities, constructing groundwater remediation systems, and restoring sites. The scenario described under the Unrestricted Future Land-Use Alternative for the Reactors on the River geographic area (Section 5.3.6.2) represents the most conservative conditions for noise generation at the Hanford Site, and would be applicable as a conservative scenario for the 300 Area in the All Other Areas geographic area. Because the activities associated with the Restricted Future Land-Use Alternative (R1) in the All Other Areas geographic area would be less extensive than those associated with the

Table 5-42. Cumulative Impacts of Airborne Contaminants from Excavation of Five Sites in the 300 Area.[a]

Type of Air Contaminant	Contaminant Name	Concentration in the Immediate Vicinity[b]	Onsite Occupational Standard or Guideline[c]	Concentration at Nearest Property Line[d]	Offsite Air Quality Standard or Guideline[e]
Fugitive Dust ($\mu g/m^3$)	PM_{10}	1,300	5,000, 8-hr average	140	150, 24-hr average
Radioisotopes (pCi/m^3)	Sr-90	140	2,000, annual average	15	50, annual average
	Cs-137	140	60,000, annual average	15	400, annual average
	Pu-239, -240	0.5	3, annual average	0.06	0.02, annual average
	U-238	5.0	300, annual average	0.5	0.10, annual average
Products of Fuel Combustion ($\mu g/m^3$)	total suspended particulates	120	15,000, 8-hr average	13	–
	carbon monoxide	790	55,000, 8-hr average	84	9,000, 8-hr average
	nitrogen dioxide	1,200	9,000, 8-hr average	130[f]	50, annual average
	sulfur dioxide	170	13,000, 8-hr average	17	20, annual average

[a]Procedures and assumptions for estimating concentrations of airborne contaminants are discussed in Appendix G. The five sites are assumed to be 200 m (660 ft) apart and aligned in the direction the wind is blowing. The estimated concentrations of fugitive dust and fuel combustion products do not include background concentrations.

[b]Concentrations immediately downwind from the excavation site are potential concentrations that workers could be exposed.

[c]Occupational standards for fugitive dust and combustion products are PELs listed in 29 CFR 1910. Occupational guidelines for airborne radionuclides are listed in Federal Guidance Report No. 11 (EPA 1988b).

[d]Concentrations at the nearest property line are potential concentrations that the general public could be exposed.

[e]Air quality standards for fugitive dust, CO, and NO_2 are National Ambient Air Quality Standards (40 CFR 50-99). The standard for SO_2 is a Washington State standard. Guidelines for airborne radionuclides are DCGs listed in DOE Order 5400.5 (DOE 1993a).

[f]The concentration of NO_2 appears to exceed the air quality standard. All of the estimated concentrations, however, are levels that would be expected during normal daily working hours, whereas most air quality standards are average levels during longer periods of time (e.g., during a 365-day year). Using conservative background concentrations during nonworking periods, and in consideration of changes in wind direction, it can be shown that averaged levels of NO_2 would not exceed the air quality standard.

DCG = Derived Concentration Guidelines.
PEL = Permissible Exposure Limits.

conservative scenario, adverse noise impacts also are expected to be less. Because noise impacts of the most conservative scenario are not expected to violate State of Washington noise standards, the noise impacts of implementing the Restricted Future Land-Use Alternative (R1) in the All Other Areas geographic area would not be significant.

5.5.6.2.1 Potential Mitigation Measures. Mitigation measures that would reduce any potential noise impacts include monitoring of occupational noise exposure and providing hearing protection to construction/excavation personnel.

5.5.6.3 Noise Effects, Restricted Future Land-Use Alternative (R2). This alternative involves constructing caps over past-practice wastes and TSD facilities, constructing groundwater remediation systems, and restoring sites. Because associated remedial activities would be less intense than those associated with the conservative scenario for the All Other Areas geographic area (see Section 5.5.6.2), adverse noise impacts also would be expected to be lower. Noise impacts of the most conservative scenario are not predicted to violate state of Washington noise standards. Therefore, it is assumed that noise impacts of this alternative would not be significant.

5.5.7 Cultural Resources

5.5.7.1 Effects on Prehistoric Resources, No-Action Alternative. The No-Action Alternative could have significant impacts on prehistoric archaeological resources in the All Other Areas geographic area. The No-Action Alternative would involve surface decontamination and stabilization of past-practice waste sites and TSD facilities, and continuation of environmental monitoring and maintenance activities. Prehistoric resources that could be affected include two recorded Native American sites within the area. These consist of a Native American fishing camp and an occupation area. Prehistoric sites that remain unrecorded also may be subjected to primary (destruction) and secondary (damage) impacts.

5.5.7.1.1 Potential Mitigation Measures. Potential mitigation measures for Prehistoric Resources under the No-Action Alternative include the following:

- Before any ground disturbance activities, consultations would be conducted with the DOE-RL Historic Preservation Officer, the Washington SHPO, and concerned Native American Tribal groups and governments.

- All cultural resources-related work would be conducted in accordance with the *Hanford Cultural Resources Management Plan* (Chatters 1989).

- Whenever possible, avoidance of cultural resource areas identified during project planning and before field operations would serve as the primary form of mitigation.

- Whenever practicable, a full survey of the affected areas would be conducted.

- Surface mapping of all artifact material and data recovery for surface and subsurface materials would be performed only if this action does not pose a potential health risk to field investigators.

- When practicable, an archaeological monitor would be onsite during ground disturbing activities to ensure that construction impacts are limited to the remediation area only. This action would be taken only if it does not pose any potential health risk to the archaeological monitor.

- An interpretive program outlining the history of the Hanford Site would be presented to personnel involved in the remedial activities to foster greater awareness and sensitivity for the area's cultural resources.

- Remediation and maintenance personnel also would be made aware of the significance of cultural resources in the area, and of the consequences regarding destruction of sites or pedestrian collection of artifact materials.

5.5.7.2 Effects on Prehistoric Resources, Restricted Future Land-Use Alternatives (R1 and R2). The Restricted Future Land-Use Alternatives (R1 or R2) potentially would have significant impacts on prehistoric resources in the All Other Areas geographic area. Identified prehistoric cultural resources that could be adversely affected under the Restricted Future Land-Use Alternatives (R1 and R2) include one long-term occupation area, three campsites (one is listed on the National Register), a lithic scatter, and a rock cairn. In addition to these, three other prehistoric sites (not described) have been recorded in the Restricted Future Land-Use Alternative (R1 and R2) impact areas. Numerous prehistoric and historic isolated artifacts also have been recorded in these impact areas. Other prehistoric sites that remain unrecorded in the All Other Areas geographic area also may be subjected to primary and secondary impacts under the Restricted Future Land-Use Alternative (R1 and R2) actions.

5.5.7.2.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternatives (R1 and R2) would be the same as for the No-Action Alternative.

5.5.7.3 Effects on Historic Resources, No-Action Alternative. Recorded historic resources in the All Other Areas geographic area include a portion of the White Bluffs Road, which is potentially eligible to the National Register. A literature review and record search indicated that no recorded historic sites would be affected by the No-Action Alternative; however, the potential for primary and secondary impacts on unrecorded historic sites must be taken into account.

Potential historic resources within the All Other Areas geographic area include all items and structures that are more than 50 years old, and that might reflect the historic settlement and economic development of the area. This includes materials and structures related to the Manhattan Project and the World War II effort. Items and structures that are representative of the Cold War period must be considered for their historical significance. This would include all primary and ancillary defense mission support structures. Chapter 4.0, Figure 4-20, shows the location of major historic areas that could be impacted by the No-Action Alternative. Current surveillance and maintenance activities attempt to maintain and stabilize the existing structures within the area to ensure they are not unduly subjected to weathering and age.

5.5.7.3.1 Potential Mitigation Measures. Potential mitigation measures for Historic Resources under the No-Action Alternative include the following:

- building construction evaluations

- documentation of all historic structures determined to be eligible for the National Register in accordance with the Secretary of the Interior's Guidelines for Architectural and Engineering Documentation

- monitoring of potentially historic sites for essential repair and maintenance work

- restriction of access to historic sites to authorized personnel.

5.5.7.4 Effects on Historic Resources, Restricted Future Land-Use Alternatives (R1 and R2). A single historic resource, a livestock water cistern, was identified within the Restricted Future Land-Use Alternative (R2) impact area. Other historic sites and structures that have not been recorded could exist within the Restricted Future Land-Use Alternative (R1 and R2) impact areas. These sites potentially could be affected by either primary or secondary adverse impacts, if remedial activities are implemented.

5.5.7.4.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternatives (R1 and R2) would be the same as for the No-Action Alternative.

5.5.7.5 Effects on Areas of Concern to Native Americans, No-Action Alternative. Potentially significant impacts on Native American cultural sites under the No-Action Alternative would be an issue of concern to Native Americans. This issue is of particular concern if areas of traditional cultural uses (e.g., traditional burial areas or areas of religious use) are affected. This alternative would continue the existing restrictions on the use of some traditional fishing, hunting, and gathering sites and cultural properties of the Native Americans. Other sites in the All Other Areas geographic area that are currently used by Native Americans would remain available for their use under the No-Action Alternative.

5.5.7.5.1 Potential Mitigation Measures. Mitigation measures to address Native American concerns under the No-Action Alternative include the following:

- consulting with Native American Tribal governments/groups with regard to the potential impacts on areas that might concern them before implementation of project activities

- incorporating recommendations provided by Native American Tribal governments and organizations into project-specific cultural resource mitigation plans for proposed remedial activities

- incorporating recommendations provided by Native American tribal governments and organizations into revegetation plans for proposed remedial activities

- involving representatives of Native American Tribal governments and organizations in archaeological monitoring during remedial activities.

5.5.7.6 Effects on Areas of Concern to Native Americans, Restricted Future Land-Use Alternatives (R1 and R2). Potentially significant impacts on Native American cultural sites under the Restricted Future Land-Use Alternatives (R1 and R2) would be an issue of concern to Native Americans. This issue is of particular concern if areas of traditional cultural uses (e.g., traditional burial grounds or areas of religious use) are affected. Remedial actions associated with these alternatives could encroach on the traditional hunting, fishing, and gathering sites and cultural properties of the Native Americans. Encroachment on the traditional tribal areas may be interpreted by the tribes as an

abrogation of the 1855 Treaties. Any major excavations of sites that contain artifacts or human remains, or are of spiritual importance to Native Americans, would be significant because the site would be unavoidably altered.

Implementation of either of the Restricted Future Land-Use Alternatives would reduce potential exposures to contamination and allow Native American and other uses of the All Other Areas geographic area. Restrictions would remain on soil-disturbing activities and groundwater use. Because residual contamination would remain under either of these alternatives, agricultural uses, such as grazing, would continue to be restricted.

5.5.7.6.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternatives (R1 and R2) would be the same as for the No-Action Alternative.

5.5.8 Visual and Aesthetic Resources

5.5.8.1 Effects on Visual and Aesthetic Resources, No-Action Alternative. The No-Action Alternative would involve surface decontamination and/or stabilization of past-practice waste sites, and TSD facilities, and continuation of existing environmental monitoring activities. These activities would not result in significant impacts on visual and aesthetic resources.

5.5.8.2 Effects on Visual and Aesthetic Resources, Restricted Future Land-Use Alternative (R1). Short-term impacts on visual resources would occur under the Restricted Future Land-Use Alternative (R1), but they are not expected to be significant. Remedial activities would include excavating, loading, and hauling contaminated soil from past-practice waste sites and TSD facilities; constructing groundwater remediation systems, and restoring sites. During the construction period, excavation activities would alter the natural terrain. Stockpiled soil would be located along open excavations while remedial activities were occurring. Depending on the number and size of the sites, they could be visible in the 300 and 600 Areas from Route 4. In addition, construction activities would generate fugitive dust, which temporarily could reduce visual clarity in the area. After the sites have been remediated, the excavations would be backfilled and revegetated, thus removing the stockpiled mounds and open pits, and reducing fugitive dust sources. Other visual impacts could include the construction of treatment facilities. Treatment plants in the All Other Areas geographic area would most likely be constructed near the 300 Area and would be visually compatible with existing facilities.

5.5.8.2.1 Potential Mitigation Measures. Potential mitigation measures for visual and aesthetic resources include the following:

- minimizing overall disturbance to the extent possible
- controlling fugitive dust (see Section 5.5.5)
- completing remediation in a timely manner
- conducting restoration activities immediately in remediated areas and contemporaneous with ongoing remedial activities in other areas
- restoring remediated areas by reshaping excavations to approximate original conditions and revegetating with native species.

5.5.8.3 Effects on Visual and Aesthetic Resources, Restricted Future Land-Use Alternative (R2). The Restricted Future Land-Use Alternative (R2) would involve placing caps over past-practice waste sites and TSD facilities, constructing groundwater remediation systems, and restoring sites. The caps potentially would have significant impacts on visual and aesthetic resources, depending on the design used. If the reference cap were used (Appendix E), the size and shape of the caps would be noticeable, with vegetation on the top of the cap contrasting with riprap on the sides. The caps could be noticeable in open space areas or mixed in with the facilities of the 300 and 600 Areas. Viewer attention would be focused on the caps, as their rigid geometric design and large size contrast visually with the natural landscape features and flat terrain. In addition, the reference cap design includes placement of large obelisk surface markers with posted warning signs near the caps, which would appear out of place in the landscape.

Construction activity associated with cap construction also would result in short-term impacts on the visual and aesthetic resources of the area. Construction equipment, haul trucks, and work crews would intrude on the surrounding viewscape. These activities also would result in the generation of fugitive dust, which could reduce visual clarity and obscure viewsheds. Other visual impacts could include the construction of treatment facilities. Treatment plants in the All Other Areas geographic area would be constructed near the 300 Area and would be visually compatible with existing facilities.

5.5.8.3.1 Potential Mitigation Measures. Potential mitigation measures would include those described for the Restricted Future Land-Use Alternative (R1), as well as the following: using surface markers designed to be compatible with the surrounding landscape and using natural materials in cap construction to minimize contrast with the surrounding landscape.

5.5.9 Human Health Risks

5.5.9.1 Human Health Risks, No-Action Alternative. Under the No-Action Alternative, activities would include surface decontamination and/or stabilization of past-practice waste sites and TSD facilities, environmental monitoring, and security functions. Potential human exposures to radiological and chemical contaminants would continue to be prevented by engineering and institutional controls, including Hanford Site access restrictions; restrictions on contact with, or proximity to, radioactive and hazardous materials; and restrictions on the use and withdrawal of groundwater. As long as these controls remain in place, risks to workers and the general public from contaminants in the All Other Areas geographic area are expected to remain within acceptable limits. Therefore, the No-Action Alternative, with continued use of engineering and institutional controls, is not expected to have significant impacts on human health.

Consideration of the No-Action Alternative for the Hanford Site requires analysis of potential human health risks in the event that engineering and institutional controls are removed. To assess these health effects, a risk assessment was performed for the Reactors on the River, Central Plateau, and All Other Areas geographic areas. Human health risks were calculated for exposures to radioactive materials, carcinogenic chemicals, and noncarcinogenic chemicals. The risk assessment used four exposure scenarios: agricultural, residential, industrial, and recreational. These exposure scenarios and other assumptions used in the risk assessment are discussed in Appendix B. The risk assessment results for the loss of institutional controls in the area under the No-Action Alternative are discussed in Section 5.7.3.

The risk assessment performed for the No-Action Alternative also included evaluation of an accident scenario. This scenario involves a range fire that burns a 2.6-km^2 (1-mi^2) area of the Hanford Site, releasing into the atmosphere any radioactive contaminants taken up by plants growing within that area. This type of accident was chosen for the No-Action Alternative because it is a natural occurrence not caused by any specific remedial activity (Appendix B5).

The airborne pathway was the only exposure pathway considered for estimating the impacts of this accident. Radiation doses from the airborne releases were estimated for onsite remediation workers, for a member of the public located at the NPAL, and for offsite populations. The NPAL for the accident analyses are along the Columbia River, State Route 240, and the roads leading to the Wye Barricade on the Hanford Site.

Table 5-43 lists the maximum estimated radiation doses that would result from the range fire and other accident scenarios for the future land-use alternatives. The maximum estimated radiation dose to an onsite worker for this scenario is less than 0.1% of the 5,000-mrem/yr annual dose limit for workers. The maximum dose to a member of the public at the NPAL is below the DOE standard of 10 mrem for public exposure to airborne releases as established in DOE Order 5400.5 (DOE 1993a).

5.5.9.2 Human Health Risks, Restricted Future Land-Use Alternative (R1). The Restricted Future Land-Use Alternative (R1) involves excavating, loading, and hauling contaminated soil from past-practice waste sites and TSD facilities, constructing groundwater remediation systems, and restoring sites. Remedial activities are not expected to result in significant adverse health effects to workers or the general public. Use of good health physics and industrial hygiene practices would ensure that exposures to radioactive and hazardous chemicals remain below applicable regulatory and administrative limits.

Over the long term, the Restricted Future Land-Use Alternative (R1) would result in beneficial impacts by removing some contamination, and preventing exposures to remaining contamination by restricting soil disturbing activities and groundwater use for an indefinite period. The combination of partial excavation, groundwater remediation, and use restrictions would reduce cancer risks to levels at or below the target risk range of 10^{-4} to 10^{-6}. Cancer risks could be higher if activity restrictions are violated.

The potential for adverse health effects resulting from accidents during remediation were evaluated in the risk assessment (Appendix B5). In addition to the range fire, two other accident scenarios were evaluated for the Restricted Future Land-Use Alternative (R1). The first is an explosion during the excavation of a waste site, dispersing a quantity of hazardous and radioactive material into the environment. The second involves a pump-and-treat accident where a fire is assumed to destroy a filtration unit containing concentrated contaminants from the treatment of contaminated groundwater. These scenarios are described in more detail in Section 5.7 and Appendix B5.

For the **excavation accident**, the maximum radiation dose to remediation workers, evaluated at 100 m (328 ft) from the accident location, is more than three orders of magnitude below the regulatory limit for radiation workers of 5,000 mrem/yr (see Table 5-43). Estimated doses at the NPAL and at the Hanford Site boundary are small compared to the allowable annual dose to a member of the general public from airborne sources of 10 mrem.

Table 5-43. Consequences of Accidents During Remediation, All Other Areas Geographic Area.

Accident Scenario	MEI Doses (mrem)			Maximum Population Dose (person-rem), Population, and Direction
	MEI at 100 m (327 ft)	MEI at the NPAL and Distance	Site Boundary Dose and Distance	
Groundwater Treatment	3.5 E+02 *1.4 E-04*[a]	1.9 E+02 at 120 m (3,950 ft) *9.5 E-05*[a]	7.4 at 840 m (2,800 ft) *3.7 E-06*[a]	0.94 to a population of 57,116 to the south of the 300 Area *3.2 E-04*[b]
Accidental Dispersion During Excavation	0.61 *2.4 E-07*[a]	0.33 at 120 m (3,950 ft) *1.7 E-07*[a]	5.9 E-02 at 840 m (2,800 ft) *3.0 E-08*[a]	6.2 E-02 to a population of 57,116 to the south of the 300 Area *3.1 E-05*[b]
Range Fire	1.7 *6.8 E-07*[a]	0.95 at 120 m (3,950 ft) *4.8 E-07*[a]	5.5 E-02 at 840 m (2,800 ft) *2.8 E-08*[a]	6.3 E-03 to a population of 57,116 to the south of the 300 Area *3.2 E-06*[b]

[a]Increased probability of this individual contracting a fatal cancer.
[b]Increase in LCFs in this population.
LCF = latent cancer fatality.
MEI = maximally exposed individual.
NPAL = nearest public access location.

For the **groundwater treatment accident**, the estimated maximum radiation dose to workers would be 7% of the regulatory limit of 5 rem/yr for radiation workers (see Table 5-43). The estimated dose at the NPAL is much higher than the 10-mrem limit, and the estimated dose at the Hanford Site boundary approaches the limit. Therefore, adverse impacts of the Restricted Future Land-Use Alternative (R1) on human health are considered potentially significant.

*5.5.9.2.1 **Potential Mitigation Measures**.* Potential mitigation measures for the Restricted Future Land-Use Alternative (R1) are those that are designed to prevent accidents during remedial activities or to reduce the severity of their impacts should they occur. Appropriate engineering and administrative measures would be applied during routine remedial activities so that the protection of workers, the general public, and the environment is ensured. For remediation and nearby workers, this involves wearing appropriate protective clothing; using respiratory protection, when necessary; and limiting exposures to contaminants in accordance with ALARA guidelines, and good health physics and industrial hygiene practices. For the general public, it involves the use of practices and procedures designed to reduce the transport of radioactive and hazardous materials offsite. These include use of dust suppressants during excavation; use of containment structures, when necessary; and other similar measures to control the spread of contaminants.

*5.5.9.3 **Human Health Risks, Restricted Future Land-Use Alternative (R2)**.* The Restricted Future Land-Use Alternative (R2) would involve placing caps over past-practice waste sites and TSD facilities, constructing groundwater remediation systems, and restoring sites. As with the Restricted Future Land-Use Alternative (R1), remedial activities under this alternative are not expected to result

in significant adverse health effects to workers or the general public. Implementation of the Restricted Future Land-Use Alternative (R2) would result in long-term beneficial impacts by preventing human exposures to contamination by use of caps and institutional controls. The institutional controls would include restrictions on soil-disturbing activities, and withdrawal and use of groundwater. The combination of caps and use restrictions would reduce cancer risks to levels at or below the target risk range of 10^{-4} to 10^{-6}. If activity restrictions are violated, cancer risks could be higher, approaching those estimated for the No-Action Alternative.

Because no significant excavation would occur under this alternative, the excavation accident scenario described under the Unrestricted Future Land-Use Alternative would not apply here. The groundwater treatment accident scenario probably would have the same impacts under the Restricted Future Land-Use Alternative (R2) as for the Unrestricted Future Land-Use Alternative. Therefore, adverse impacts of accidents under the Restricted Future Land-Use Alternative (R2) on human health are considered potentially significant.

5.5.9.3.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative (R2) are the same as for the Restricted Future Land-Use Alternative (R1).

5.5.10 Occupational Impacts

Potential occupational impacts associated with implementing the future land-use alternatives in the All Other Areas geographic area were estimated by comparing the field labor hours identified in Appendix H for each alternative with the BLS and DOE incident rates (NSC 1993; EG&G 1993). The estimates assume that all remediation waste is transported by truck for onsite disposal, as truck transport requires more labor and, thus, results in a more conservative analysis. Other assumptions used in this analysis are discussed in Appendix I.

5.5.10.1 Effects on Industrial Health and Safety, No-Action Alternative. Labor hour estimates are not available for the No-Action Alternative; therefore, no occupational impacts were estimated, and mitigation measures were not evaluated.

5.5.10.2 Effects on Industrial Health and Safety, Restricted Future Land-Use Alternatives (R1 and R2). Table 5-44 presents the potential occupational impacts for the Restricted Future Land-Use Alternatives (R1 and R2) for the All Other Areas geographic area based on BLS incident rates. Total cases include all work-related deaths and illnesses, and those work-related injuries that result in loss of consciousness, restriction of work or motion, transfer to another job, or a requirement for medical attention. It is the sum of lost workday cases and nonfatal cases without lost workdays. Lost workdays are those days that, because of occupational injury or illness, an employee was away from work or limited to restricted work activity. Lost workdays are estimated from lost workday cases.

Table 5-44. Summary of Occupational Impacts per BLS Statistics.

Future Land-Use Alternative (labor hours)	Estimated Total Cases	Estimated Lost Workday Cases	Estimated Nonfatal Cases Without lost Workdays	Estimated Lost Workdays
Restricted (R1) (4,165,919)	290	160	130	4,206
Restricted (R2) (19,407,701)	1,378	806	572	21,825

Table 5-45 presents the potential occupational impacts based on DOE incident rates. The occupational impacts estimated using DOE incident rates are substantially lower than the impacts estimated using BLS incident rates. DOE incident rates historically have compared favorably to private industry rates. The analysis using DOE incident rates is expected to more accurately reflect potential occupational impacts.

Potential occupational impacts are greatest for the Restricted Future Land-Use Alternative (R2). This is because cap construction results in substantial labor requirements for the transport of cap materials.

*5.5.10.2.1 **Potential Mitigation Measures**.* Potential mitigation measures include continued emphasis on safety awareness and worker training.

5.5.11 Volumes, Disturbed Areas, and Costs

This section presents cost estimates for the No-Action Alternative and future land-use alternatives being considered for the All Other Areas geographic area. Estimates of volumes and areas of disturbance also are provided. The assumptions and methodology used to estimate the costs of each future land-use alternative are described in Appendix H. Impacts of each alternative are summarized in Table 5-46.

*5.5.11.1 **Effects on Volumes, Disturbed Areas, and Costs, No-Action Alternative**.* The No-Action Alternative involves moving large quantities of surface soils to consolidate the contamination within original site boundaries and stabilize the site with clean fill dirt. Some backfill may be required, but no volumes are calculated. The costs for the No-Action Alternative have not been determined for each geographic area, but they are summarized for the Hanford Site in Table 5-24. These costs are not specific to the All Other Areas geographic area, but rather apply to the entire Hanford Site.

*5.5.11.1.1 **Potential Mitigation Measures**.* Potential mitigation measures include efforts to reduce the cost of institutional controls.

*5.5.11.2 **Effects on Cost Analysis, Restricted Future Land-Use Alternative (R1)**.* The Restricted Future Land-Use Alternative (R1) would involve excavating, loading, and hauling contaminated soil from past-practice waste sites and TSD facilities, constructing groundwater remediation systems, and restoring sites. Volumes to be excavated for the Restricted Future Land-Use Alternative (R1) include 1.6 million BCM (2.1 million BCY) of contaminated soil and 1.6 million BCM (2.1 million BCY) of uncontaminated soil (see Table 5-46). The total area disturbed is about 309 ha (765 ac). Two haul

options are analyzed for transporting contaminated soil to the ERDF: truck and rail. A swell factor for soil (bank volumes) of 18% is assumed. Uncontaminated soil would be used as backfill for waste sites.

The costs of remedial actions for this alternative are $1.0 billion if waste is hauled to the ERDF by truck or $0.7 billion if waste is hauled by rail (Tables 5-46 and 5-47).

5.5.11.2.1 Potential Mitigation Measures. Sensors to monitor contamination as excavation proceeds would prevent excavation of noncontaminated soils. Excavation of waste in combination with technologies such as soil washing also would result in reduced disposal requirements.

Continuing emphasis would be placed on the development and implementation of new remedial technologies to reduce the volumes, levels of disturbance, and costs associated with remediating waste sites in the All Other Areas geographic area. These new technologies may include *in-situ* treatments, which could significantly reduce the volumes of contaminated soils requiring excavation and disposal.

5.5.11.3 Effects on Cost Analysis, Restricted Future Land-Use Alternative (R2). The Restricted Future Land-Use Alternative (R2) would involve placing caps over past-practice waste sites and TSD facilities; constructing perimeter roads around caps; constructing groundwater remediation systems, which may include well sites, pumphouses, pipelines, and treatment facilities; and restoring sites, including grading embankments and slopes, and revegetating sites. The volumes of materials required to construct caps over past-practice waste sites and TSD facilities are shown in Table 5-48. The total area disturbed by remedial actions is 384 ha (948 ac). Two haul options for cap material are analyzed: truck and rail. The costs of remedial actions for this alternative are approximately $3.2 billion if cap materials are hauled by truck and $0.8 billion if hauled by rail (Tables 5-46 and 5-49).

Table 5-45. Summary of Occupational Impacts per DOE Statistics.

Future Land-Use Alternative (labor hours)	Estimated Total Cases	Estimated Lost Workday Cases	Estimated Lost Workdays
Restricted (R1) (4,200,000)	72	31	482
Restricted (R2) (19,400,000)	335	145	2,244

Table 5-46. Comparison of Volumes, Disturbed Areas, and Costs Associated with the All Other Areas Geographic Area Future Land-Use Alternatives.

Resources	Alternatives		
	No Action	Restricted (1)	Restricted (2)
Capping Materials LCM[a] (x 10^3)	0	0	8,663
Excavated Volumes BCM[a] (x 10^3)	--	--	--
Uncontaminated Soil	0	1,574	0
Contaminated Soil	0	1,603	0
Groundwater Treatment Costs in 1994 Dollars (millions)	0	31	31
Areas of disturbance (ha)	43	309	384
Project Costs in 1994 Dollars (millions)	2,424[b]	1,032 (truck haul) 672 (rail haul)	3,159 (truck haul) 794 (rail haul)

[a]Loose Cubic Meter (LCM) = 1.31 Loose Cubic Yard (LCY)
Bank Cubic Meter (BCM) = 1.31 Bank Cubic Yard (BCY)
ha = 2.47 ac.
[b]Costs for 100 years of institutional control for the Hanford Site. The costs are not broken down by geographic areas.

5.5.11.3.1 Potential Mitigation Measures. More site characterization has the potential to reduce the number and size of waste sites to be remediated. The use of a RCRA Subtitle C cap or a Modified RCRA cap instead of the reference cap described in Appendix E would reduce the volumes of cap materials required, associated areas of disturbance, and the costs of remedial actions. Minimum technology requirements for a RCRA Subtitle C cap are specified in 40 CFR 264.310. The Modified RCRA cap is conceptually similar to the RCRA Subtitle C cap, but it has been modified to better suit the conditions at the Hanford Site. The unit cost for a RCRA Subtitle C cap or Modified RCRA cap is \$51/m^2 (\$5/ft^2) and \$72/m^2 (\$7/ft^2), respectively. The unit cost for the reference cap is \$134/m^2 (\$12/ft^2) (DOE-RL 1994a).

Continuing emphasis would be placed on the development and implementation of new remedial technologies to reduce the volumes, levels of disturbance, and costs associated with remediating waste sites in the All Other Areas geographic area. These new technologies may include *in-situ* treatments, which could significantly reduce the volumes of contaminated soils requiring excavation and disposal.

Table 5-47. Summary of Potential Costs for the Restricted Future Land-Use Alternative (R1), All Other Areas Geographic Area.

Resource	Project Cost in 1994 Dollars (millions)			
	Waste Sites	Groundwater	Transportation	
			Trucks	Rail
Mobilization and Preparatory Work	5.8	--	--	--
Monitoring, Sampling, and Analysis	428	--	--	--
Surface Water Collection and Control	0.4	--	--	--
Solids Collection and Containment	98	--	--	--
Site Restoration	83	--	--	--
Demobilization	1.7	--	--	--
Total Costs	616.9	31	390	25
Fuel Use (millions) L (gal)	23 (6.1)	0 (0)	19 (5.0)	4.6 (1.2)
Labor Hours (millions)	2.4	0.3	2.5	0.1

Table 5-48. Volumes of Capping Materials Required for the Restricted Future Land-Use Alternative (R2), All Other Areas Geographic Area.

Material	Volumes (x 10^3) LCM	(LCY)
Drainage Gravel	389	(510)
Gravel	389	(510)
Basalt	3,888	(5,093)
Asphalt Base	128	(168)
Contour Fill	778	(1,019)
Lower Silt	1,295	(1,696)
Upper Silt	1,295	(1,696)
Sand	194	(254)
Asphalt	308	(403)
Total	8,663	(11,349)

LCM = Loose Cubic Meter.
LCY = Loose Cubic Yard.

Table 5-49. Summary of Potential Costs for the Restricted Future Land-Use Alternative (R2), All Other Areas Geographic Area.

Resource	Project Cost in 1994 Dollars (millions)			
	Waste Sites	Groundwater	Transportation	
			Trucks	Rail
Mobilization and Preparatory Work	5.7	--	--	--
Monitoring, Sampling, and Analysis	84	--	--	--
Surface Water Collection and Control	0.5	--	--	--
Solids Collection and Containment	460	--	--	--
Site Restoration	120	--	--	--
Demobilization	1.2	--	--	--
Total Costs	671.4	31	2,500	91
Fuel Use (millions) L (gal)	40 (10.3)	0 (0)	120 (31.8)	17 (4.6)
Labor Hours (millions)	3.5	0.3	16.7	0.4

5.6 Socioeconomic Impacts

The objective of the socioeconomic impact analysis is to assess the impacts of the various alternatives in each of the four geographic areas on the socioeconomic environment in the Richland-Kennewick-Pasco Metropolitan Statistical Area (which covers Benton and Franklin counties, inclusively, and is referred to as the "Tri-Cities"). The analysis addresses impacts on employment and general economic conditions, population, housing, public services, and infrastructure. This analysis also provides supporting information for the environmental justice analysis (Section 5.12), which evaluates the potential disproportional impacts on minority and low-income populations.

5.6.1 Methodology

Quantitative analyses were prepared for the potential impacts on employment, population, housing starts and prices, and taxable retail sales. These variables provide a summary of the socioeconomic impacts of the future land-use alternatives under consideration, and provide data for qualitative assessments of other socioeconomic impacts. For example, taxable retail trade (which includes services, contracting, wholesaling, finance and real estate, and other transactions in addition to the retail trade) and employment are measures of general economic conditions, while taxable retail sales and housing prices provide information about state and local government revenues. Available data on these variables were obtained from state and local sources and used to develop regression equations to relate the variables to Hanford Site employment levels. The regression equations were then used to estimate the impact of increased Hanford Site employment during remedial activities on economic conditions in the Tri-Cities. Appendix F describes the methodology used to estimate the quantitative impacts.

The key variable for estimating socioeconomic impacts is the number of full-time equivalent (FTE) workers required to perform remediation under each future land-use alternative. For the purposes of conservative estimations for this EIS, the effects of the alternatives are compared to a baseline scenario that assumes that Hanford employment remains at 15,600, which was the size of the workforce as of July 1995 (DOE-RL 1995). This conservative estimate assumes that future remedial activities will require employment of additional workers. However, as the DOE continues to restructure its workforce at the Hanford Site to meet its changing mission, it is unlikely that the

current workforce will increase significantly. This assumption allows assessment of the socioeconomic impacts against the status quo as it existed in 1995.

Projections over time of nonagricultural employment in the Tri-Cities, taxable retail sales, population, and housing market conditions for the baseline scenario indicate positive trends, even with a static Hanford Site employment level. These trends show the effects of non-Hanford economic growth and provide a basis for assessing the impacts of changes in Hanford activity.

The socioeconomic impacts of the alternatives in each geographic area were assessed independently. Remediation of each geographic area was assumed to start in the year 2000. The 2000 starting date was based on draft planning documents from the DOE showing most remedial activities (as opposed to planning and design activities) beginning on or after 2000. To provide a conservative assumption to this EIS, it was assumed that all remedial actions would be completed by 2018.

The total number FTE workers in any given year would depend on which remedial actions were undertaken during that year. In addition, activities in different geographic areas could be performed concurrently with activities in other geographic areas. Therefore, the timing of the various remedial actions would affect the total socioeconomic impacts. This means that the socioeconomic impacts of the preferred alternative, when selected, would not necessarily be the sum of the impacts from the individual areas.

The following analyses assume that waste is hauled to the ERDF by truck. The truck-haul scenarios require much larger labor inputs and, therefore, have much greater potential impacts resulting in a more conservative analysis. Use of rail to transport waste to the ERDF would correspondingly reduce socioeconomic impacts.

5.6.2 No-Action Alternative

The No-Action Alternative would involve continuing existing environmental monitoring, maintenance, and security programs, and would not involve remedial actions. The No-Action Alternative applies to all four geographic areas. For purposes of this analysis, it was assumed that Hanford employment levels would remain at the current level of 15,600 employees. This is equivalent to the baseline condition used for comparison of the future land-use alternatives.

Nonagricultural employment in the Tri-Cities would continue to increase under the No-Action Alternative as a function of economic growth unrelated to the Hanford Site. Nonagricultural employment is predicted to be roughly 60% higher in 2018 than in 1994 under the No-Action Alternative. Taking no action would not adversely affect growth in Tri-Cities employment.

Similarly, taxable retail sales (a measure of overall economic activity, and a key component of revenue for state and local governments) would continue to increase. Population growth also would continue to increase, with a total population in the Tri-Cities approximately 44% higher in 2018 than the 1994 population. Increased population growth would affect home prices and housing starts, which also would continue to increase.

Continued economic growth would increase the demand for police, fire, and utility services, infrastructure additions, and social services. However, growth trends for the No-Action Alternative, which are the same as the baseline scenario, are gradual and are not expected to place unanticipated or unusual demands on infrastructure or services.

5.6.3 Columbia River Geographic Area

Two future land-use alternatives were analyzed for the Columbia River geographic area, unrestricted and restricted use. Actions required to achieve unrestricted use were assumed to start in

2000 and be completed in 2018. Actions required to achieve restricted use were assumed to start in 2000 and be completed by 2002. The level of effort required to implement the Restricted Future Land-Use Alternative would be too small to be meaningful if stretched out to 2018. Under these assumptions, the Unrestricted Future Land-Use and the Restricted Future Land-Use alternatives would require approximately 637 and 112 FTE workers, respectively.

5.6.3.1 Employment and Economic Activity. For the Unrestricted Future Land-Use Alternative, Hanford employment would be about 4.1% above the baseline. For the Restricted Future Land-Use Alternative, Hanford employment would be about 0.7% higher during the period 2000-2002. Figure 5-28 shows the impacts of the higher Hanford employment on nonagricultural employment in the Tri-Cities.

The impacts of the Restricted Future Land-Use Alternative would be small (0.2% above baseline) and short-term. The maximum impact of the Unrestricted Future Land-Use Alternative would be about 0.9%, at the beginning of remedial activities. These impacts are not considered significant. The percentage impacts would decline over time, because nonagricultural employment would grow for the baseline projection even though Hanford employment is assumed to be constant. The decline in the percentage increase in 2018 reflects the downsizing of Hanford employment as the remedial activities are completed.

The Restricted Future Land-Use Alternative would have minimal impact (0.1%) on taxable retail sales (Figure 5-29). The maximum impact for the Unrestricted Future Land-Use Alternative would be about 0.6%. These impacts would have no significant impacts on the Tri-Cities' economy.

5.6.3.2 Population and Housing. The Restricted Future Land-Use Alternative would have minimal impact on Tri-Cities population, while the Unrestricted Future Land-Use Alternative would have a maximum increase of 0.6% above the baseline (Figure 5-30). The small impacts on population carry through to the housing market. The Unrestricted Future Land-Use Alternative would generate a maximum increase of 1.2% in housing prices, while the Restricted Future Land-Use Alternative would result in an increase of 0.2% (Figure 5-31). The Unrestricted Future Land-Use Alternative would generate an increase of approximately 2.2% in housing starts, while the Restricted Future Land-Use Alternative would generate an increase of 0.4% (Figure 5-32). These impacts would not be significant.

5.6.3.3 Public Services, Infrastructure, and Utilities. The impacts of both the Unrestricted and Restricted Future Land-Use Alternatives for the Columbia River geographic area would be too small to affect public services, infrastructure, or utilities in the Tri-Cities. Population growth and new housing starts, which might have such impacts, are projected to be too small to provide sufficient new demand for these services, especially given the larger increases projected under the baseline scenario.

5.6.4 Reactors on the River Geographic Area

Three future land-use alternatives were analyzed for the Reactors on the River (unrestricted and restricted [R1 and R2]). Based on a starting date of 2000 and a completion date of 2018, these levels of effort translate into approximately 495, 362, and 824 FTE workers for the Unrestricted Future Land-Use Alternative, the Restricted Future Land-Use Alternative (R1), and the Restricted Future Land-Use Alternative (R2), respectively.

5.6.4.1 Employment and Economic Activity. Hanford employment for the Unrestricted Future Land-Use Alternative would be approximately 3.2% above the baseline. Employment would be 2.3 and 5.3% above the baseline for the Restricted Future Land-Use Alternative (R1) and the Restricted Future Land-Use Alternative (R2), respectively. It is anticipated that some of the increased employment could be staffed by the existing workforce.

Figure 5-28. Predicted Increases in Nonagricultural Employment.

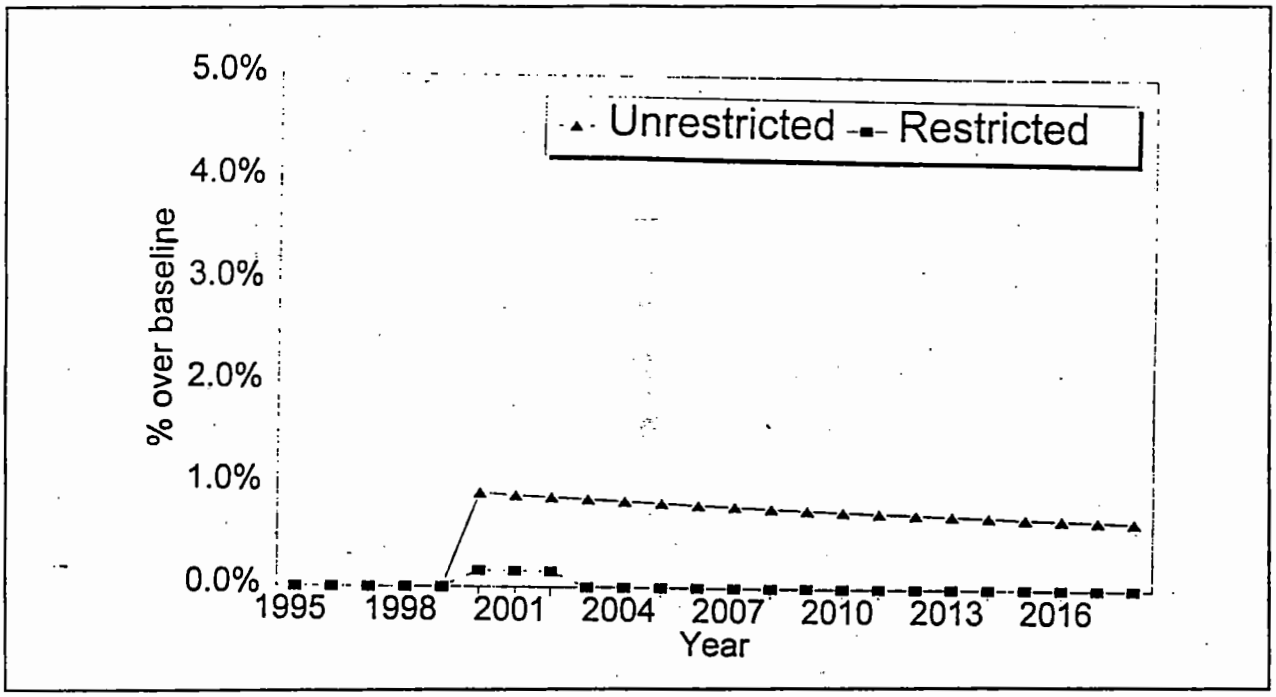


Figure 5-29. Predicted Increases in Taxable Retail Sales.

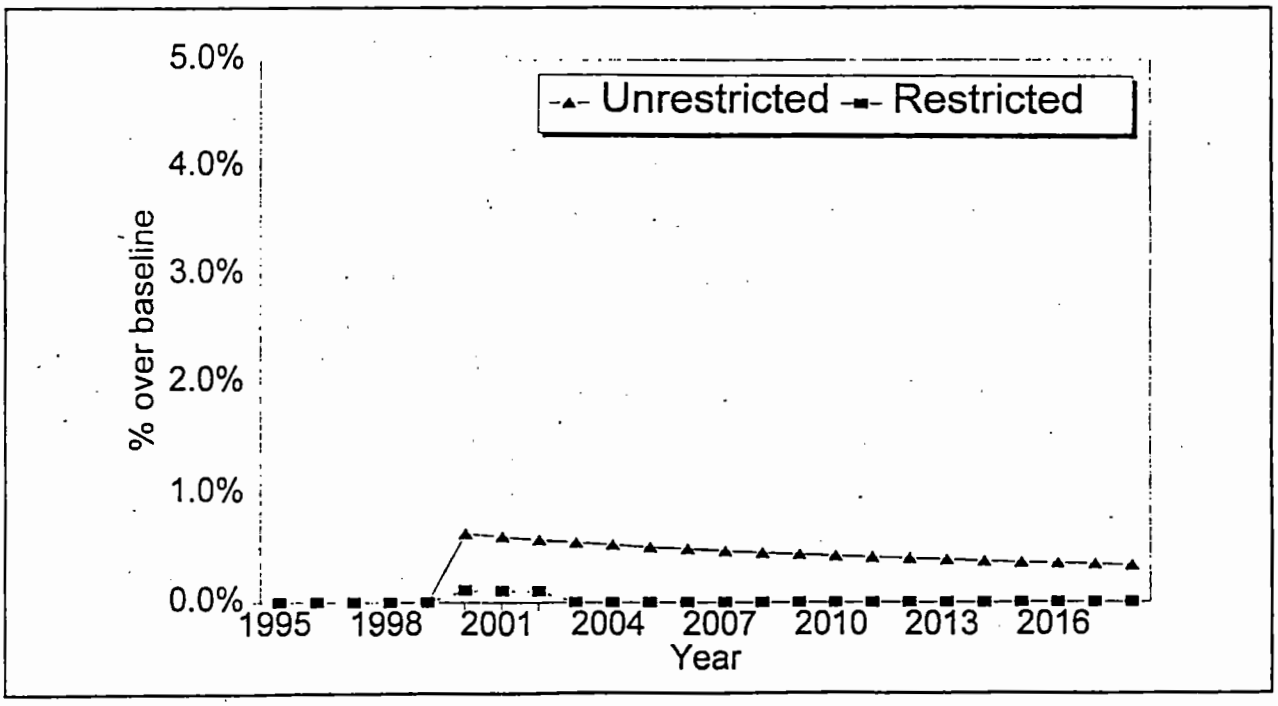


Figure 5-30. Predicted Increases in Population.

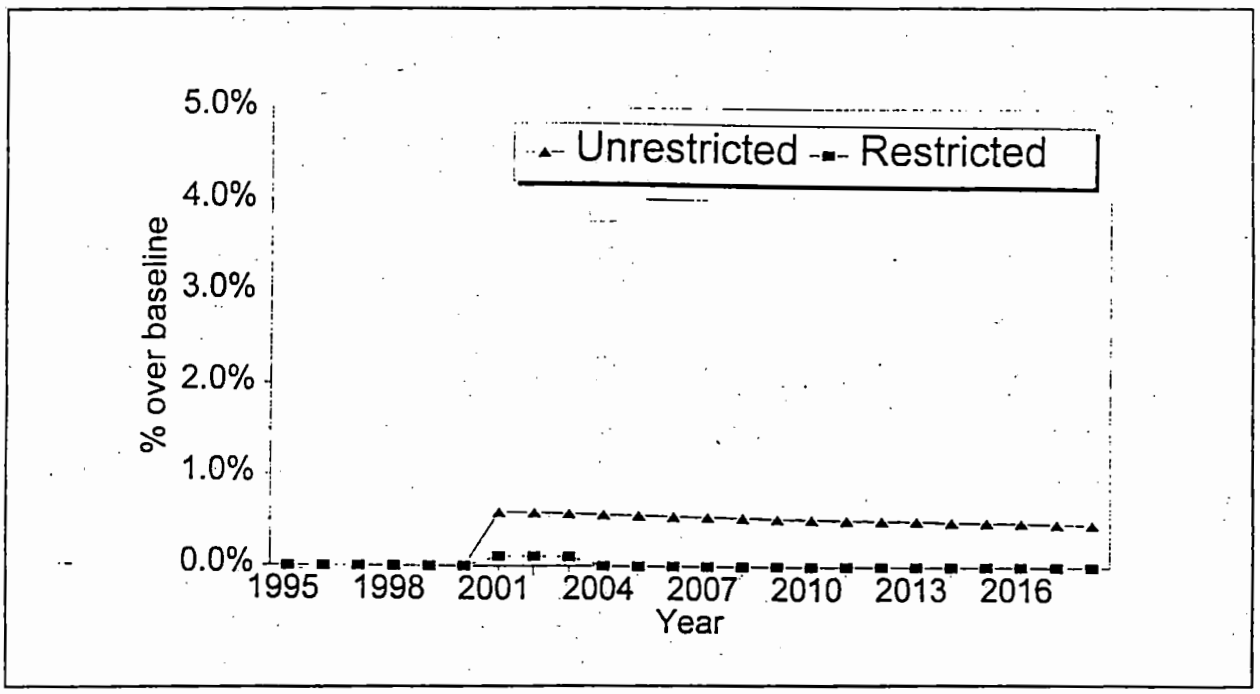
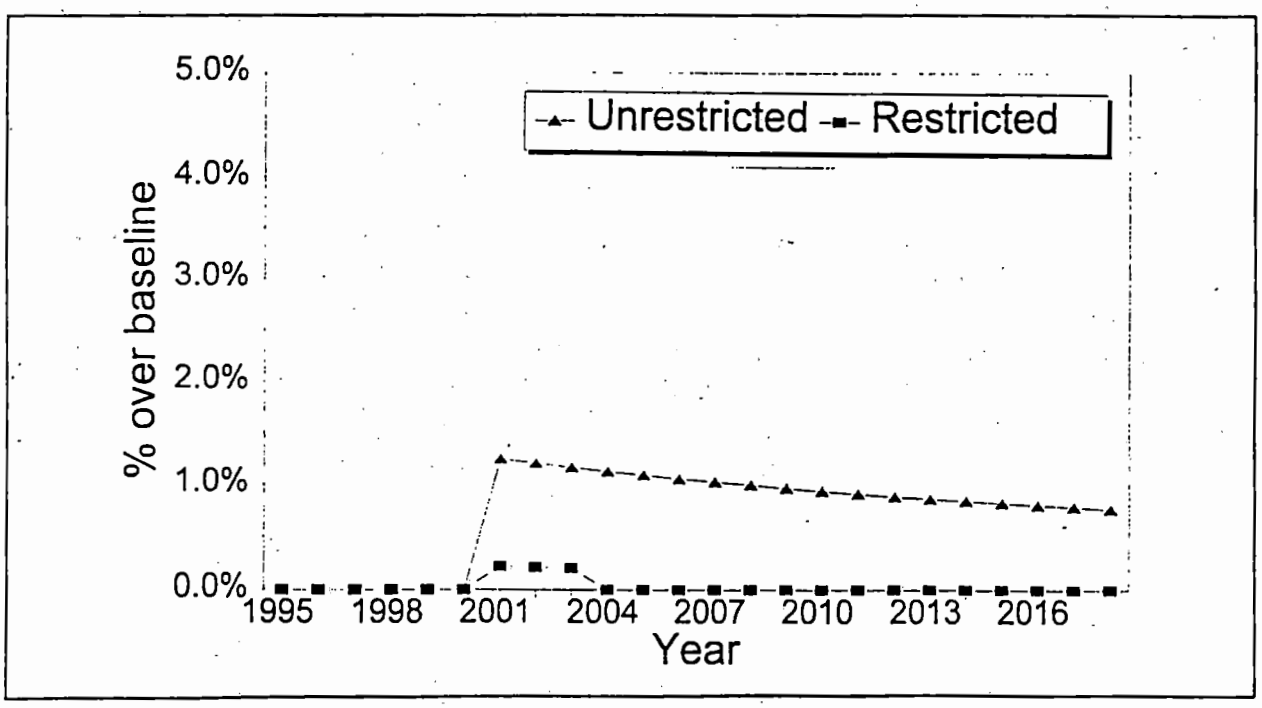


Figure 5-31. Predicted Increases in Home Prices.



The impact on nonagricultural employment for the Unrestricted Future Land-Use Alternative, the Restricted Future Land-Use Alternative (R1), and the Restricted Future Land-Use Alternative (R2) would be about 0.7, 0.5, and 1.2% at maximum, respectively (Figure 5-33).

Impacts on taxable retail sales, which reflects general economic activity in the Tri-Cities, would be about 0.5, 0.4, and 0.8% at maximum for the Unrestricted Future Land-Use Alternative, the Restricted Future Land-Use Alternative (R1), and the Restricted Future Land-Use Alternative (R2), respectively (Figure 5-34).

The impacts on employment and economic activity of all three future land-use alternatives for the Reactors on the River geographic area are not considered significant.

*5.6.4.2 **Population and Housing**.* The maximum impacts of the three alternatives on the Tri-Cities' population would be about 0.5, 0.3, and 0.8% above the baseline for the Unrestricted Future Land-Use Alternative, the Restricted Future Land-Use Alternative (R1), and the Restricted Future Land-Use Alternative (R2), respectively (Figure 5-35). The maximum impacts on housing prices would be 1.0, 0.7, and 1.6% for the Unrestricted Future Land-Use Alternative, the Restricted Future Land-Use Alternative (R1), and the Restricted Future Land-Use Alternative (R2), respectively (Figure 5-36). Maximum impacts on housing starts would be about 1.7 and 1.2% for the Unrestricted Future Land-Use Alternative and Restricted Future Land-Use Alternative (R1), respectively (Figure 5-37). These impacts are not considered significant. For the Restricted Future Land-Use Alternative (R2), the maximum predicted increase in housing starts would be about 2.8%, which would be a significant, although short-term, impact. Using the existing workforce to supply some of the increased employment required under these alternatives could reduce the predicted increases in economic indicators, such as housing starts.

*5.6.4.3 **Public Services, Infrastructure, and Utilities**.* The predicted population increases associated with the three future land-use alternatives for the Reactors on the River geographic area are not expected to result in significant increases on requirements for public services, such as police and fire protection, education, and social services. The predicted increase in housing starts under the Restricted Future Land-Use Alternative (R2) could result in a short-term increase in demand for new infrastructure and utilities.

5.6.5 Central Plateau Geographic Area

The Exclusive Future Land-Use Alternative for the Central Plateau geographic area would involve about 315 FTE workers[4], assuming the work begins in the year 2000 and finishes in 2018.

*5.6.5.1 **Employment and Economic Activity**.* Hanford employment would increase by about 2% for the Exclusive Future Land-Use Alternative. The maximum impact on nonagricultural employment in the Tri-Cities would be about 0.6% (Figure 5-38). The maximum impact on general economic activity, as measured by taxable retail sales, would be about 0.3% (Figure 5-39). These impacts would be too small to be significant.

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[4]This employment figure is based on BHI's baseline planning estimates, which assume that a modified RCRA C cap would be used to cap past-practice waste sites. Use of the reference cap design, described in Appendix E, would substantially increase labor hours, and could increase FTE workers.

Figure 5-32. Predicted Increases in Housing Starts.

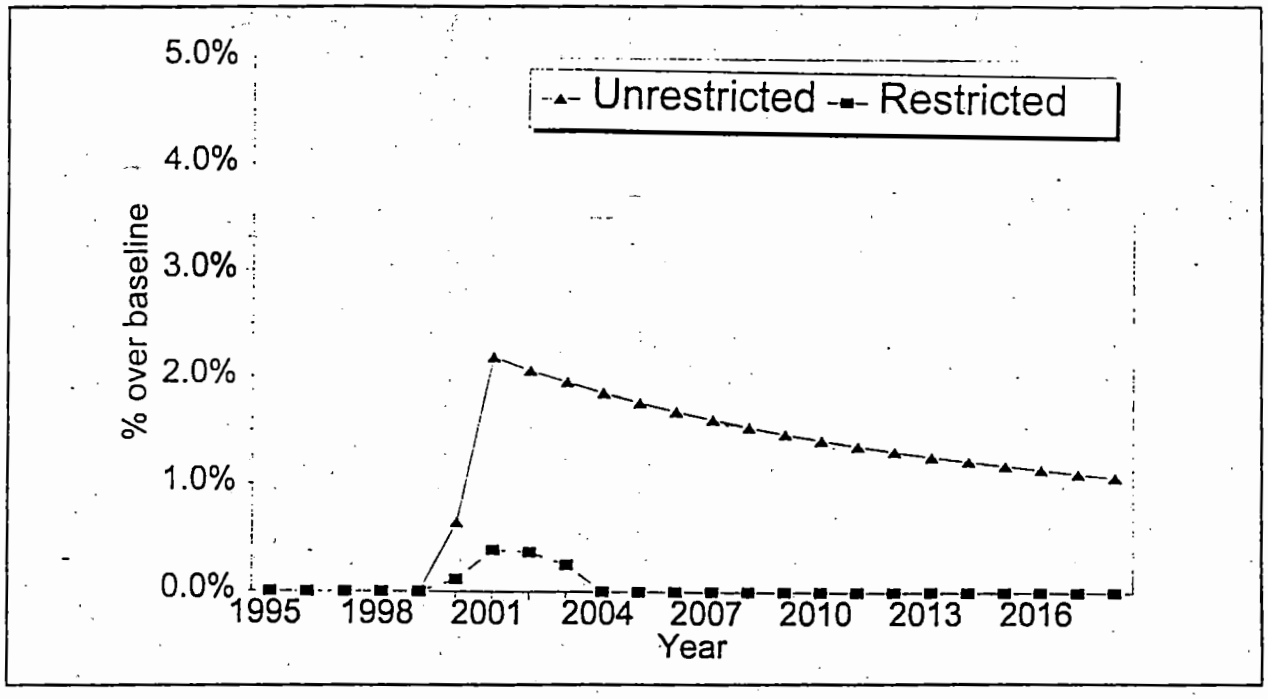

Figure 5-33. Predicted Increases in Nonagricultural Employment.

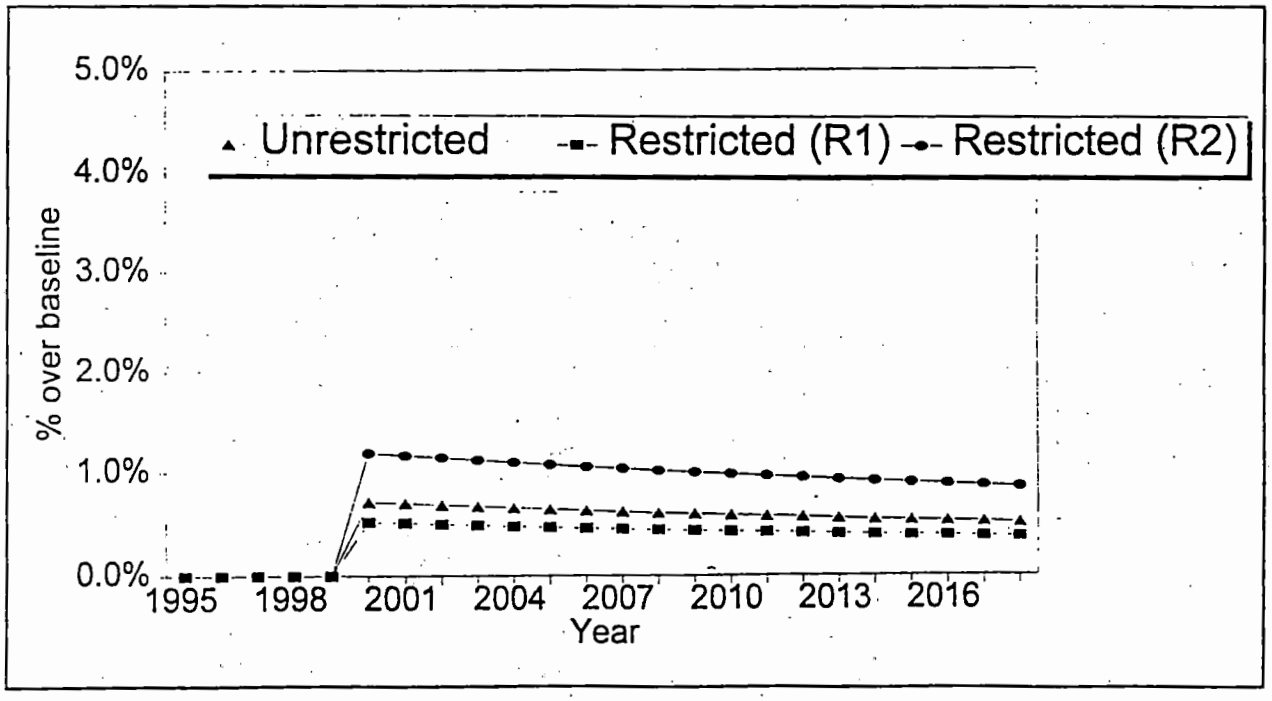

Figure 5-34. Predicted Increases in Taxable Retail Sales.

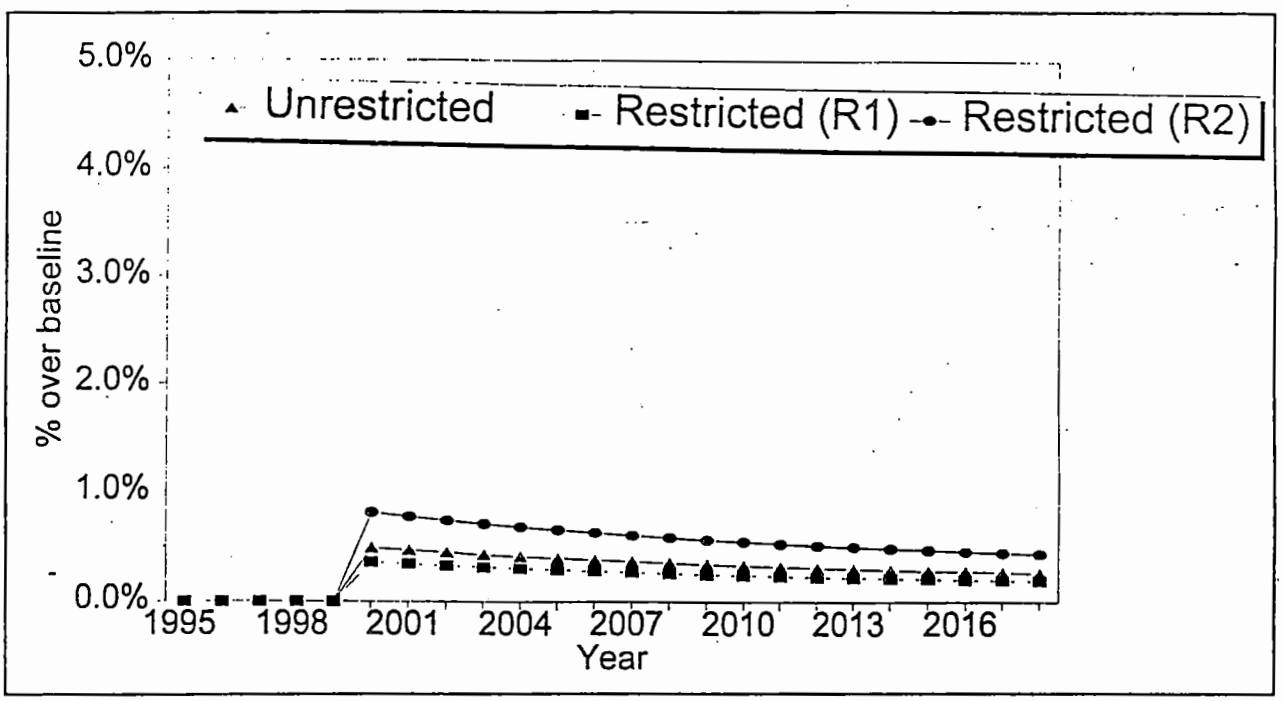

Figure 5-35. Predicted Increases in Population.

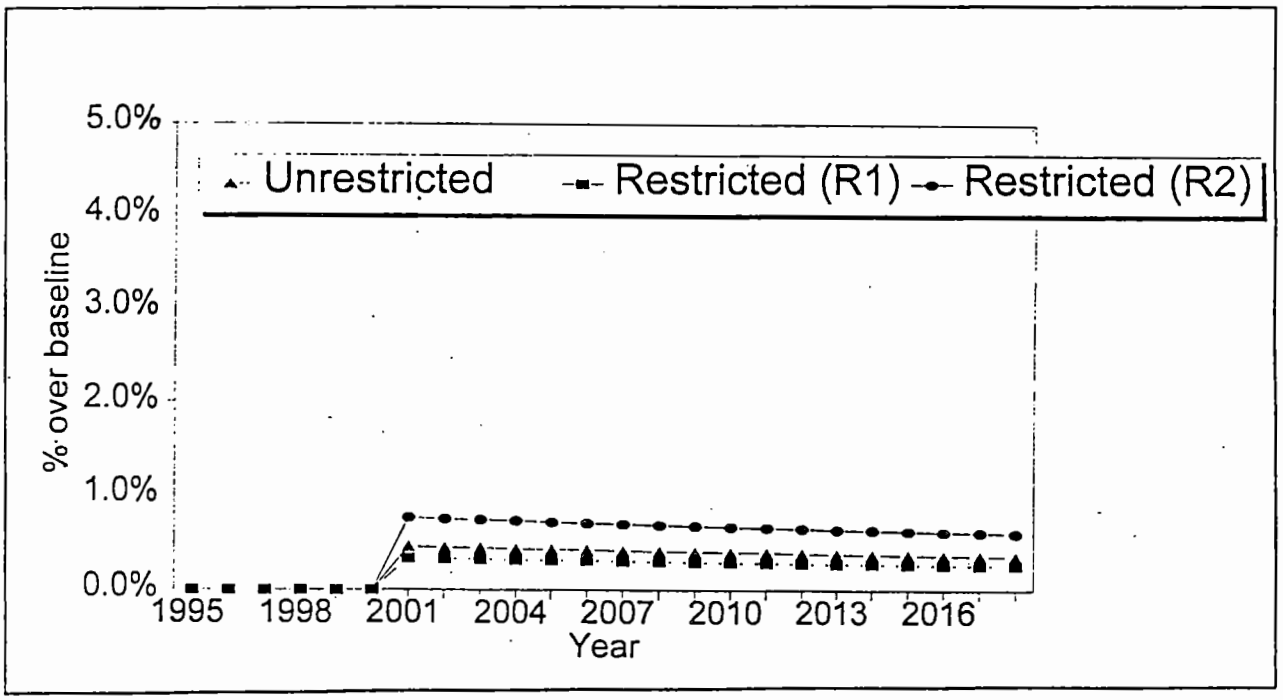

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Figure 5-36. Predicted Increases in Home Prices.

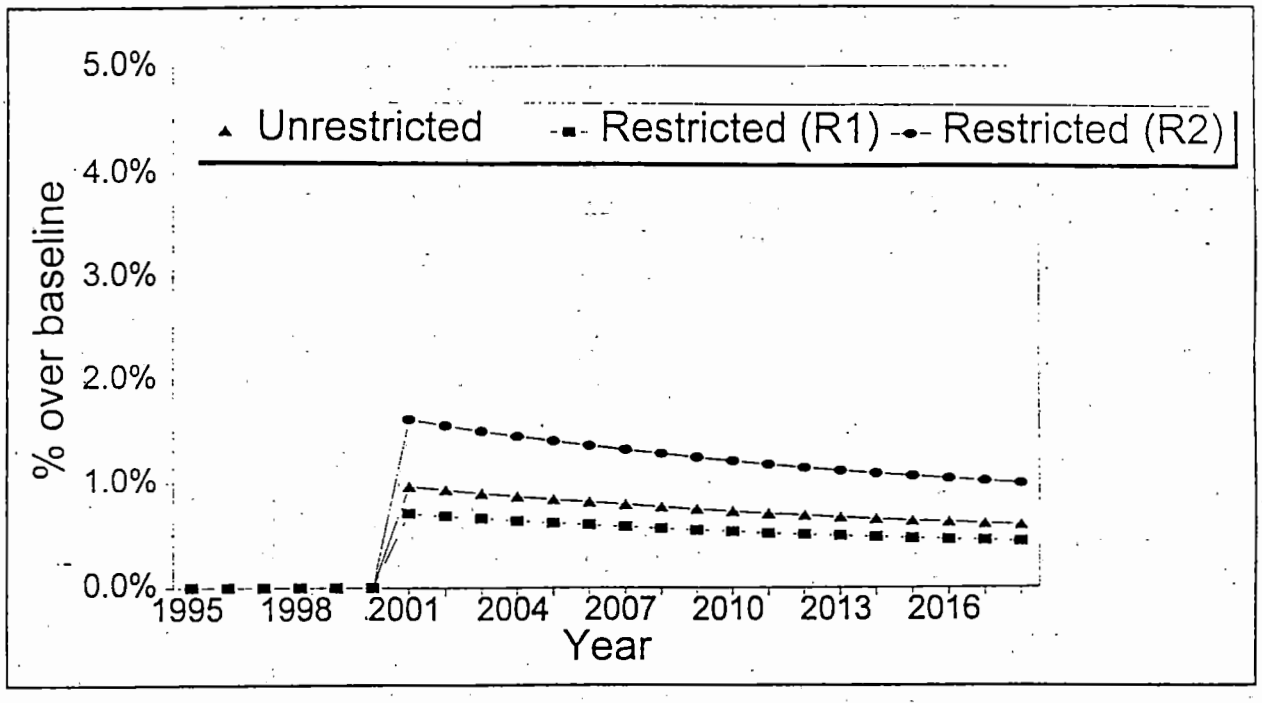


Figure 5-37. Predicted Increases in Housing Starts.

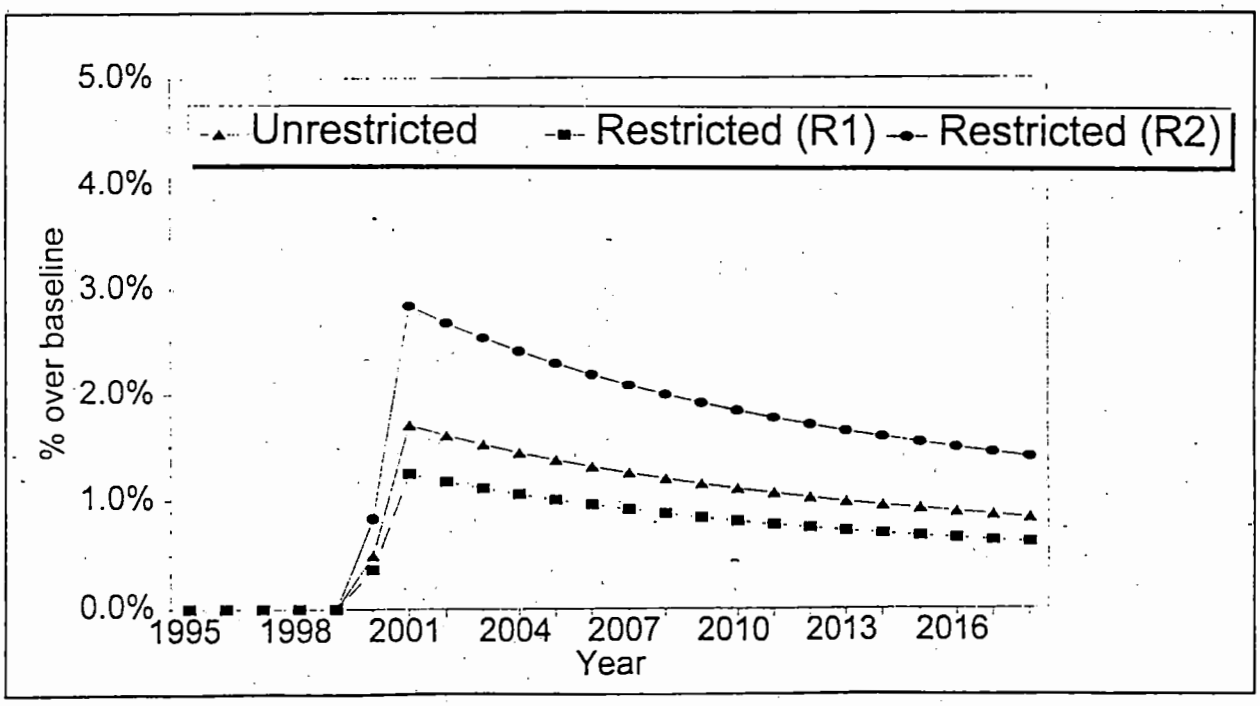


Figure 5-38. Predicted Increases in Nonagricultural Employment.

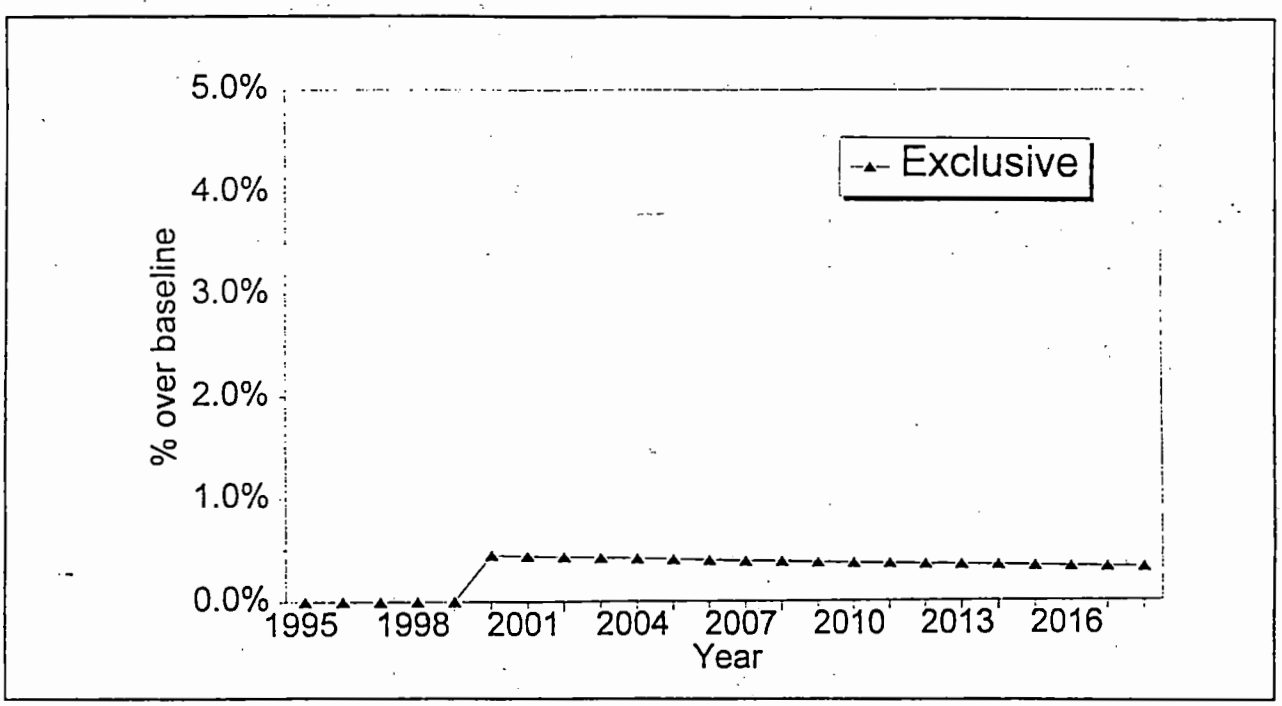
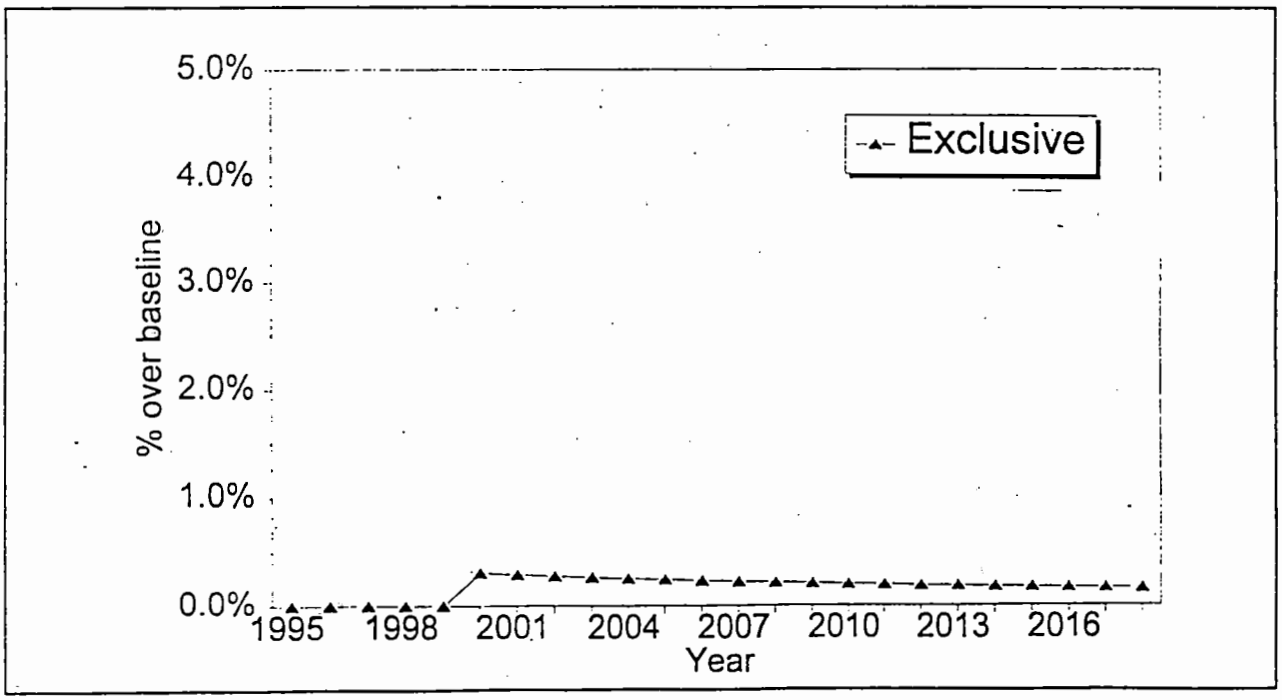


Figure 5-39. Predicted Increases in Taxable Retail Sales.



5.6.5.2 Population and Housing. The Exclusive Future Land-Use Alternative would generate about a maximum 0.3% increase in Tri-Cities population (Figure 5-40). Average home prices would increase by a maximum of about 0.6% (Figure 5-41). Housing starts would increase by a maximum of 1.1% (Figure 5-42). These impacts are not considered significant.

5.6.5.3 Public Services, Infrastructure, and Utilities. The small increase in population for the Exclusive Future Land-Use Alternative would have no significant impact on public services, infrastructure, or utilities.

5.6.6 All Other Areas Geographic Area

The two future land-use alternatives for the All Other Areas geographic area are the Restricted Future Land-Use Alternatives (R1 and R2). The period of performance for these remedial actions is 2000 to 2006. The corresponding FTE workers are 414 for the Restricted Future Land-Use Alternative (R1) and 1,630 for the Restricted Future Land-Use Alternative (R2).

5.6.6.1 Employment and Economic Activity. Hanford employment would increase by 2.7% above the baseline for the Restricted Future Land-Use Alternative (R1) and 10.5% above the baseline for the Restricted Future Land-Use Alternative (R2). Nonagricultural employment would show about a 0.6% maximum increase for the Restricted Future Land-Use Alternative (R1) and a 2.4% maximum increase for the Restricted Future Land-Use Alternative (R2) (Figure 5-43). The maximum impact on taxable retail sales would be about 0.4% for the Restricted Future Land-Use Alternative (R1) and about 1.6% for the Restricted Future Land-Use Alternative (R2) (Figure 5-44). The impacts of the Restricted Future Land-Use Alternative (R1) would be too small to be significant. The impacts of the Restricted Future Land-Use Alternative (R2) would be significant but short term.

5.6.6.2 Population and Housing. Population would increase by about 0.4% above the baseline at most for the Restricted Future Land-Use Alternative (R1) and by 1.5% above the baseline for the Restricted Future Land-Use Alternative (R2) (Figure 5-45). Home prices would increase by a maximum of 0.8% for the Restricted Future Land-Use Alternative (R1) and 3.2% for the Restricted Future Land-Use Alternative (R2) (Figure 5-46). Housing starts would increase by a maximum of 1.3% for the Restricted Future Land-Use Alternative (R1) and 2.4% for the Restricted Future Land-Use Alternative (R2) (Figure 5-47). The impacts of the Restricted Future Land-Use Alternative (R1) would be too small to be considered significant, while the impacts of the Restricted Future Land-Use Alternative (R2) would be significant, but short term.

5.6.6.3 Public Services, Infrastructure, and Utilities. The population growth for the Restricted Future Land-Use Alternative (R1) would be too small to have a significant impact on public services, infrastructure, or utilities. For the Restricted Future Land-Use Alternative (R2), however, there would be significant impacts in these areas. The projected additional population could be large enough to require additional investment in public services and infrastructure, including utilities. Higher sales tax and property tax revenues could offset some of the costs of meeting these new demands for services. However, the impacts would be more complex in this case because of their short duration. That is, the added demand for services and the increased taxes would end after 2006. This means that the investments to meet additional demands for public services could leave excess capacity when the additional workers required for the remedial activities leave after the work is completed in 2006.

Figure 5-40. Predicted Increases in Population.

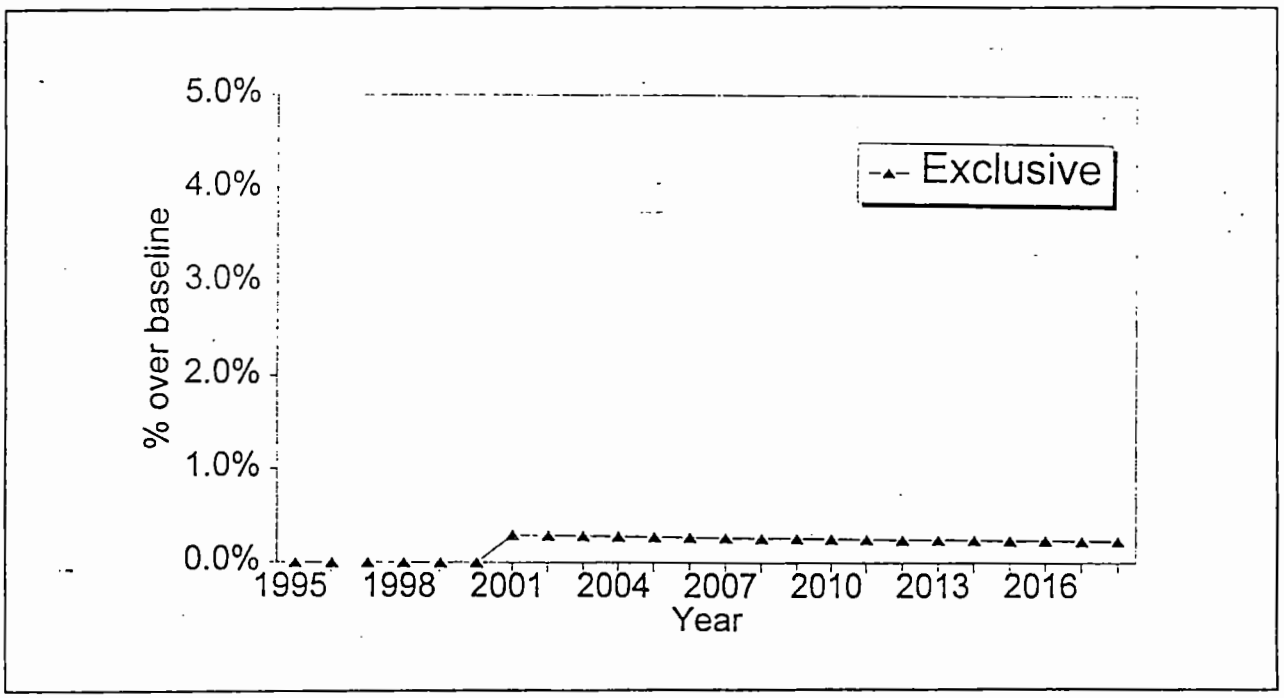


Figure 5-41. Predicted Increases in Home Prices.

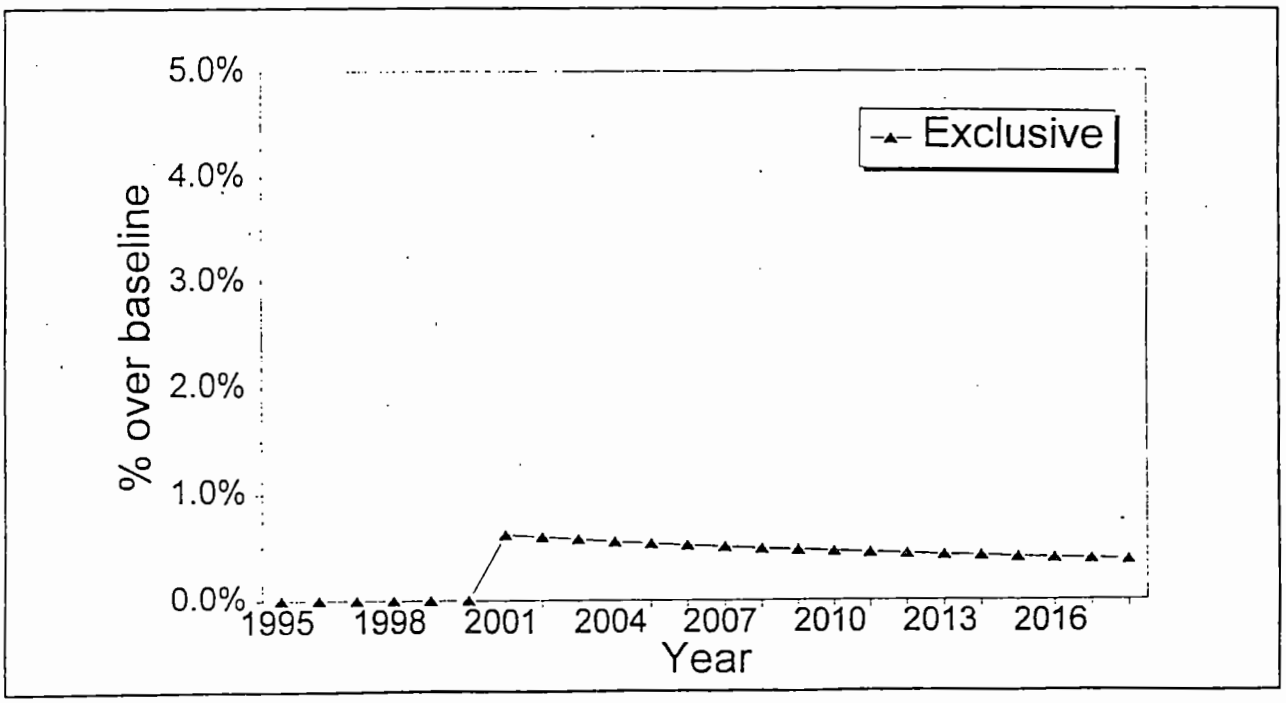


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Figure 5-42. Predicted Increases in Housing Starts.

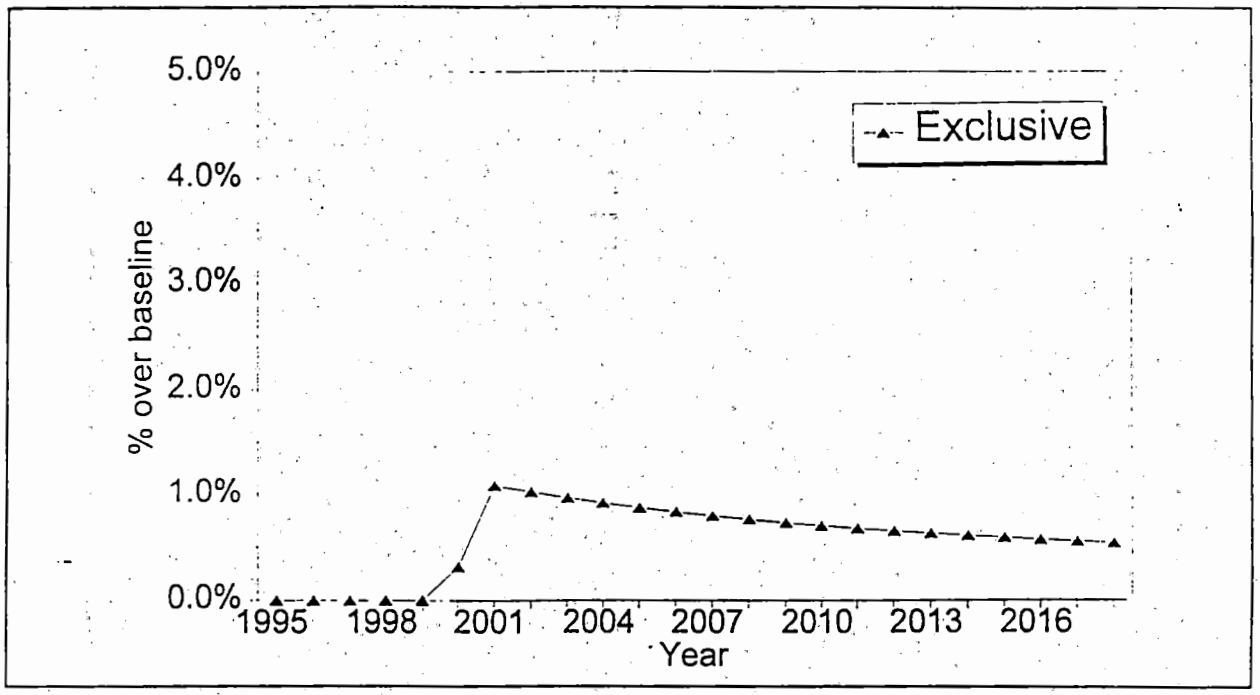


Figure 5-43. Predicted Increases in Nonagricultural Employment.

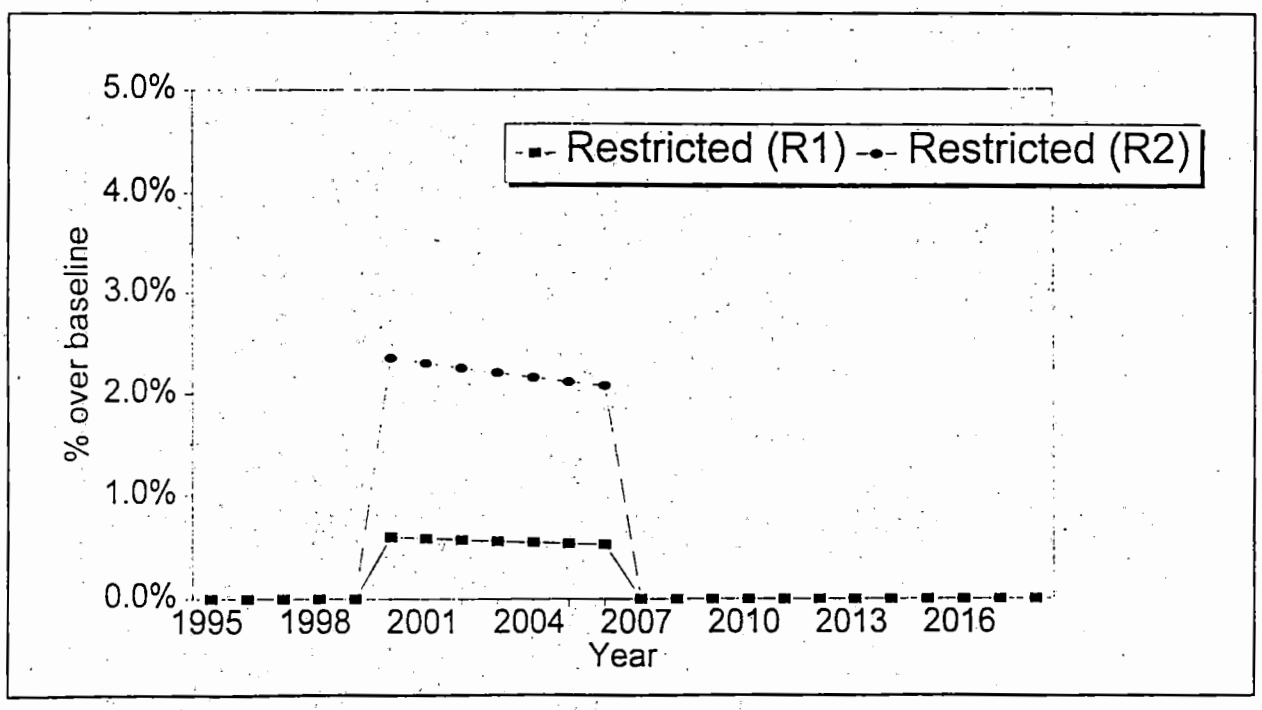


Figure 5-44. Predicted Increases in Taxable Retail Sales.

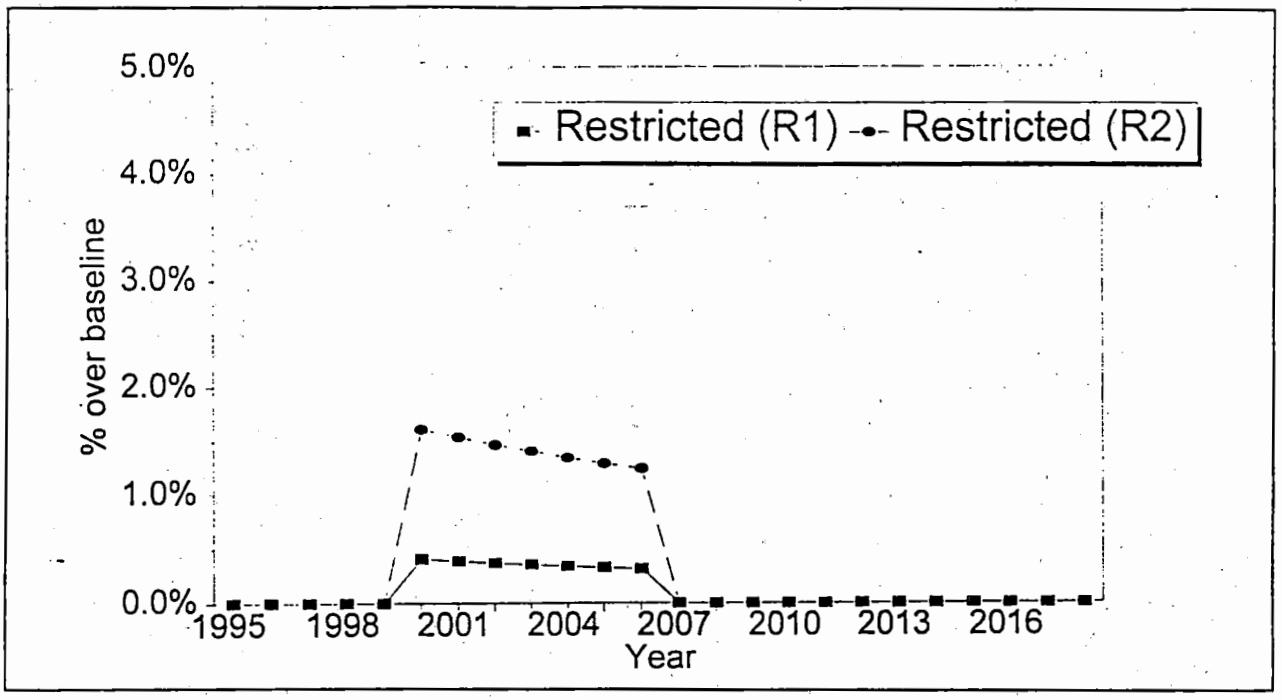


Figure 5-45. Predicted Increases in Population.

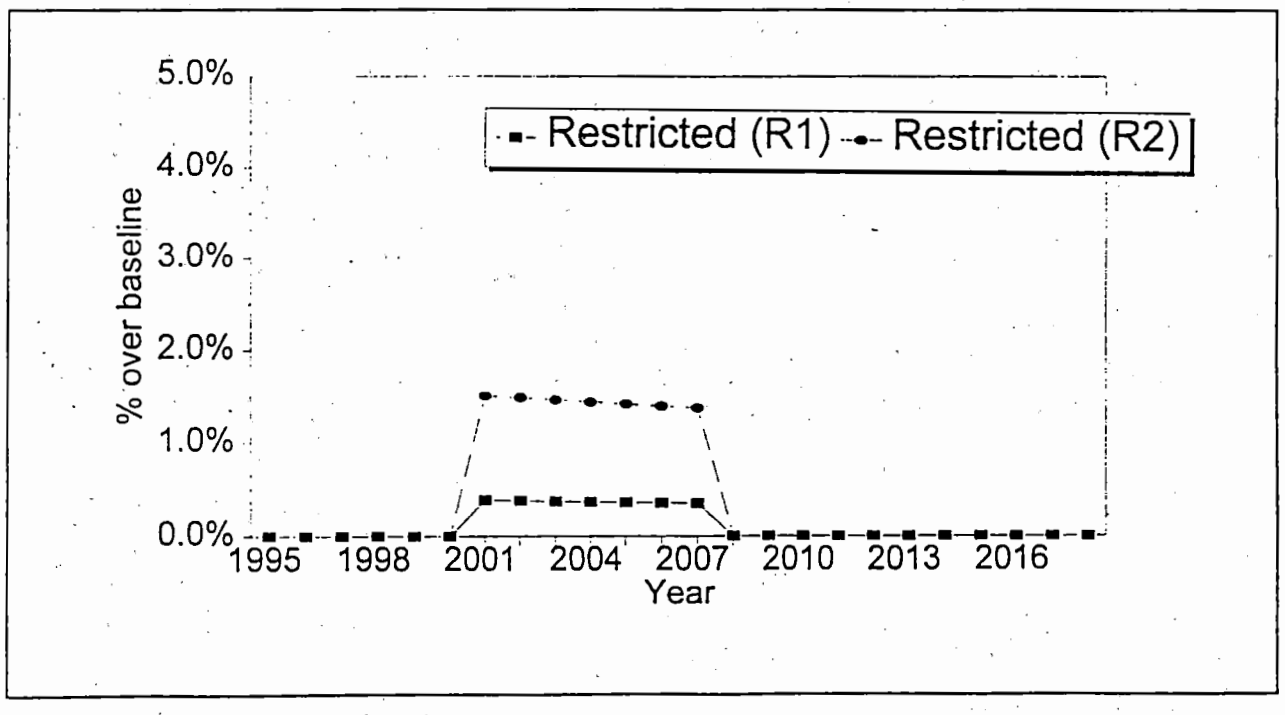


Figure 5-46. Predicted Increases in Home Prices.

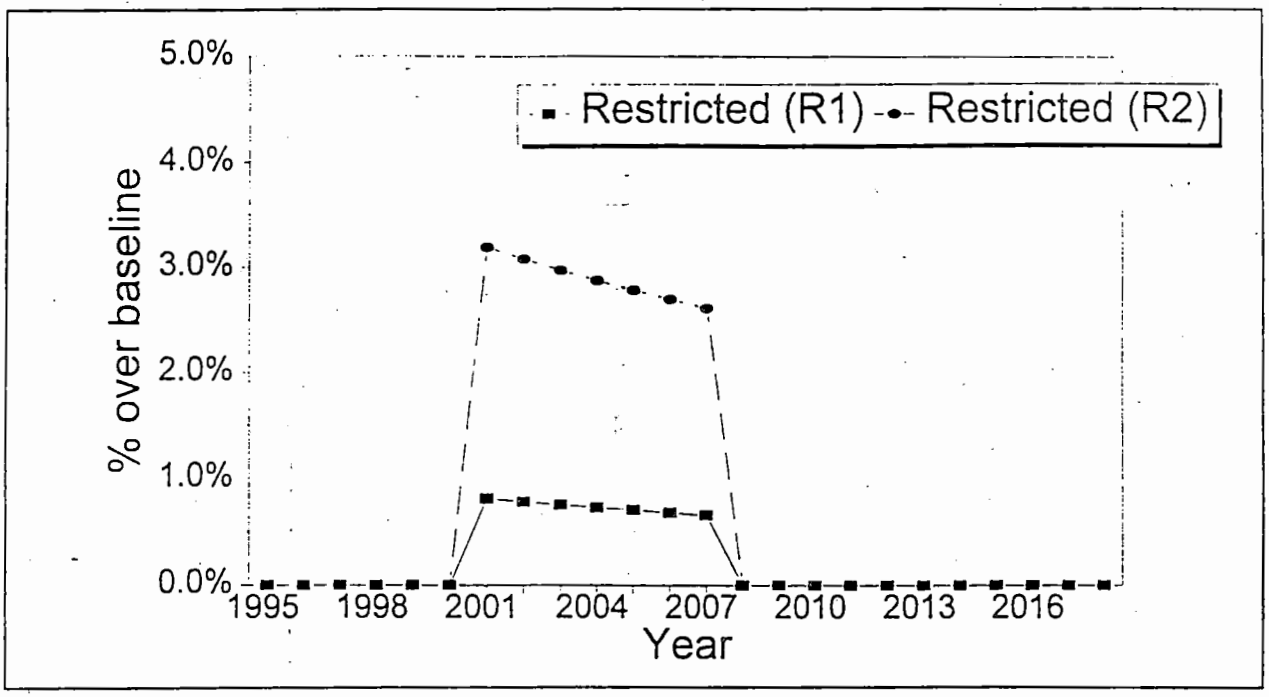
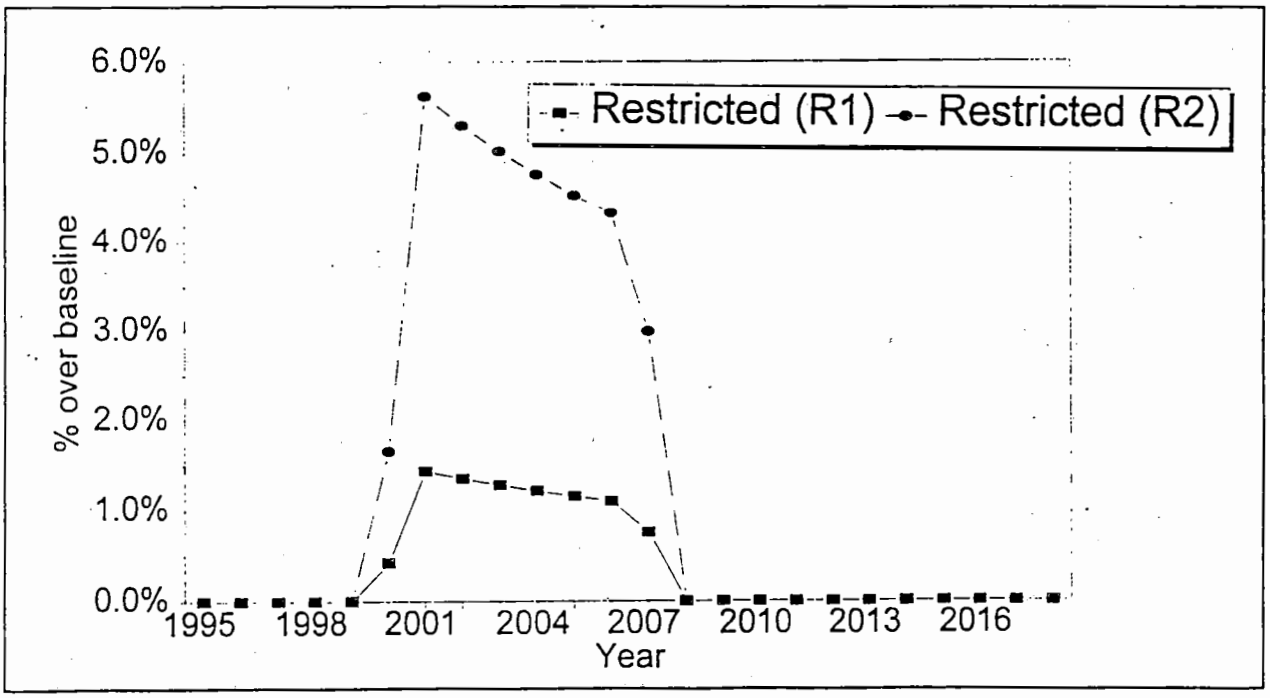


Figure 5-47. Predicted Increases in Housing Starts.



Two factors could mitigate the potential impacts of the Restricted Future Land-Use Alternative (R2). First, maximizing use of the existing workforce to supply the employment needs of this alternative could reduce the impacts associated with an influx of workers. Second, the effects of the abrupt decrease in employment may not be as evident when considering the overall impact of remediation across the Hanford Site. Remediation in the Reactors on the River and Central Plateau geographic areas would require until 2018 to complete, and could absorb some of the workers available when remediation is completed in the All Other Areas geographic area.

5.7 Baseline Risk Assessment

Consideration of the No-Action Alternative for the Hanford Site requires analysis of potential human health risks in the event that engineering and institutional controls are removed. To assess these health effects, a baseline risk assessment was performed for the Reactors on the River, Central Plateau, and All Other Areas geographic areas (Appendix B). The risk assessment used four exposure scenarios: agricultural, residential, industrial, and recreational. Assumptions were made for each of these scenarios concerning the type and extent of human contact with potentially contaminated media (soil, water, air, and food). With the exception of minor changes, these scenarios are the same as those used in the *Hanford Site Baseline Risk Assessment Methodology*[5] (DOE-RL 1993a). A detailed description of each of these exposure scenarios is presented in Appendix B4.

Potential human health risks under each of the four future land-use scenarios were calculated for present conditions, as well as for future generations. The risk assessment for present conditions, which used the year 1989 as a reference point, provides a baseline for risks over the entire Hanford Site. Potential health risks were calculated after removal of institutional controls at periods of 40, 100, 140, 1,000, and 10,000 years into the future.

5.7.1 Radiation Exposure Effects

Radiation exposure and its consequences are topics of interest to the general public near nuclear facilities. For this reason, this EIS places more emphasis on the consequences of exposure to radiation than on other topics. This subsection explains basic concepts used in the evaluation of radiation effects in order to provide the background for later discussion of impacts.

The effects on humans of radiation emitted during disintegration (decay) of a radioactive substance depends on the kind of radiation (alpha and beta particles, and gamma and x-rays) and the total amount of radiation energy absorbed by the body. The total energy absorbed per unit quantity of tissue is referred to as absorbed dose. The absorbed dose, when multiplied by factors that take into account different sensitivities of various tissues, is referred to as effective dose equivalent, or where the context is clear, simply dose. The common unit of effective dose equivalent is the roentgen equivalent man (rem). Small doses are frequently reported in millirem (equivalent to 1/1000 of a rem).

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[5]At the time of this writing, the *Hanford Site Baseline Risk Assessment Methodology* was used to conduct the baseline risk assessment. Since that time, it has been updated and revised in the *Hanford Site Risk Assessment Methodology* (DOE-RL 1995).

An individual may be exposed to ionizing radiation externally, from a radioactive source outside the body, and/or internally, from ingesting or inhaling radioactive material. The external dose is different from the internal dose. An internal dose continues to be delivered as long as the radioactive source is in the body, although both radioactive decay and elimination of the radionuclide by ordinary metabolic processes decrease the dose rate with the passage of time. The dose from internal exposure is calculated over 50 years following the initial exposure.

The maximum annual allowable radiation dose to the members of the public from DOE-operated nuclear facilities is 100 millirem/yr, as stated in DOE Order 5400.5 (DOE 1993a). It is estimated that the average individual in the United States receives a dose of about 300 mrem/yr from all sources combined, including natural and medical sources of radiation. For perspective, a chest x-ray results in an approximate dose of 83 mrem. A person must receive an acute (short-term) dose of approximately 600,000 mrem (600 rem) before there is a high probability of near-term death (DOE 1995a).

The maximally exposed individual (MEI) is defined in the *Hanford Site Environmental Report for 1994* (PNL 1995) as "an hypothetical person who lives at a location and has a lifestyle such that it is unlikely that other members of the public would receive higher radiation doses." For 1994, the total potential dose (via air and water pathways) to the MEI from Hanford operations was calculated to be 0.05 mrem (PNL 1995).

Radiation can cause a variety of adverse health effects in humans. The most significant adverse health effect used to depict the consequences of environmental and occupational radiation exposures is induction of LCFs. This effect is referred to as LCFs, because it may never actually be the cause of death. In addition to LCFs, other health effects could result from environmental and occupational exposures to radiation. These effects include nonfatal cancers among the exposed population and genetic effects in subsequent generations.

The factor used in this EIS to relate a dose to its health effect was 0.0004 LCFs/person-rem for workers and 0.0005 LCFs/person-rem for individuals among the general population. The latter factor is slightly higher because the general population may include sensitive subpopulations, such as young children. These factors are consistent with "U.S. Nuclear Regulatory Commission (NRC) Standards for the Protection Against Radiation," 56 FR 23363. The dose-to-risk conversion factors presented above and used in this EIS to relate radiation exposures to LCFs also are used in the *Hanford Site Baseline Risk Assessment Methodology* (DOE-RL 1993a).

5.7.2 Nonradiological Health Effects

EPA guidance categorizes chemical contaminants as carcinogenic or noncarcinogenic, or both. The method used to evaluate contaminants for potential health effects is dependent on whether the contaminant is classified as a carcinogen or a noncarcinogen. The methodology also depends on whether the exposed individual is a member of the public or a worker because of the differences in exposure pathways.

*5.7.2.1 **Chemical Carcinogenic Effects***. Certain chemicals, like radiation, have long been known to be capable of causing carcinogenic effects at high doses, but their carcinogenicity at low doses has been considered only recently. Most of the data for chemical carcinogens has come from chronic exposures at high dose levels and, with few exceptions, the data are too limited, to enable quantitative

analysis of dose-incidence curves. In those cases where data are available, the relationship between incidence and exposure are compatible with nonthreshold functions similar to those for radiation-induced cancers (NCRP 1989).

5.7.2.2 Chemical Noncarcinogenic Effects. Noncarcinogenic and criteria pollutant health effects are presented using the method described in the *Hanford Site Baseline Risk Assessment Methology* (DOE-RL 1993a). This approach presents noncarcinogenic effects in terms of a hazard quotient, which is the ratio between the calculated concentrations in air or drinking water and the reference dose or reference concentration, respectively.

$$\text{Noncancer Hazard Quotient} = E/RfC$$

where:

E = exposure level (or intake)
RfC = reference concentration.

E and RfC are expressed in the same units and represent the same exposure period (chronic, subchronic, or short term).

The noncancer hazard quotient assumes that there is a level of exposure (i.e., reference concentration) below which even sensitive populations are unlikely to experience adverse health effects. If the exposure level (E) exceeds this threshold (that is, if E/RfC exceeds unity), there may be concern for potential noncancer health effects. As a rule, the value of E/RfC of unity or greater, the greater the level of concern.

Where appropriate, to assess the overall potential for offsite (public) noncarcinogenic effects posed by more than one chemical, an HI approach was used following DOE-RL (1993a). This approach assumes that simultaneous subthreshold exposure to several chemicals could result in an adverse health effect. The method also assumes that the magnitude of the adverse effect will be proportional to the sum of the ratios of the subthreshold exposures to acceptable exposures. The HI is equal to the sum of the hazard quotients (where exposure level and the reference concentration represent the same exposure period).

5.7.3 Baseline Risk Assessment Results

5.7.3.1 Reactors on the River Geographic Area. The results of the risk assessment for the Reactors on the River geographic area are summarized in Table 5-50. Hazard indices for current and future times range over several orders of magnitude. As is the case the cancer risks, the wide variation is due to the distribution of waste sites and groundwater plumes. Hazard indices exceeding 1.0 were calculated for several locations in the Reactors on the River geographic area, indicating a potential for significant noncancer health effects in these locations. ILCRs generally use a linear equation to estimate risk. However, it is stated in EPA (1989) that using the linear equation is valid only at low risk levels (i.e., below 1×10^{-2}). For the purposes of this risk assessment, ILCR values that exceed 1×10^{-2} are reported as $> 1 \times 10^{-2}$. These values are not intended to represent accurate cancer risk estimates.

Table 5-50. Cancer Risk and Hazard Index Ranges, Reactors on the River Geographic Area.

Reference Time	Exposure Scenario	Hazard Index Range	Incremental Lifetime Cancer Risk Range
T_0 (year 1989)	Agricultural	3.12 E-02 - 9.71 E+01	1.47 E-06 - >1.00 E-02
	Residential	3.12 E-02 - 8.86 E+01	1.25 E-06 - >1.00 E-02
	Industrial	2.09 E-02 - 2.54 E+01	2.71 E-07 - >1.00 E-02
	Recreational	7.38 E-04 - 1.85 E+00	2.27 E-08 - 1.36 E-02
T_{40} (year 2029)	Agricultural	3.94 E-02 - 1.02 E+03	6.94 E-06 - >1.00 E-02
	Residential	3.94 E-02 - 2.38 E+02	6.94 E-06 - >1.00 E-02
	Industrial	2.41 E-02 - 1.14 E+01	2.81 E-06 - >1.00 E-02
	Recreational	6.73 E-04 - 6.34 E-01	2.45 E-07 - >1.00 E-02
T_{100} (year 2089)	Agricultural	1.79 E-02 - 2.66 E+01	6.59 E-06 - >1.00 E-02
	Residential	1.79 E-02 - 7.02 E+00	6.59 E-06 - >1.00 E-02
	Industrial	9.29 E-03 - 5.88 E-01	2.65 E-06 - >1.00 E-02
	Recreational	2.60 E-04 - 6.04 E-02	2.39 E-07 - >1.00 E-02
T_{140} (year 2129)	Agricultural	1.11 E-02 - 1.07 E+01	6.49 E-06 - >1.00 E-02
	Residential	1.11 E-02 - 3.51 E+00	6.49 E-06 - >1.00 E-02
	Industrial	4.67 E-03 - 4.05 E-01	2.60 E-06 - >1.00 E-02
	Recreational	1.31 E-04 - 5.07 E-02	2.37 E-07 - >1.00 E-02
T_{1000} (year 2989)	Agricultural	4.35 E-03 - 2.38 E+04	6.36 E-06 - >1.00 E-02
	Residential	4.35 E-03 - 2.25 E+04	6.36 E-06 - >1.00 E-02
	Industrial	2.24 E-05 - 1.62 E+04	2.55 E-06 - >1.00 E-02
	Recreational	1.55 E-06 - 4.98 E+02	2.34 E-07 - >1.00 E-02
T_{10000} (year 11989)	Agricultural	4.34 E-03 - 2.26 E+04	6.35 E-06 - >1.00 E-02
	Residential	4.34 E-03 - 2.14 E+04	6.35 E-06 - >1.00 E-02
	Industrial	1.91 E-05 - 1.54 E+04	2.55 E-06 - >1.00 E-02
	Recreational	1.46 E-06 - 4.74 E+02	2.34 E-07 - 9.20 E-03

Figures 5-48 through 5-51 show the current (T_0) spatial distribution of cancer risk over the Hanford Site by means of risk isopleths for the agricultural, residential, industrial, and recreational scenarios, respectively. The risk isopleths represent lines of constant risk and can be read in the same way as elevation contour lines on a topographic map. The solid lines indicate the risk isopleths, while the dashed lines indicate the outlines of the Reactors on the River and the other geographic areas. Isopleths are depicted for risk values of 10^{-6} to greater than 10^{-2}. The shading indicates the risk range between adjacent contour lines. The risk isopleth maps were developed to enable general comparisons among land-use scenarios and timeframes; the maps have limitations for other uses. For example, locations of contour lines are approximate because of uncertainties in the waste inventories and concentration data used as the source terms (see Appendix B5 for a discussion of uncertainty). Contour information is most accurate for locations containing higher concentrations of waste sites (Figure 5-52). Because of the uncertainties, the isopleths should not be used to calculate risk gradients from one area of the Hanford Site to another. The uncertainties also make it difficult to compare the risks with risk estimates in other documents (e.g., site-specific risk assessments), and such comparisons should be treated with caution.

Figure 5-48. Baseline Risk Isopleths for the Agricultural Scenario at T_0 (Year 1989).

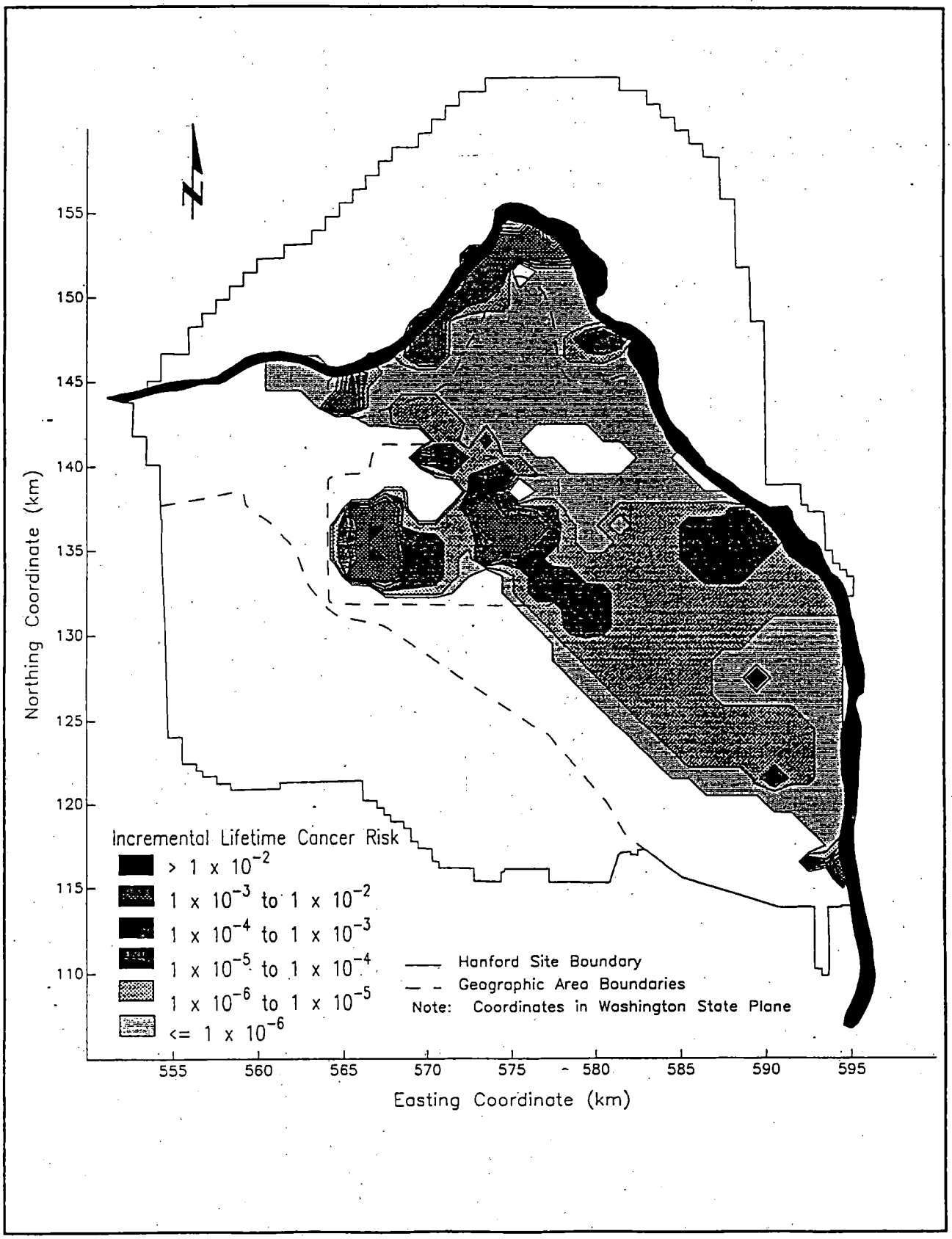

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Figure 5-49. Baseline Risk Isopleths for the Residential Scenario at T_0 (Year 1989).

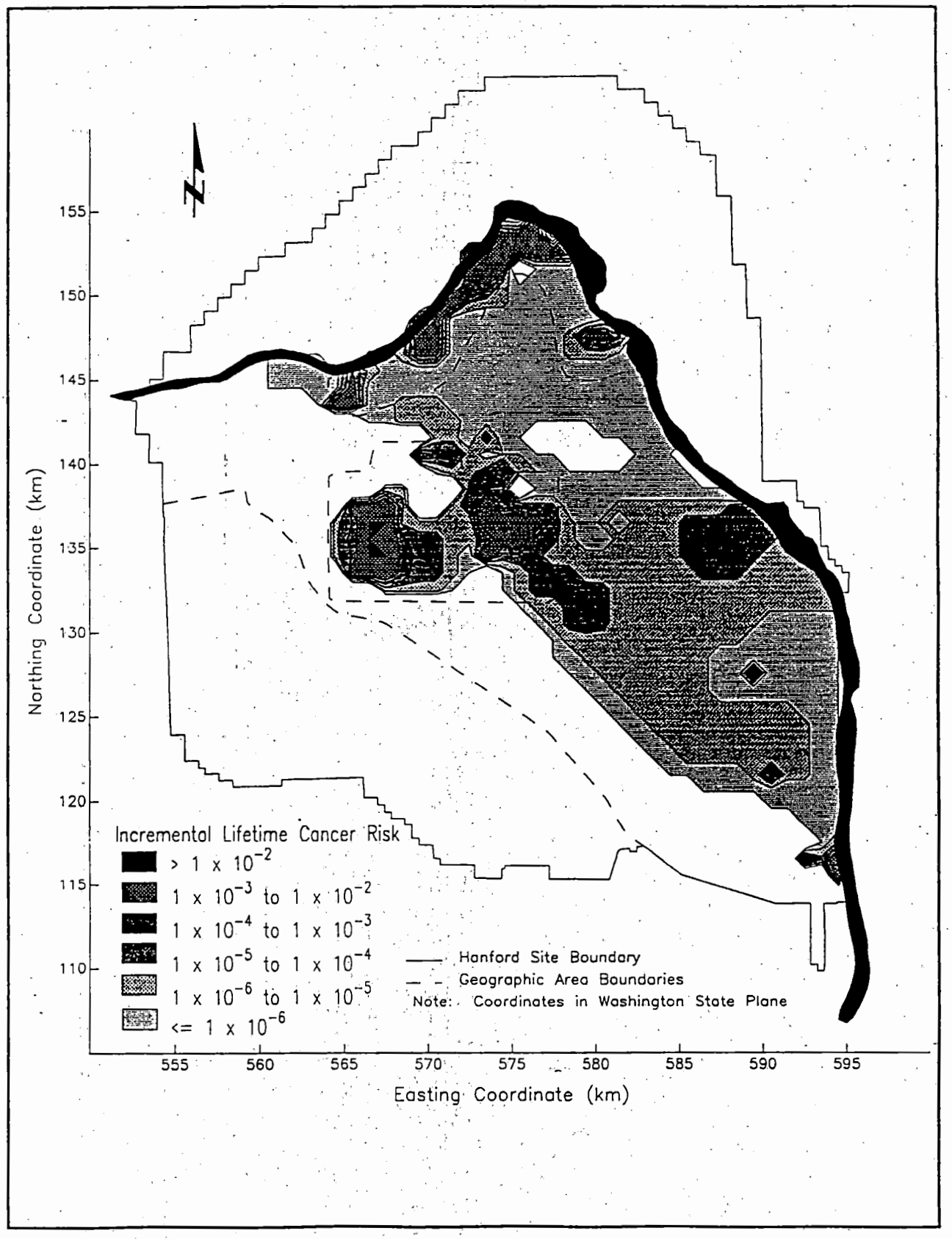


Figure 5-50. Baseline Risk Isopleths for the Industrial Scenario at T_0 (Year 1989).

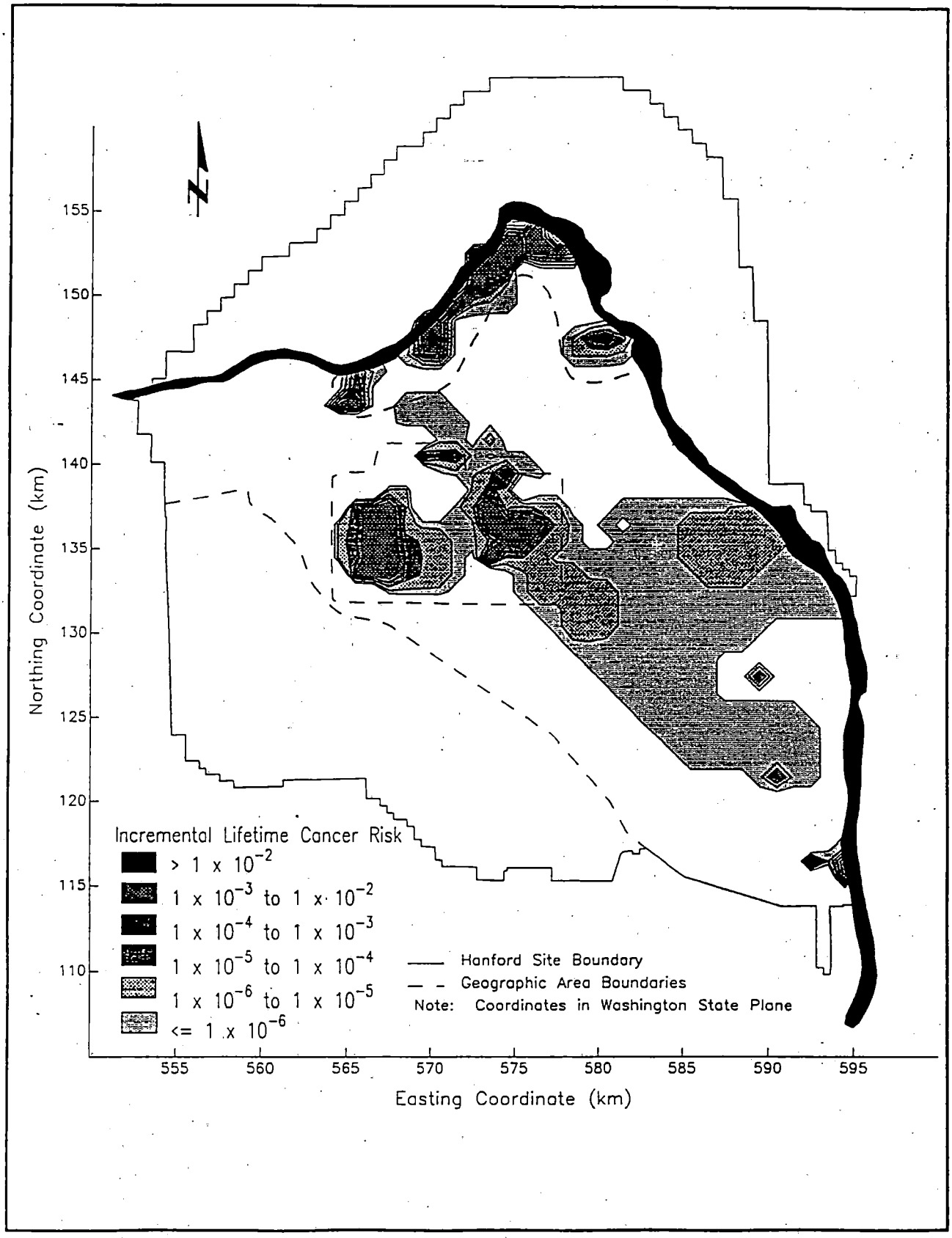


Figure 5-51. Baseline Risk Isopleths for the Recreational Scenario at T_0 (Year 1989).

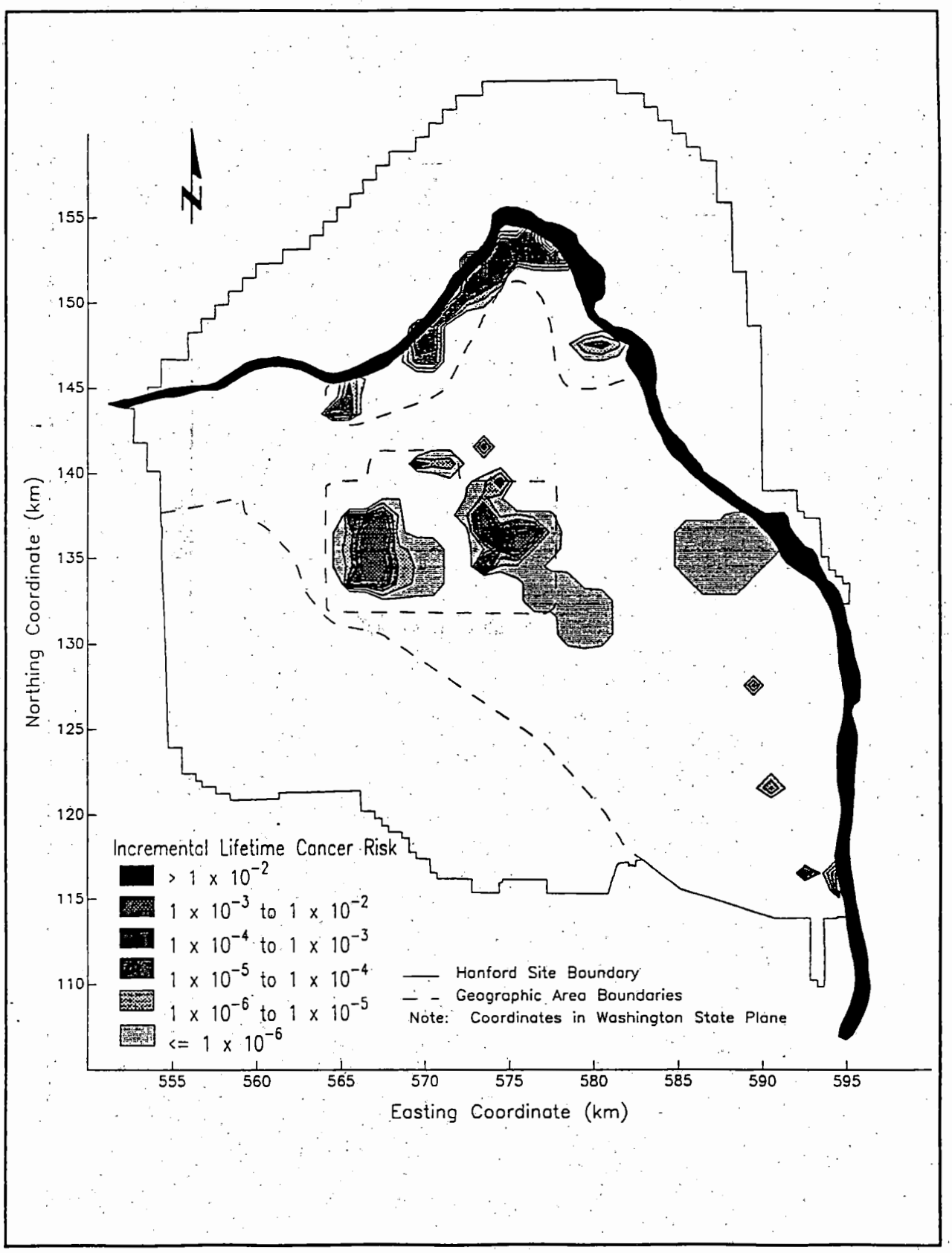
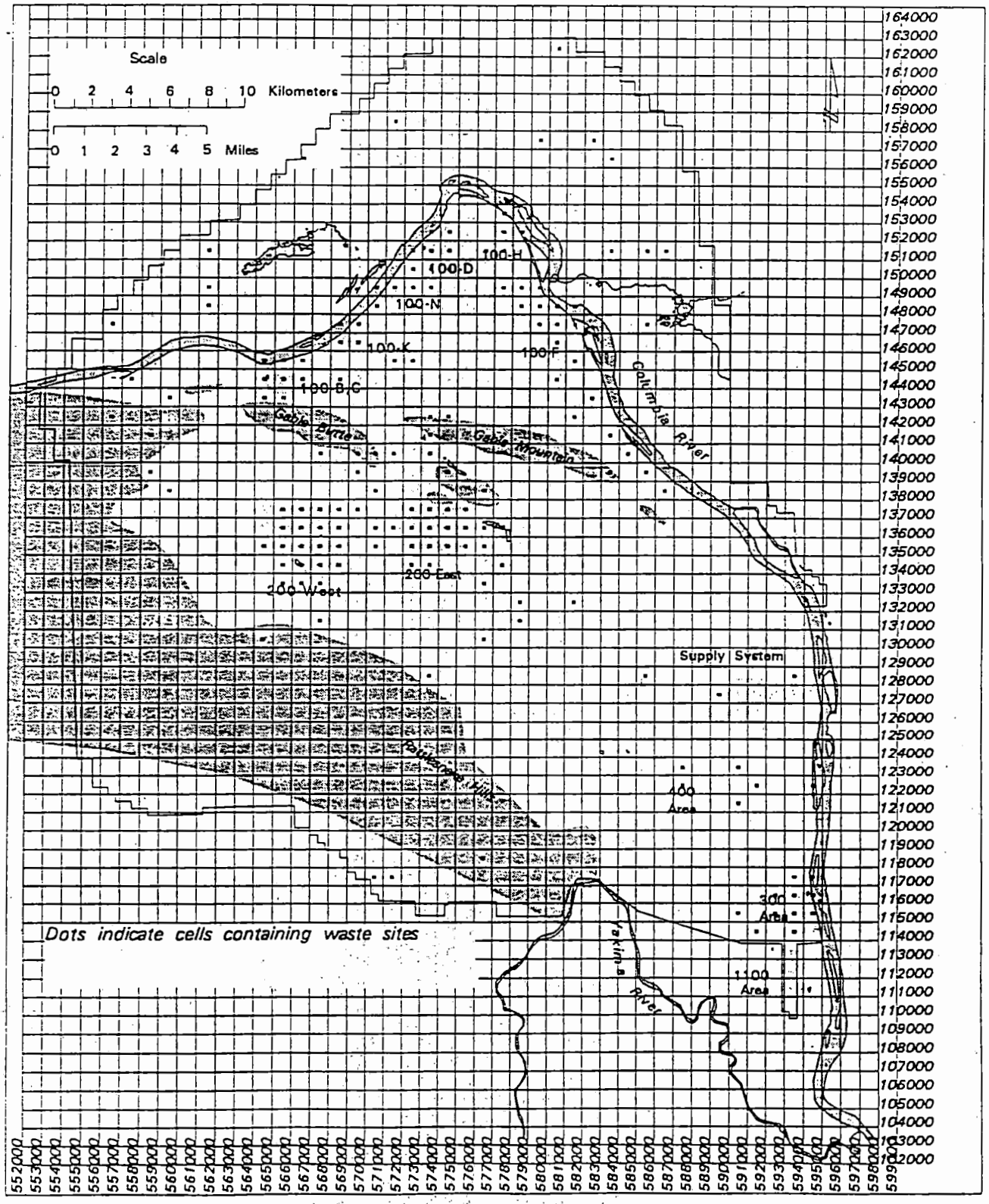


Figure 5-52. Cells Containing Waste Sites Analyzed for Health and Ecological Risks.



The risk isopleth maps (Figures 5-48 through 5-51) indicate that the removal of institutional controls at the present time (T_0) without remediation would result in potential risks exceeding the target risk range of 10^{-4} to 10^{-6} in large portions of the Reactors on the River geographic area. Areas of higher risk within this geographic area are located in the vicinity of the individual reactor areas. This is to be expected because the risk distribution corresponds closely to the distribution of actual waste sites (see Figure 5-52).

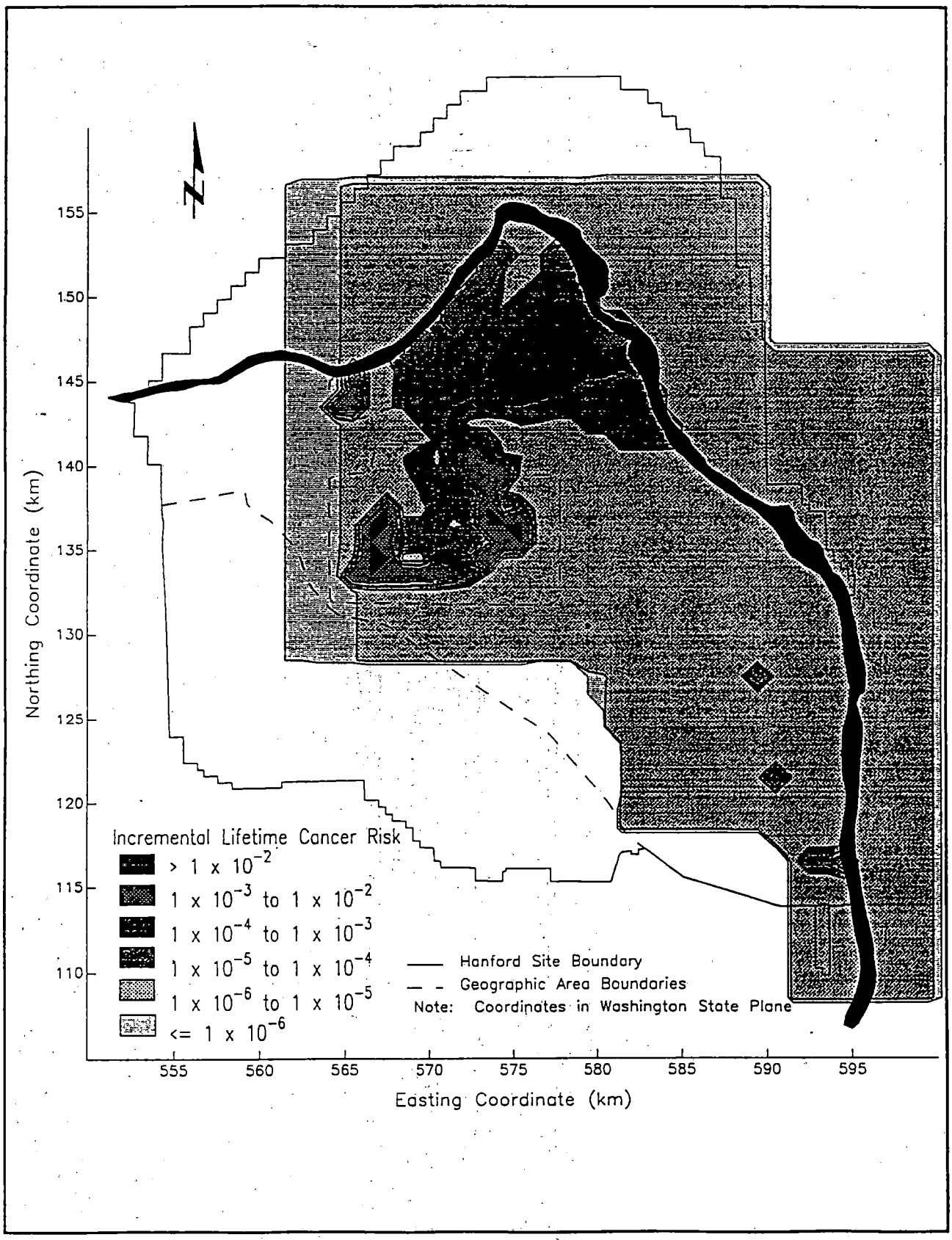
Isopleth maps generated for future timeframes indicate that over time, risks are redistributed. Figures 5-53 through 5-57 show how sitewide risks under the agricultural scenario change over time by providing "snapshots" of risk distribution at 40, 100, 140, 1,000, and 10,000 years into the future, respectively. The isopleth maps indicate that areas with highest risk become smaller over time. Depending on the nature of the contaminants at various locations, the reduction may be caused by decay of radioactive contaminants, degradation of certain chemical contaminants, or dilution and dispersion of contaminants in groundwater. The isopleth maps also indicate that risk increases over time in other portions of the Reactors on the River geographic area. This effect is largely caused by the movement of contaminants from waste sites into groundwater, which spreads the contaminants to other areas. The redistribution of risk through groundwater contamination would maintain levels of risk in portions of the Reactors on the River geographic area above the target range of 10^{-4} to 10^{-6} for at least 1,000 years.

The risk distributions under the residential scenario (see Figure 5-49 and Figures 5-58 through 5-62) are nearly identical to the agricultural scenario. Although the food chain pathways are different in these scenarios (farmers are assumed to consume more foods produced onsite), groundwater contamination is the main source of risk for both scenarios and may mask differences in other pathways. Therefore, as with the agricultural scenario, risks associated with the residential scenario would remain above the target range of 10^{-4} to 10^{-6} for at least 1,000 years.

Figure 5-50 and Figures 5-63 through 5-67 show the distribution of risk for the industrial scenario. There are some differences in the risk distribution for this scenario compared to the agricultural or residential scenario, although these differences tend to decrease with time. These differences can be explained mostly by the predominance of the groundwater in controlling overall risk. Exposure pathways are similar for the agricultural, residential, and industrial scenarios, except for the amount of groundwater consumed. In the agricultural and residential scenarios, individuals are assumed to drink 2 L/d (0.5 gal/d) of contaminated groundwater and to take a shower with contaminated groundwater every day (365 days per year). For the industrial scenario, the assumption is that a worker would consume 1 L/d (0.3 gal/d) of contaminated groundwater and take one shower with contaminated groundwater only on workdays (250 d/yr). It should also be noted that, although the maximum cancer risk is greater than 10^{-2} for some future timeframes (see Table 5-50), the area at this risk level is very small (see Figures 5-58 through 5-62).

The final exposure scenario considered is the recreational scenario (see Figure 5-51 and Figures 5-68 through 5-72). As in the other three scenarios, the baseline (T_0) risk levels associated with the recreational scenario exceed the target risk range in much of the Reactors on the River geographic area (see Figure 5-51). However, unlike the other scenarios, risk levels under the recreational scenario decrease to the target range within 40 years (see Figure 5-68). Localized areas of higher risk remain adjacent to the reactors. This difference from the other scenarios reflects the predominance of groundwater in driving the overall risk. In the recreational scenario, contaminated groundwater is assumed to be used only 7 days per year, corresponding to an average frequency of recreational activity. This greatly reduces the estimated future risk, compared to the other scenarios in which much more contaminated groundwater is consumed.

Figure 5-53. Baseline Risk Isopleths for the Agricultural Scenario at T_{40} (Year 2029).



9613470.0510

Figure 5-54. Baseline Risk Isopleths for the Agricultural Scenario at T_{100} (Year 2089).

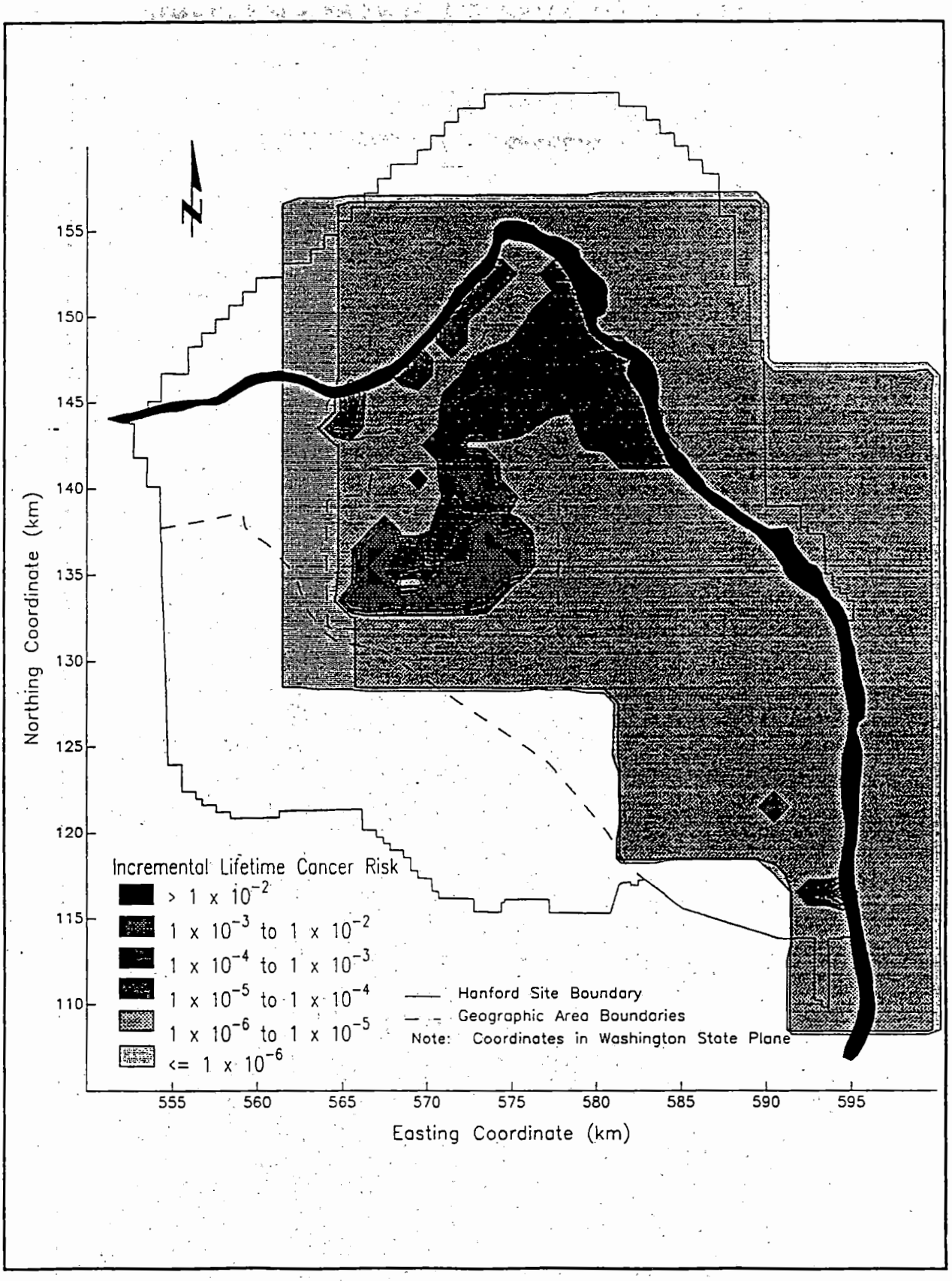
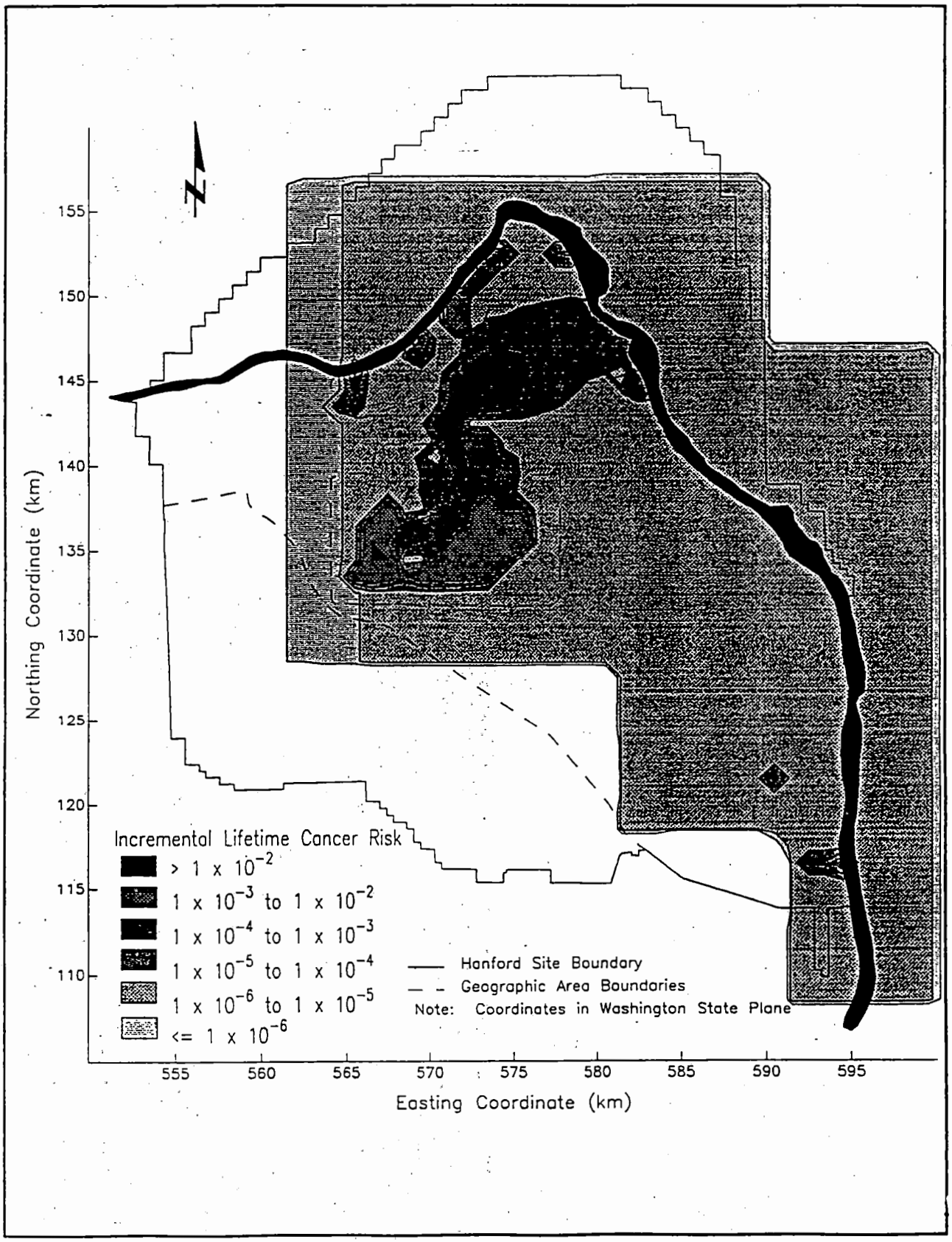


Figure 5-55. Baseline Risk Isopleths for the Agricultural Scenario at T_{140} (Year 2129).



9613470.0511

Figure 5-56. Baseline Risk Isopleths for the Agricultural Scenario at T_{1000} (Year 2989).

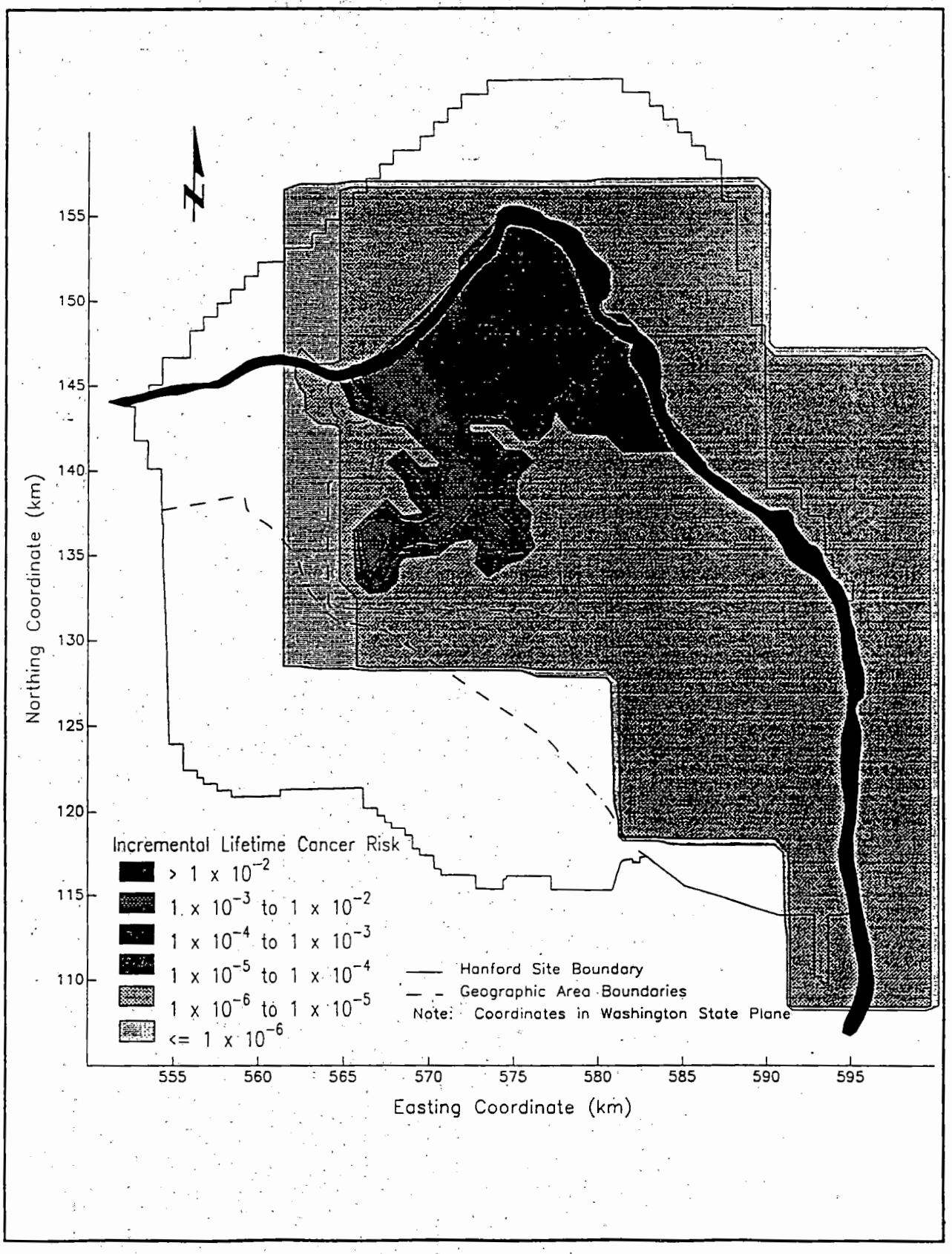


Figure 5-57. Baseline Risk Isopleths for the Agricultural Scenario at T_{10000} (Year 11989).

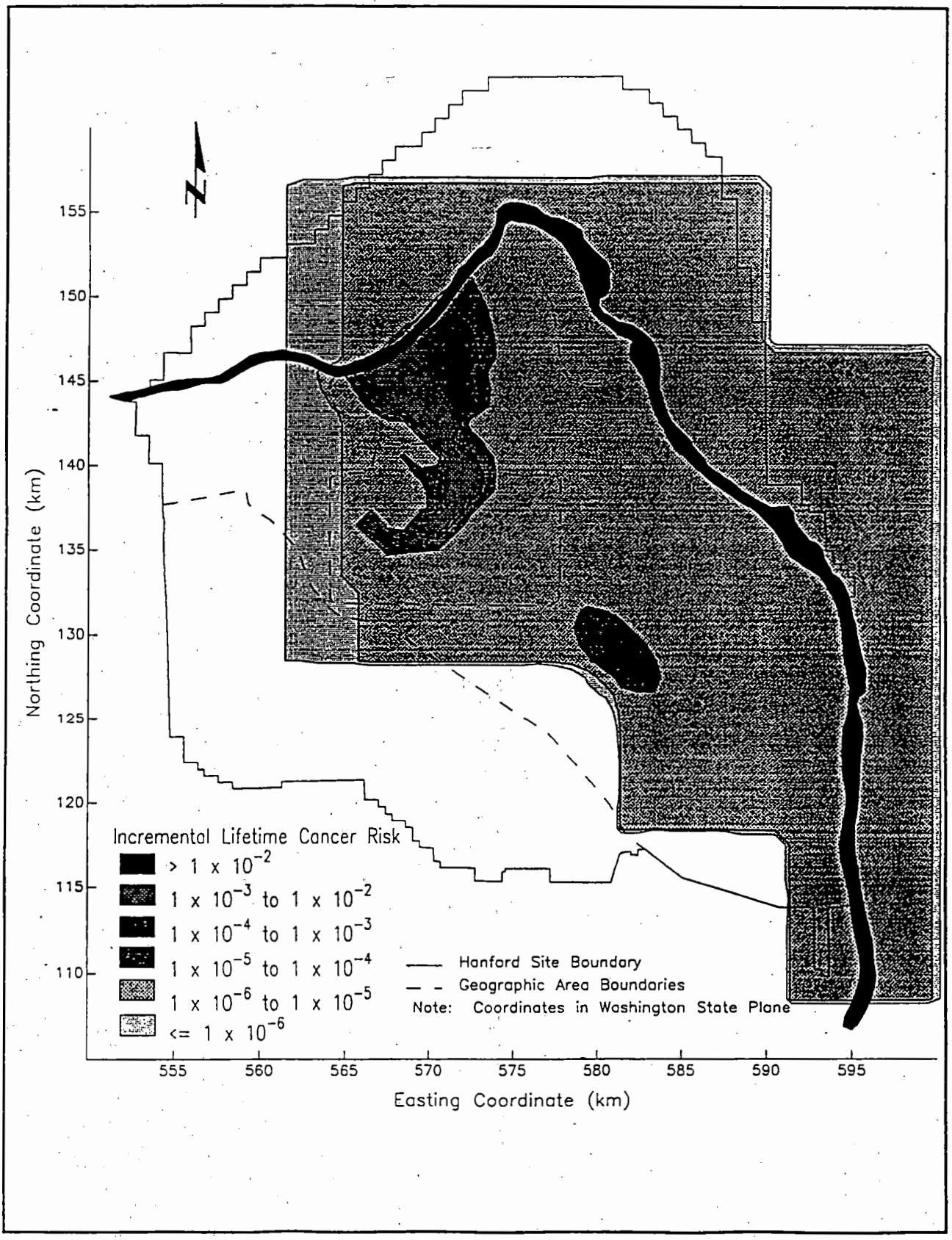


Figure 5-58. Baseline Risk Isopleths for the Residential Scenario at T_{40} (Year 2029).

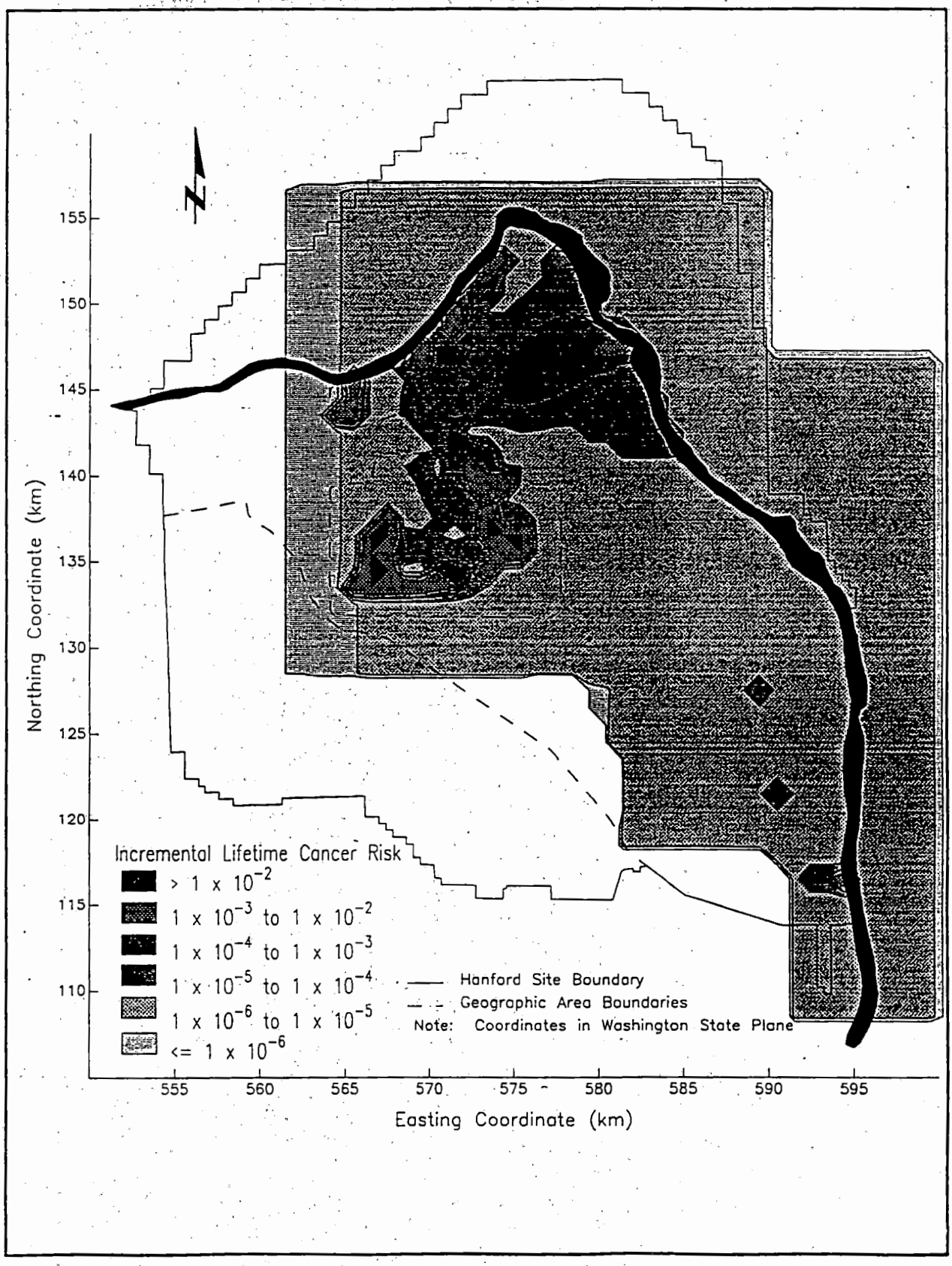


Figure 5-59. Baseline Risk Isopleths for the Residential Scenario at T_{100} (Year 2089).

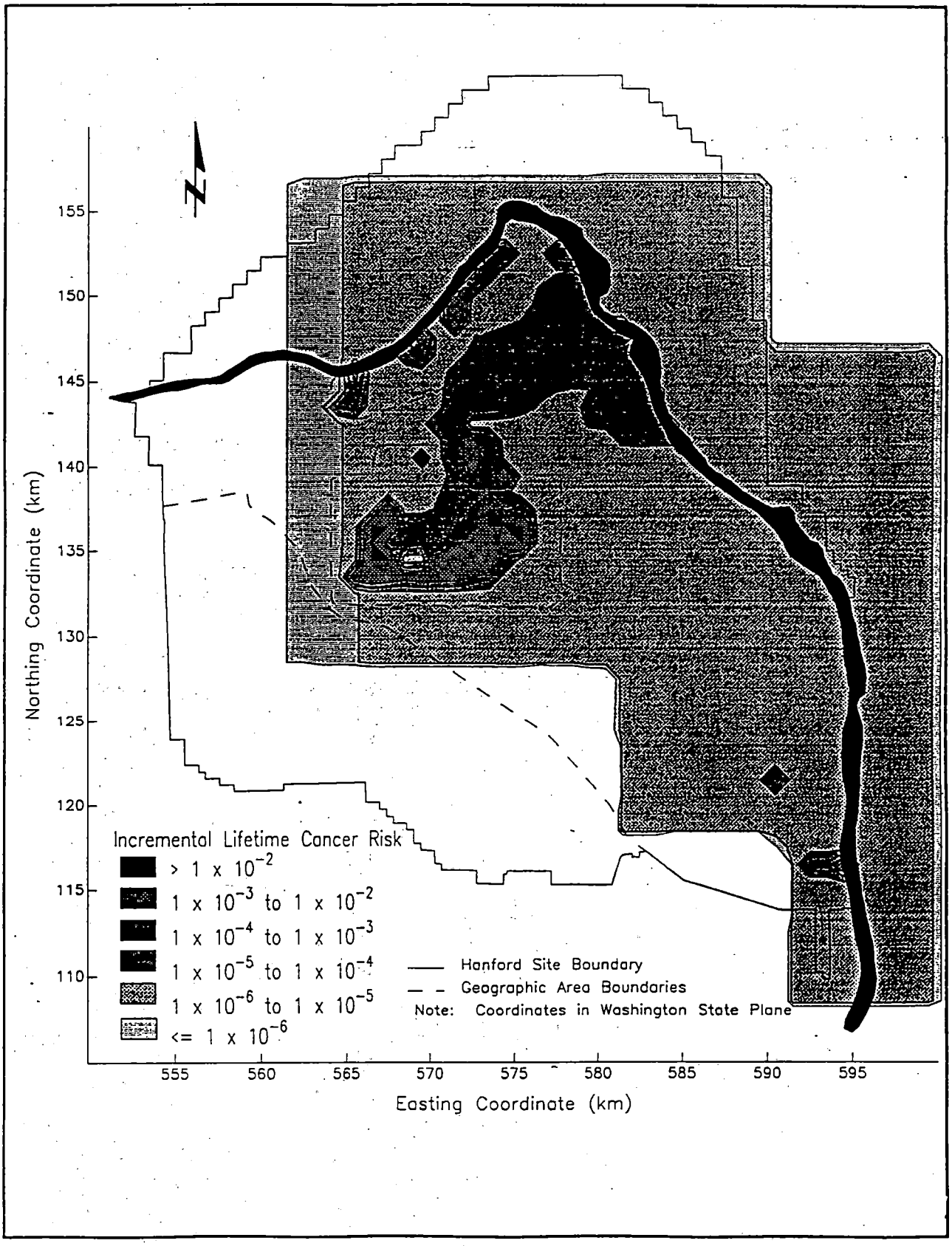


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Figure 5-60. Baseline Risk Isopleths for the Residential Scenario at T_{140} (Year 2129).

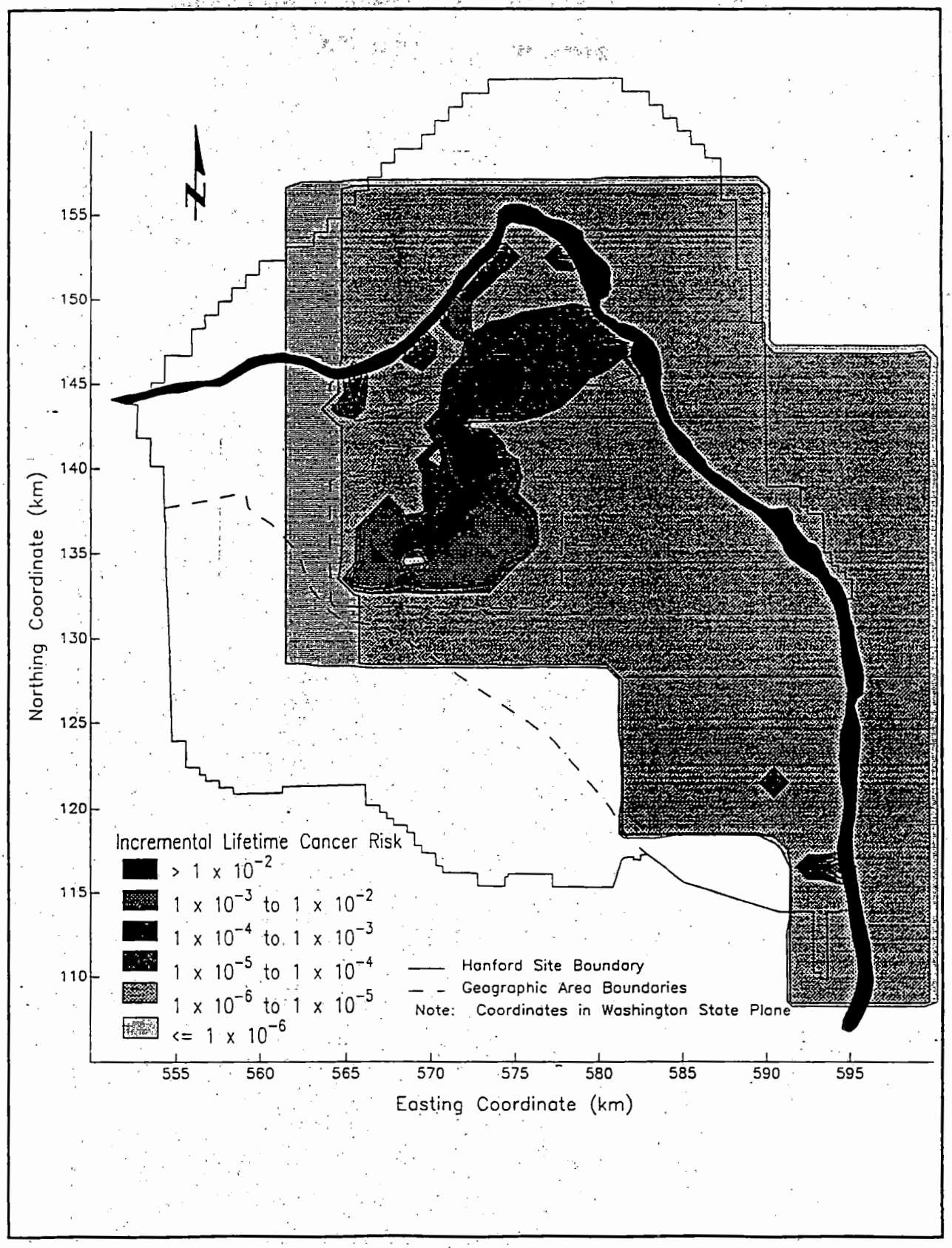

Figure 5-61. Baseline Risk Isopleths for the Residential Scenario at T_{1000} (Year 2989).

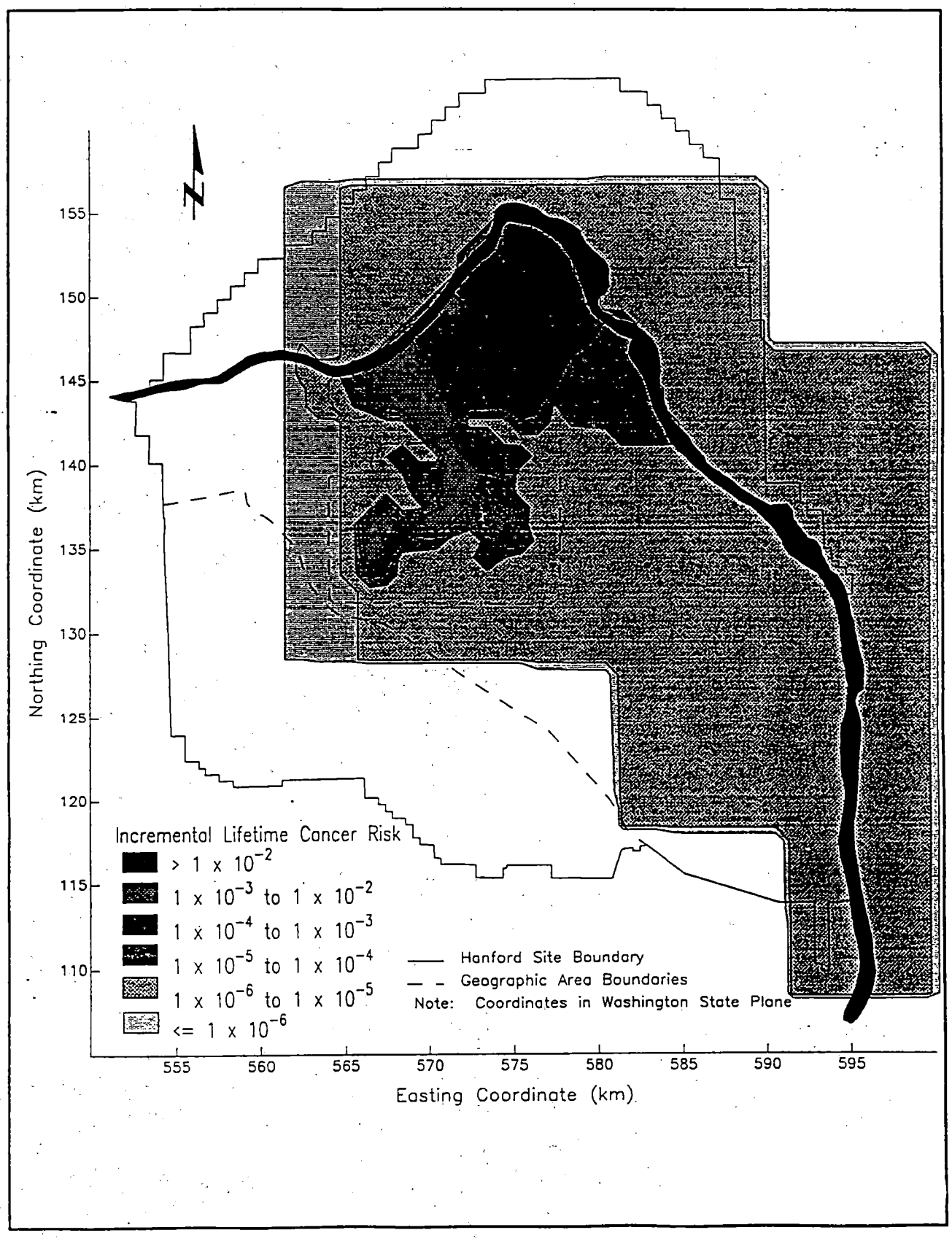

Figure 5-62. Baseline Risk Isopleths for the Residential Scenario at T_{10000} (Year 11989).

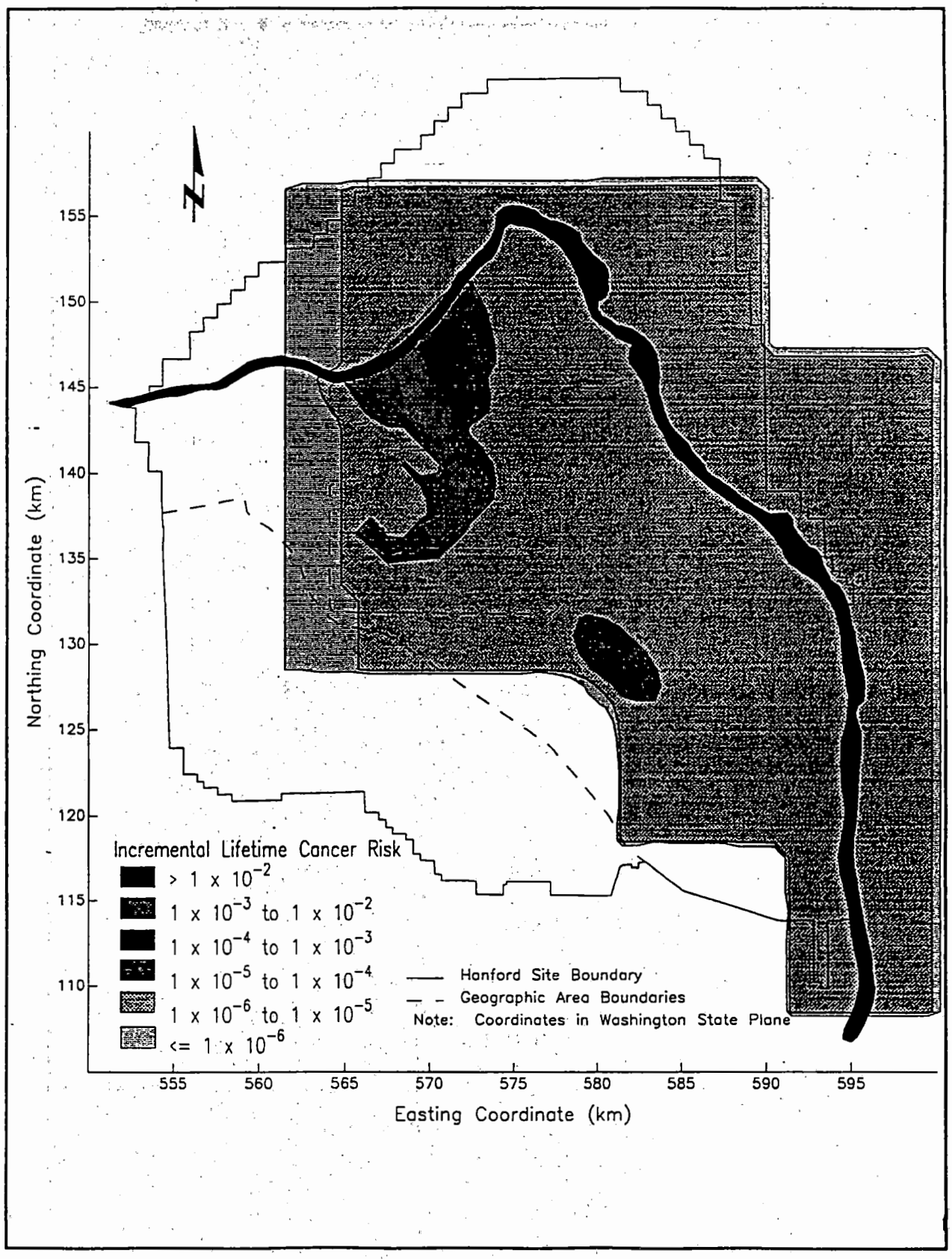

Figure 5-63. Baseline Risk Isopleths for the Industrial Scenario at T_{40} (Year 2029).

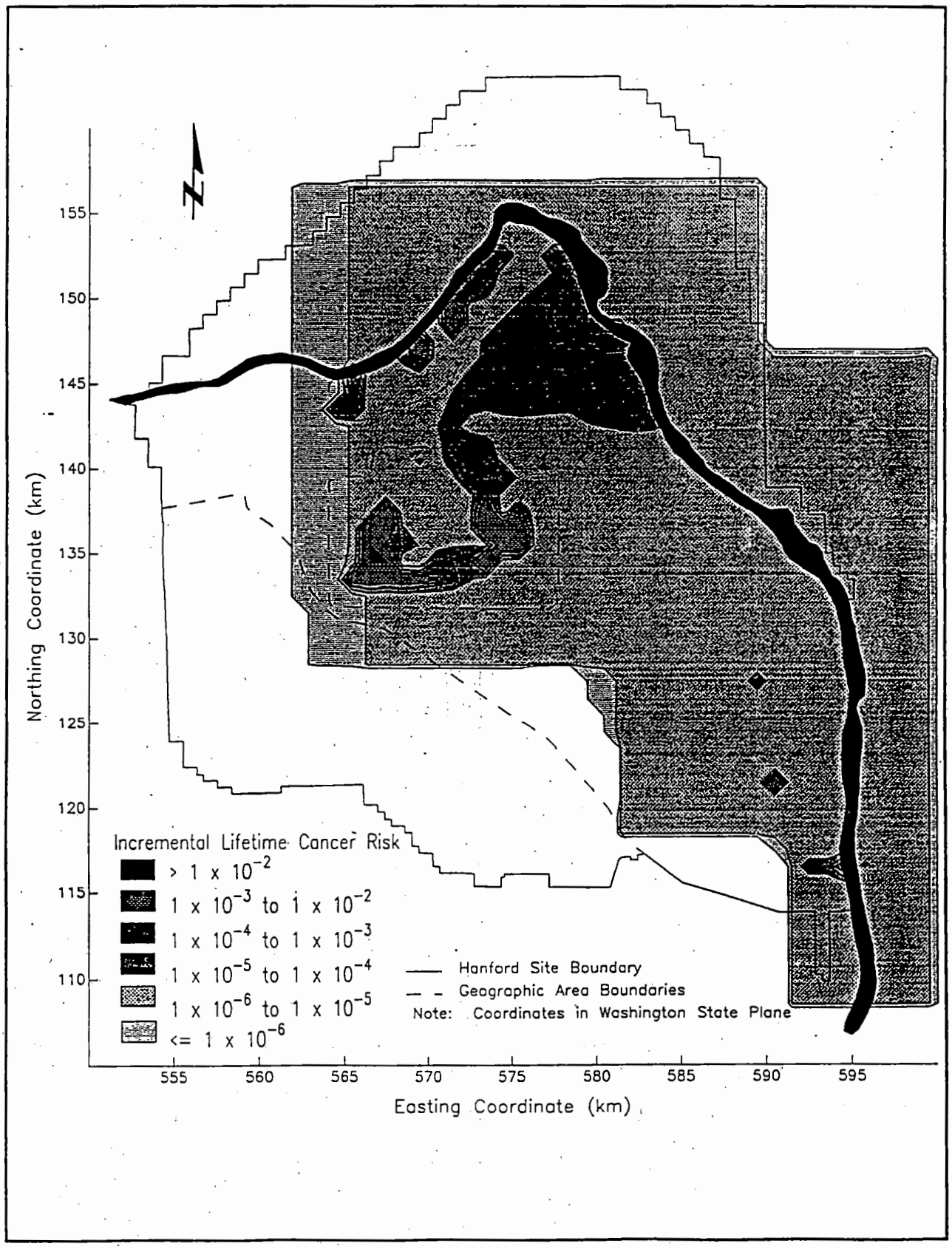

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Figure 5-64. Baseline Risk Isopleths for the Industrial Scenario at T_{100} (Year 2089).

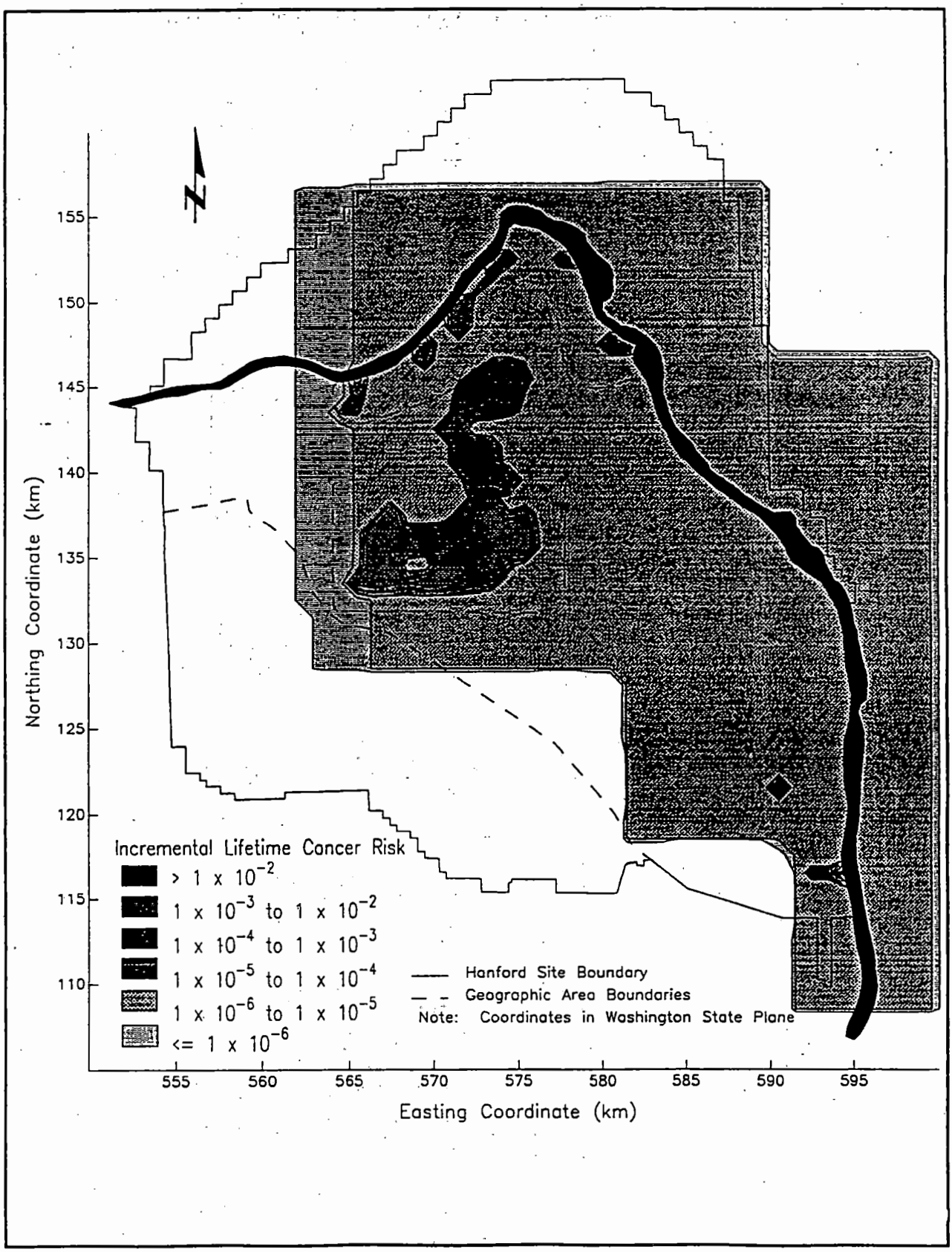

Figure 5-65. Baseline Risk Isopleths for the Industrial Scenario at T_{140} (Year 2129).

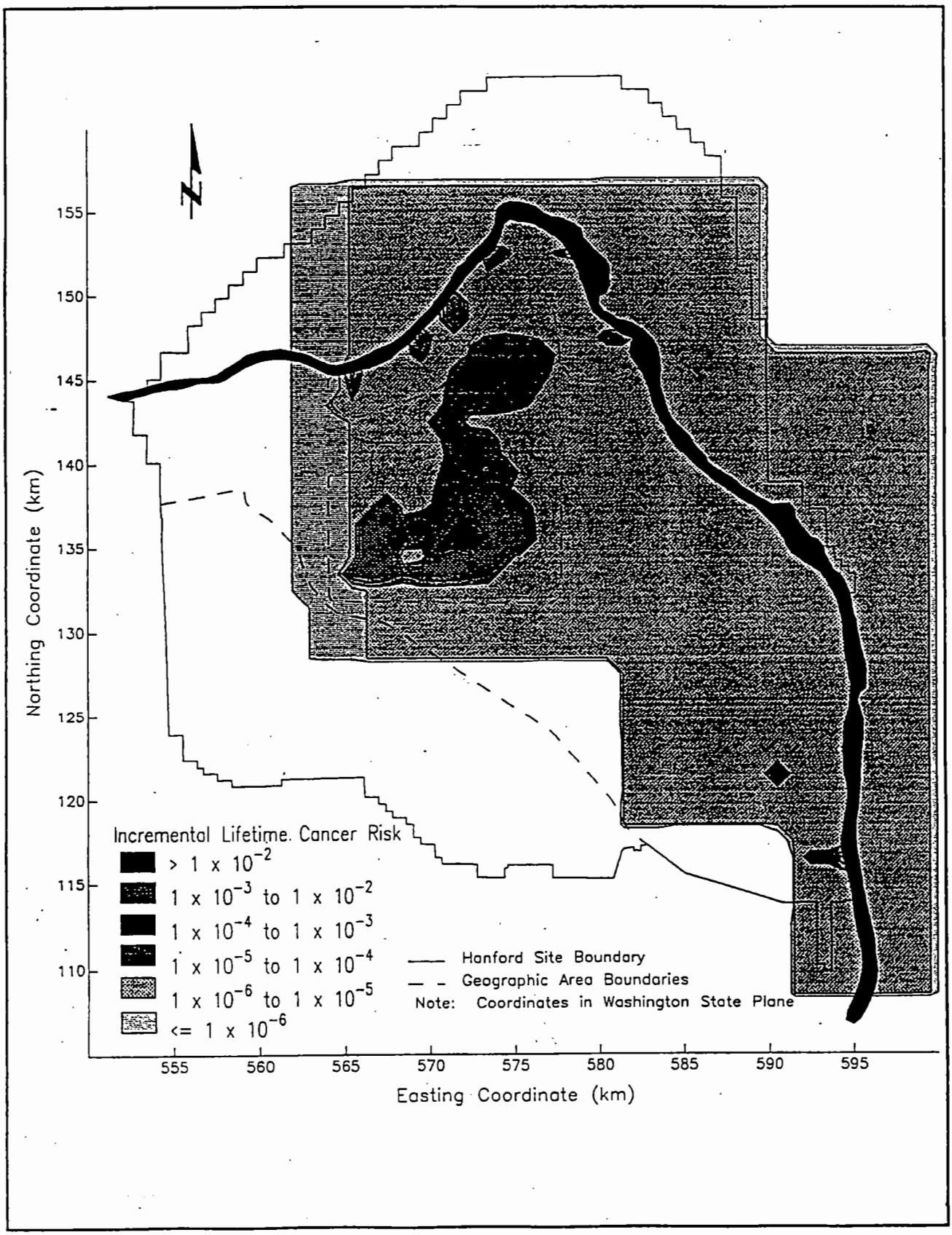

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Figure 5-66. Baseline Risk Isopleths for the Industrial Scenario at T_{1000} (Year 2989).

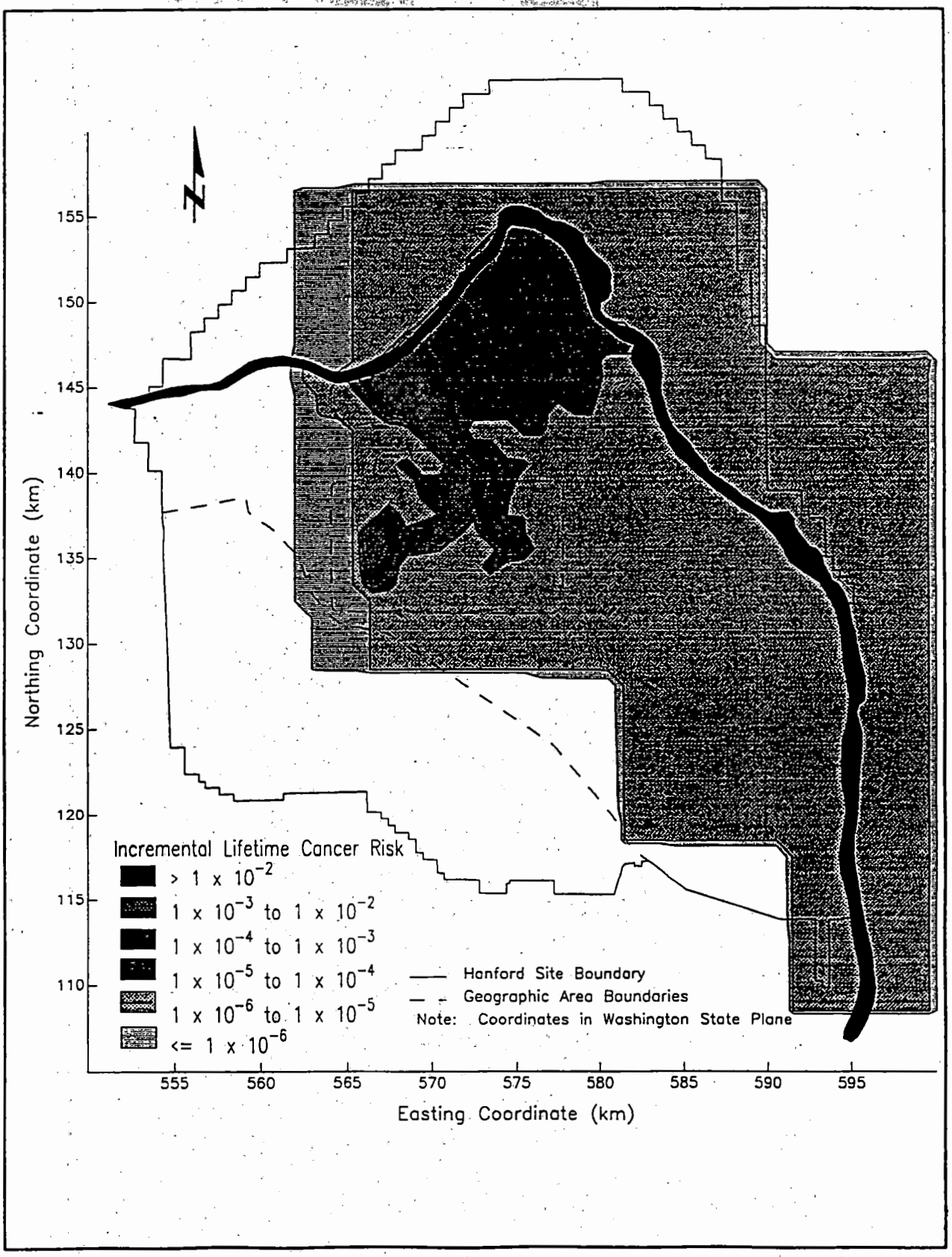

Figure 5-67. Baseline Risk Isopleths for the Industrial Scenario at T_{10000} (Year 11989).

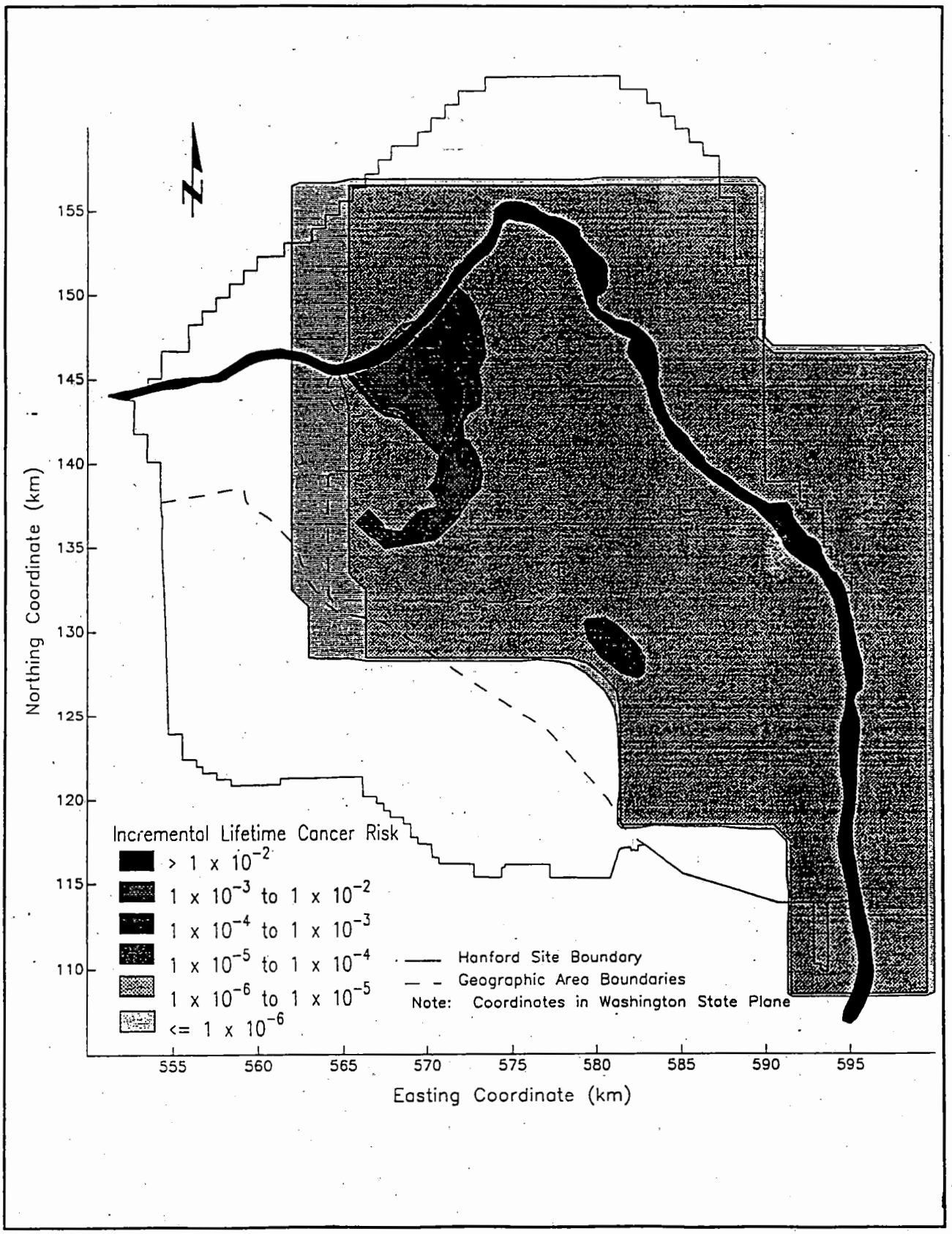

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Figure 5-68. Baseline Risk Isopleths for the Recreational Scenario at T_{40} (Year 2029).

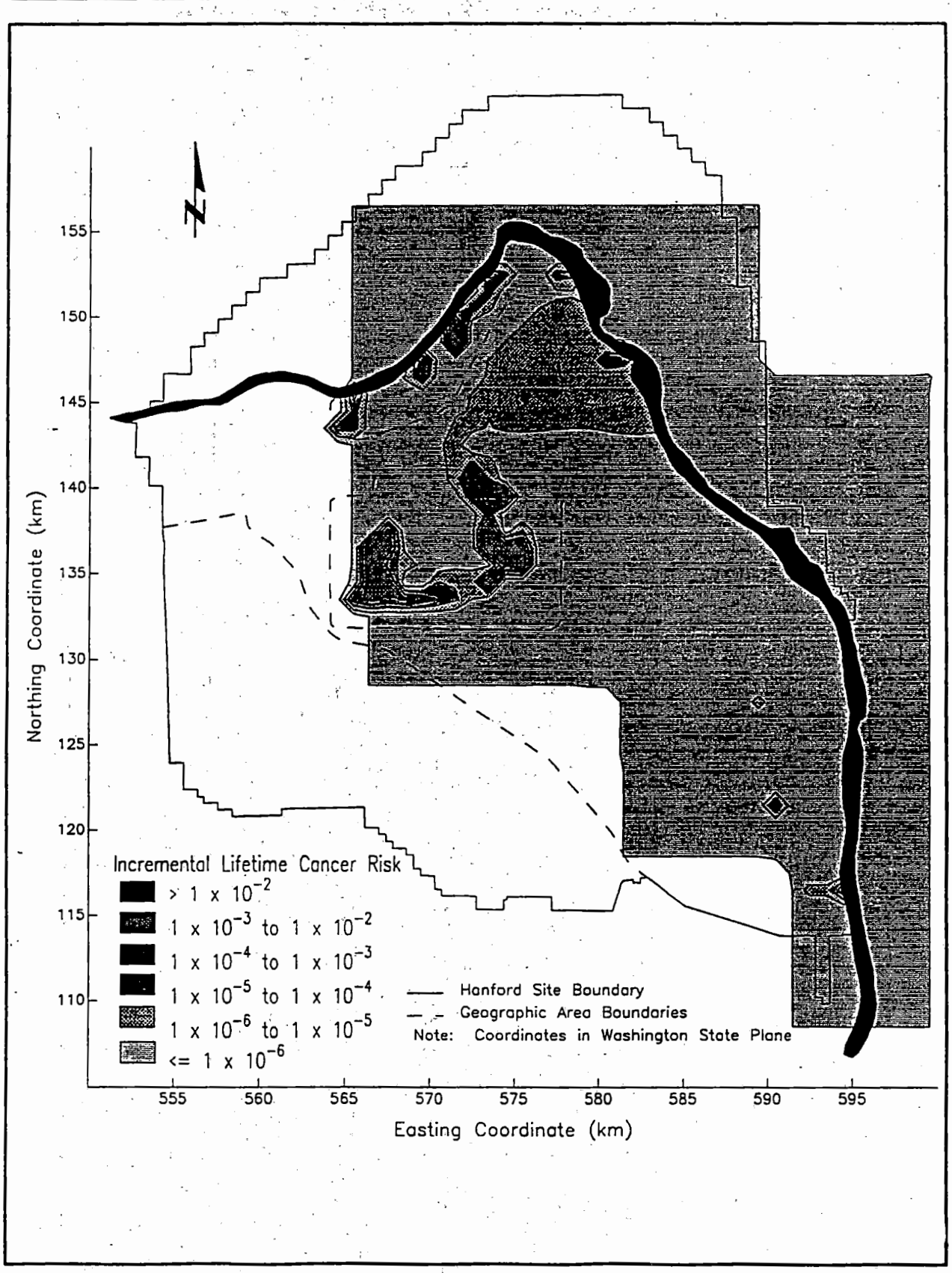
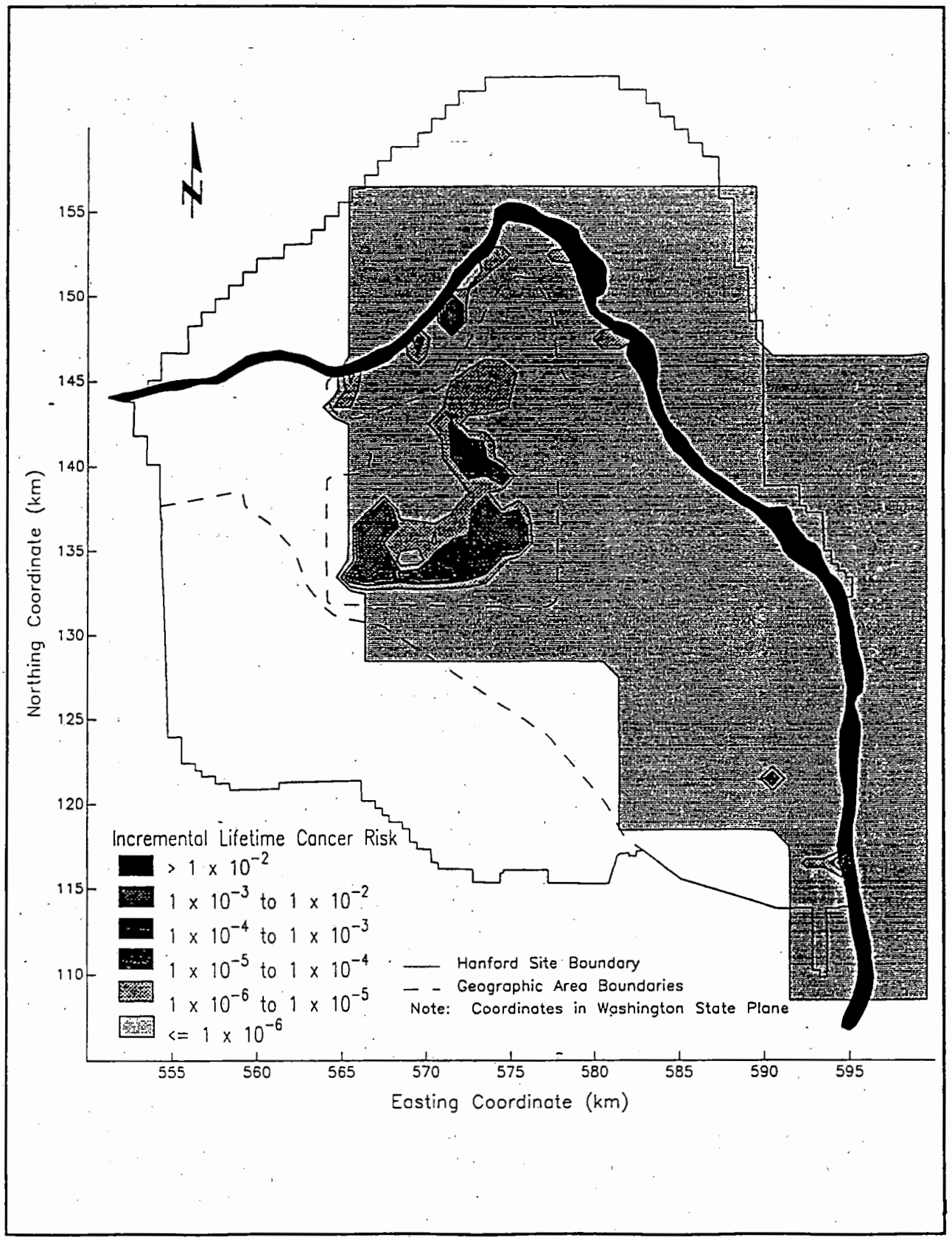


Figure 5-69. Baseline Risk Isopleths for the Recreational Scenario at T_{100} (Year 2089).



9613470.0518

Figure 5-70. Baseline Risk Isopleths for the Recreational Scenario at T_{140} (Year 2129).

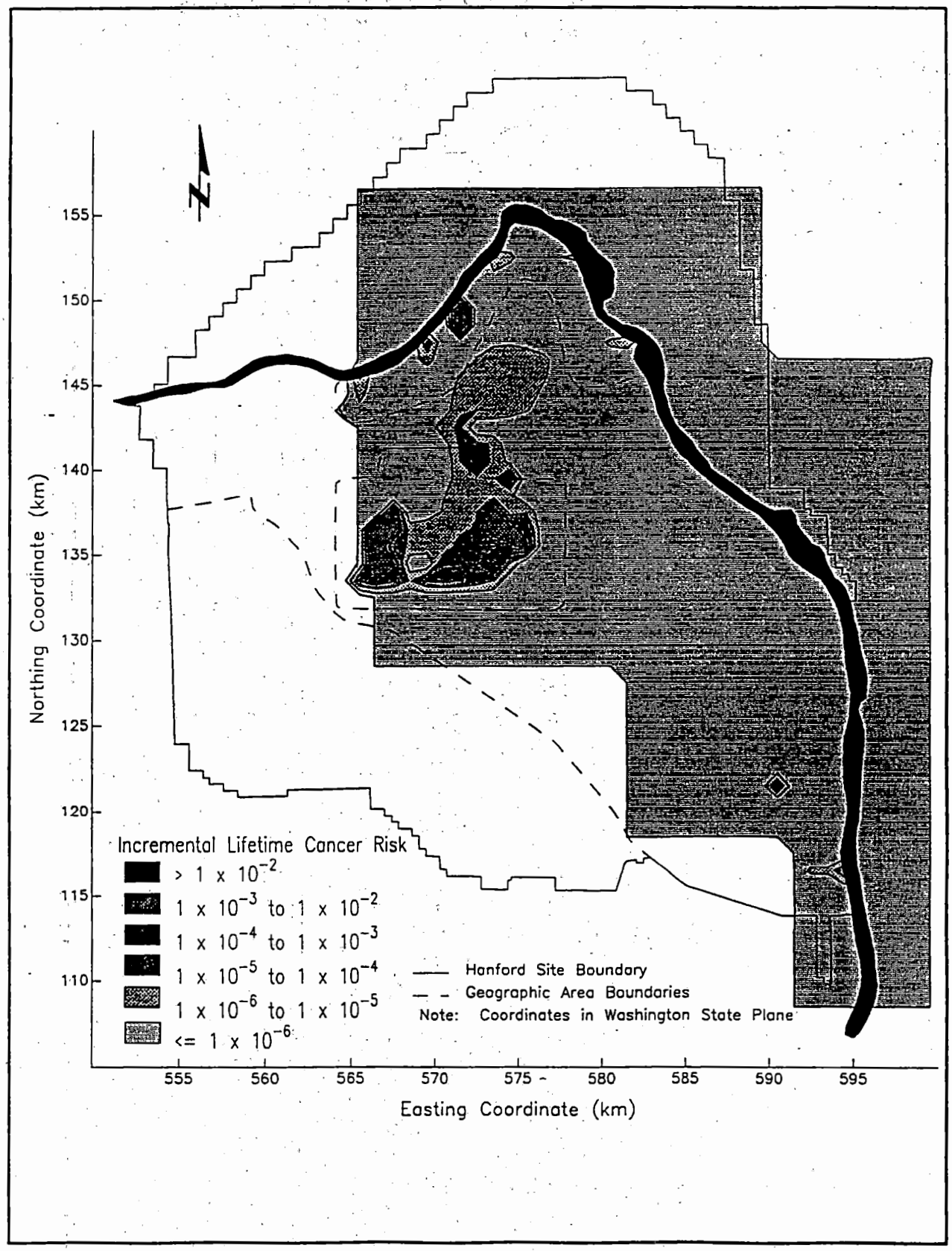
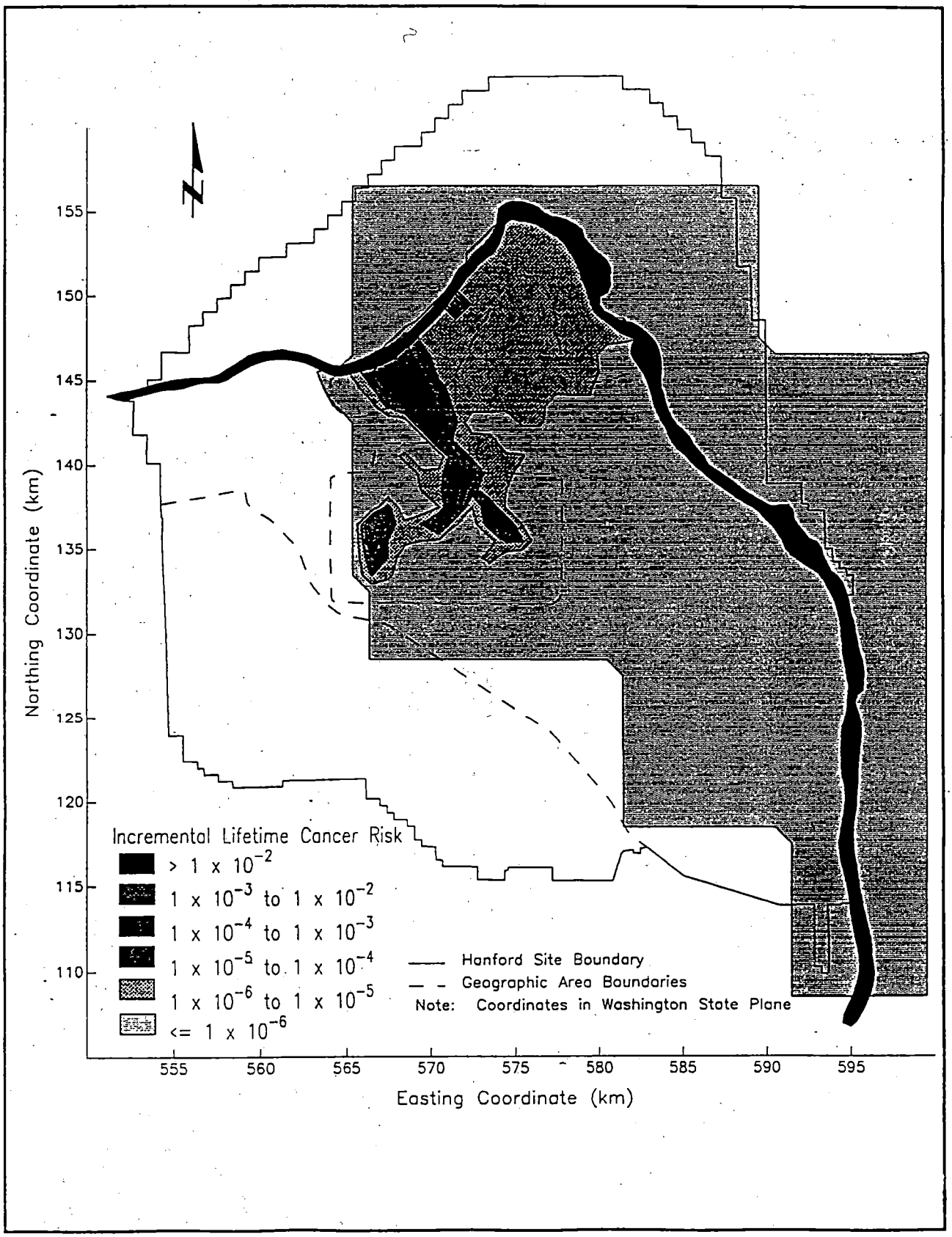
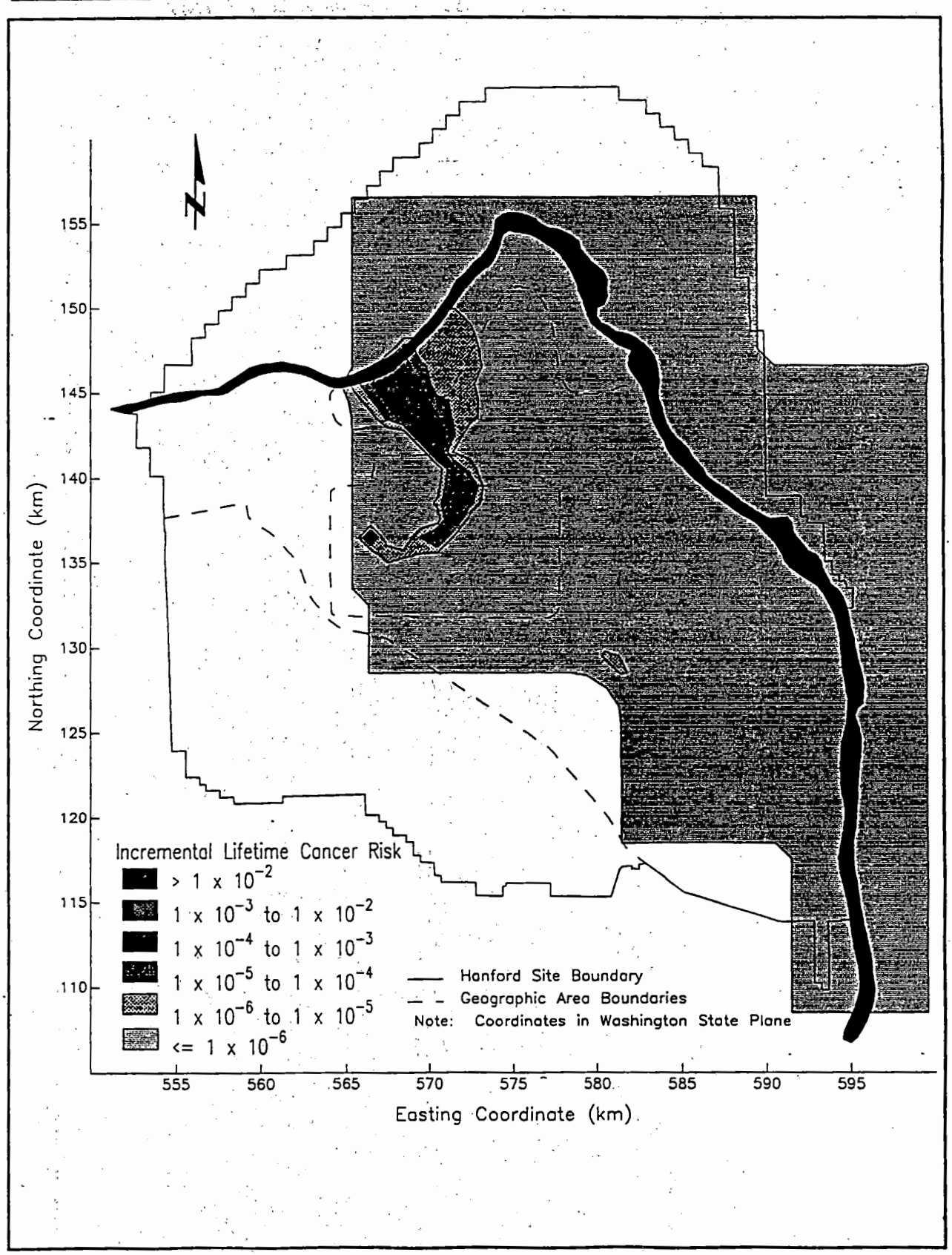


Figure 5-71. Baseline Risk Isopleths for the Recreational Scenario at T_{1000} (Year 2989).



9613470.0519

Figure 5-72. Baseline Risk Isopleths for the Recreational Scenario at T_{10000} (Year 11989).



5.7.3.2 Central Plateau Geographic Area. The removal of institutional controls in the Central Plateau geographic area under the No-Action Alternative has the potential to result in significant human health risks. The results of the baseline risk assessment indicate that, in the absence of institutional controls, ILCRs are greater than 10^{-2} for all of the exposure scenarios in portions of the Central Plateau geographic area.

The risk assessment results for the Central Plateau geographic area that are summarized in Table 5-51 and Figures 5-48 through 5-51 graphically depict the distribution of risks across the Hanford Site. As has been noted for the other geographic areas, groundwater is the major contributor to risk in the Central Plateau geographic area. The figures indicate that the risks associated with the agricultural and residential exposure scenarios exceed the target risk range (10^{-4} to 10^{-6}) in much of the Central Plateau geographic area. A slightly larger area falls within the target range under the industrial exposure scenario, and an even larger area falls within the range under the recreational exposure scenario.

Table 5-51. Cancer Risk and Hazard Index Ranges, Central Plateau Geographic Area.

Reference Time	Exposure Scenario	Hazard Index Range	ILCR Range
T_0 (year 1989)	Agricultural	2.83 E-02 - 9.99 E+02	1.47 E-06 - >1.00 E-02
	Residential	6.63 E-03 - 8.86 E+02	1.25 E-06 - >1.00 E-02
	Industrial	3.14 E-04 - 6.26 E+02	2.71 E-07 - >1.00 E-02
	Recreational	1.75 E-05 - 1.93 E+01	2.27 E-08 - 1.36 E-02
T_{40} (year 2029)	Agricultural	3.94 E-02 - 1.89 E+04	6.86 E-06 - >1.00 E-02
	Residential	3.94 E-02 - 4.42 E+03	6.87 E-06 - >1.00 E-02
	Industrial	2.41 E-02 - 5.38 E+02	2.78 E-06 - >1.00 E-02
	Recreational	6.73 E-04 - 1.64 E+01	2.43 E-07 - >1.00 E-02
T_{100} (year 2089)	Agricultural	1.79 E-02 - 1.40 E+04	6.52 E-06 - >1.00 E-02
	Residential	1.79 E-02 - 3.29 E+03	6.52 E-06 - >1.00 E-02
	Industrial	9.29 E-03 - 1.60 E+02	2.63 E-06 - >1.00 E-02
	Recreational	2.60 E-04 - 1.70 E+00	2.36 E-07 - >1.00 E-02
T_{140} (year 2129)	Agricultural	1.11 E-02 - 8.27 E+03	6.42 E-06 - >1.00 E-02
	Residential	1.11 E-02 - 1.94 E+03	6.42 E-06 - >1.00 E-02
	Industrial	4.67 E-03 - 2.00 E+02	2.58 E-06 - >1.00 E-02
	Recreational	1.31 E-04 - 6.16 E+00	2.34 E-07 - >1.00 E-02
T_{1000} (year 2989)	Agricultural	4.35 E-03 - 4.42 E+04	6.30 E-06 - >1.00 E-02
	Residential	4.35 E-03 - 4.18 E+04	6.30 E-06 - >1.00 E-02
	Industrial	2.24 E-05 - 3.00 E+04	2.53 E-06 - >1.00 E-02
	Recreational	1.55 E-06 - 9.24 E+02	2.32 E-07 - 4.68 E-02
T_{10000} (year 11989)	Agricultural	4.34 E-03 - 4.19 E+04	6.29 E-06 - >1.00 E-02
	Residential	4.34 E-03 - 3.96 E+04	6.29 E-06 - >1.00 E-02
	Industrial	1.91 E-05 - 2.85 E+04	2.52 E-06 - >1.00 E-02
	Recreational	1.46 E-06 - 8.76 E+02	2.32 E-07 - 1.68 E-02

ILCR = incremental lifetime cancer risk.

Risk isopleths for future times are shown on Figures 5-53 through 5-72. These figures indicate that the areas of highest risk tend to spread over time and contribute to risk in adjacent geographic areas. This is the result of movement of contaminated groundwater to other areas.

Hazard indices in the Central Plateau geographic area for current and future times, like ILCRs, range over many orders of magnitude (see Table 5-51) for all four exposure scenarios. As in the case of the ILCRs, this wide variation is caused by the distribution of waste sites and groundwater plumes. Maximum values of the HI exceed 1.0 for some portions of the area, indicating a potential for noncancer effects in these locations.

5.7.3.3 All Other Areas Geographic Area. The results of the baseline risk assessment for the All Other Areas geographic area indicate that, in the absence of institutional controls, estimated current ILCRs are greater than 10^{-2} for portions of the area for the agricultural and residential exposure scenarios and exceed the target risk range (10^{-4} to 10^{-6}) for the industrial and recreational scenarios.

The risk assessment for the All Other Areas geographic area is summarized in Table 5-52 (see Figures 5-48 through 5-58). As has been noted for the other geographic areas, groundwater is the major contributor to risk in the All Other Areas geographic area. Figures 5-48 and 5-49 show very similar risk contour distributions for the agricultural and residential exposure scenarios, respectively, and indicate that risks in most of the All Other Areas geographic area currently fall within the target range under these two scenarios. More of the All Other Areas geographic area falls within the target range under the industrial scenario (see Figure 5-50) and most of the All Other Areas geographic area does so under the recreational scenario. Risk isopleths for future times are shown on Figures 5-53 through 5-72. The areas of highest risk tend to shrink with the passage of time. However, the portion of the All Other Areas geographic area with risks greater than the target range is larger in the future than at present under all four exposure scenarios. This is caused by movement of contaminated groundwater, mostly from the Central Plateau, into the All Other Areas geographic area.

Hazard indices for current and future times, like ILCRs, range over many orders of magnitude (see Table 5-52). This wide variation is due to the distribution of waste sites and groundwater plumes. Maximum values of the HI exceed 1.0 for certain portions of the area, indicating a potential for noncancer effects for these locations.

5.8 Cumulative Impacts

This section summarizes cumulative impacts associated with proposed future land-use objectives for the Hanford Site. Cumulative impacts result "from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or nonfederal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time" (40 CFR 1500-1508). The cumulative impact analysis addresses effects of the proposed action in conjunction with effects of other actions taken during the duration of the proposed action in the same geographic area (DOE 1993a).

Table 5-52. Cancer Risk and Hazard Index Ranges, All Other Areas Geographic Area.

Reference Time	Exposure Scenario	Hazard Index Range	ILCR Range
T_0 (year 1989)	Agricultural	2.55 E-02 - 5.55 E+01	1.47 E-06 - 9.68 E-01
	Residential	5.98 E-03 - 1.55 E+01	1.25 E-06 - 9.67 E-01
	Industrial	2.83 E-04 - 1.76 E+00	2.71 E-07 - 1.71 E-01
	Recreational	1.58 E-05 - 3.14 E-01	2.27 E-08 - 9.29 E-03
T_{40} (year 2029)	Agricultural	9.64 E-03 - 4.57 E+04	2.98 E-30 - 1.00 E+00
	Residential	9.64 E-03 - 1.07 E+04	2.98 E-30 - 1.00 E+00
	Industrial	4.69 E-04 - 5.07 E+02	1.77 E-30 - 2.19 E-01
	Recreational	2.62 E-05 - 2.83 E+01	7.53 E-32 - 1.43 E-02
T_{100} (year 2089)	Agricultural	4.13 E-03 - 1.45 E+04	3.84 E-26 - 5.55 E-01
	Residential	4.13 E-03 - 3.39 E+03	3.84 E-26 - 5.55 E-01
	Industrial	2.38 E-03 - 1.61 E+02	2.28 E-26 - 5.48 E-02
	Recreational	6.65 E-05 - 8.98 E+00	9.69 E-28 - 3.57 E-03
T_{140} (year 2129)	Agricultural	2.41 E-03 - 8.10 E+03	1.87 E-21 - 2.21 E-01
	Residential	2.41 E-03 - 1.90 E+03	1.87 E-21 - 2.21 E-01
	Industrial	1.20 E-03 - 8.98 E+01	1.11 E-21 - 2.82 E-02
	Recreational	3.36 E-05 - 5.02 E+00	4.73 E-23 - 1.82 E-03
T_{1000} (year 2989)	Agricultural	5.17 E-04 - 1.82 E+04	7.56 E-09 - 2.64 E-01
	Residential	5.17 E-04 - 1.72 E+04	7.56 E-09 - 2.64 E-01
	Industrial	4.76 E-06 - 1.24 E+04	4.49 E-09 - 1.28 E-01
	Recreational	2.85 E-07 - 3.80 E+02	1.91 E-10 - 7.42 E-03
T_{10000} (year 11989)	Agricultural	3.20 E-23 - 1.72 E+04	4.70 E-24 - 2.53 E-01
	Residential	7.50 E-24 - 1.62 E+04	4.70 E-24 - 2.53 E-01
	Industrial	3.55 E-25 - 1.17 E+04	2.05 E-24 - 1.22 E-01
	Recreational	1.98 E-26 - 3.60 E+02	8.87 E-26 - 7.00 E-03

ILCR = incremental lifetime cancer risk.

The description of potential cumulative impacts associated with the proposed action couples impacts of the proposed action with impacts from past and existing operations at the Hanford Site and impacts that may be associated with anticipated future actions. This EIS addresses alternative land-use objectives for the Hanford Site and remedial actions required to achieve them. These remedial activities, conducted under the CERCLA process, are aimed at reducing the adverse effects of past actions at the Hanford Site.

Present and reasonably foreseeable future actions at the Hanford Site are summarized in Section 5.8.1. Additional actions where analyses are not complete, but which could contribute to cumulative impacts, are described in Section 5.8.2. Present and reasonably foreseeable future actions adjacent to the Hanford Site are referenced in Section 5.8.3. Finally, potential cumulative impacts of the proposed remedial actions and the No-Action Alternative are summarized by resource in Section 5.8.4.

5.8.1 Present and Reasonably Foreseeable Future Actions at the Hanford Site

This section describes present and reasonably foreseeable actions at the Hanford Site where potential impacts have been identified. These actions are proposed to occur in each of geographic areas considered in this EIS: the Columbia River, Reactors on the River, Central Plateau, and All Other Areas geographic areas.

5.8.1.1 Columbia River Geographic Area. Present and reasonably foreseeable actions in the Columbia River geographic area include the preferred alternative of the *Hanford Reach of the Columbia River, Comprehensive River Conservation Study and Final Environmental Impact Statement June-1994* (NPS 1994). This action addresses the need to protect the Hanford Reach as the last free-flowing stretch of the river. The preferred alternative would combine a Wild and Scenic River designation of the river and its immediate corridor with a National Wildlife Refuge (NWR) designation of the corridor and the upland areas north and east of the river (NPS 1994). Recreational access points would be improved but not expanded, and additional facilities and programs for visitor interpretation and education would be provided. Damming and major dredging would be prohibited. Development of most new industrial facilities on the Hanford Site within the immediate river corridor would be curtailed. Other DOE activities would be specifically allowed or be subject to review and approval. The following potential impacts and benefits were identified in NPS (1994).

- Prohibiting damming and dredging would provide environmental benefits by ensuring favorable conditions for salmon to migrate, and spawn; preserving biodiversity and sensitive species by preventing disturbance of habitats in the Reach; maintaining the existing high water quality by preventing adverse impacts of siltation, water temperature changes, and potential contaminant releases associated with dredging; and preventing inundation and disturbance of cultural resources sites.

- Ongoing cultural resource inventories and surveys by the DOE would maintain the existing number and quality of historic and archaeological sites and increase documentation of new and existing sites.

- Placing controls on corridor development would reduce the amount of siltation to the river and prevent disturbance of cultural and paleontological artifacts.

- Controlling the spread of exotic vegetation would prevent this vegetation from crowding out native plants. Controlling nuisance aquatic macrophytes, such as milfoil, would reduce the impacts of these plants on water quality and aquatic habitats. Revegetating disturbed areas with native plant species would restore the diversity and abundance of native plant and animal species.

- Prohibiting off-road vehicle use would prevent consequent disturbance of riparian and upland habitats and cultural resource sites.

- Prohibiting grazing on public land would minimize further damage to upland and riparian habitats, but would adversely impact tribal access for the purpose of grazing animals and private citizens currently holding grazing permits.

- Increasing river patrols would the reduce impacts of wildfires, littering, and disturbance of rare plants, wildlife, and cultural resources.

- Conducting a study to examine sloughing of the White Bluffs and identify possible protective actions could lead to reduced sloughing, which would benefit this important visual and paleontological resource. Measures to reduce the sloughing of the White Bluffs could adversely impact current irrigation practices on adjacent lands if irrigation is shown to be contributing to the sloughing.

- The Hanford Reach Study Team intends that the Wild and Scenic River designation would not impose constraints on Hanford Site remediation. New construction would be prohibited within the designated boundaries, with the exception of intakes and outfall structures and required facilities related to cleanup of the Hanford Site.

- Habitat protection and restoration efforts under the preferred alternative would benefit recreational use and access, as would increased river patrols, and improvements in public education efforts and recreational facilities.

In mandating the study, Congress provided interim protection prohibiting development of the Hanford Reach until November 1996. Congress may determine the disposition of the area studied in the Hanford Reach EIS through legislative action (NPS 1994). However, the No-Action Alternative would become effective in the absence of congressional action and the Hanford Reach would not be protected from development if the DOE relinquished control of this portion of the Hanford Site.

5.8.1.2 Reactors on the River Geographic Area. Present and reasonably foreseeable actions in the Reactors on the River geographic area are include below.

- **Decommissioning of Eight Surplus Production Reactors.** Present and reasonably foreseeable actions in the Reactors on the River geographic area include production reactor decommissioning. This action addresses the environmental impacts, benefits and costs, and institutional and programmatic needs associated with decommissioning the eight surplus production reactors in the Reactors on the River geographic area (DOE 1992). The Record of Decision (ROD) for this action was published in the 58 FR 178. The DOE decided on safe storage, followed by deferred one-piece removal, as the preferred alternative. This proposed action includes continuing surveillance, monitoring, and maintenance, followed by transport of intact reactor blocks from the present locations in the 100 Areas to the 200 West Area for disposal. Contaminated materials associated with the fuel storage basins also would be disposed of in the 200 West Area, along with contaminated equipment and components associated with the reactors. Uncontaminated portions of the fuel storage basins would be removed to provide access for machinery required to move the reactor blocks. Other uncontaminated structures and equipment would be demolished and placed in landfills in the vicinity of the reactor sites.

  Occupational radiation doses were estimated to be about 51 person-rem for this alternative and short-term public radiation doses were estimated to be near zero (DOE 1992). Near-term ecological impacts were considered minimal because of the existing disturbance from other radioactive waste management activities and nuclear facility operations. The maximum number of workers required at any time would be less than 100. Portions of the B Reactor may be preserved for display in recognition of the cultural significance of the reactor.

Approximately 6 ha (15 ac) in the 200 Areas would be disturbed to accommodate disposal of wastes resulting from decommissioning activities. This disturbance would be partially offset by the 5 ha (13 ac) that would be available for revegetation in the 100 Areas after removal or dismantlement of all 8 reactors. The anticipated workforce to accomplish these activities is 100 employees under any alternative evaluated.

- **Deactivation of the N Reactor.** An Environmental Assessment (EA) was prepared to address all nonroutine activities associated with the shutdown of the N Reactor (DOE 1995b); the Finding of No Significant Impact (FONSI) was issued on May 1, 1995. An EA identifies impacts associated with activities required to prepare the reactor for decommissioning. No additional ground disturbance would be anticipated from deactivation of the reactor. The MEI in the offsite population would receive a dose less than 0.001 mrem/yr and the collective dose to the population would be 0.025 person-rem. Deactivation would require approximately 200 workers for 3 years, with only 3 workers required after deactivation was complete. The DOE and the Washington State Department of Ecology (Ecology) are considering preparing an EIS to examine the impacts of decommissioning the reactor.

5.8.1.3 Central Plateau Geographic Area. Present and reasonably foreseeable actions in the Central Plateau geographic area include the following.

- **Decommissioning and Dismantlement of the Waste Incineration Facility (Building 232-Z) and the Plutonium Concentration Facility (Building 233-S).** Decontamination and dismantlement of these two facilities originally was going to be addressed in one EA. Because of schedule constraints, an EA is in preparation for the decommissioning of Building 232-S; decommissioning of Building 232-Z will be addressed in separate *National Environmental Policy Act of 1969* (NEPA) documentation. The proposed action in each EA will consist of decontamination of the facility followed by dismantlement. Both facilities are located in the 200 West Area. Residual plutonium would be removed from Building 232-Z, and equipment in the buildings would be decontaminated and removed for disposal. Following equipment removal, the buildings would be disposed of in an approved manner. The method of decommissioning would be determined by the success of the decontamination. Transuranic waste generated during decommissioning would be stored on the Hanford Site until a permanent disposal facility becomes available.

  Potential environmental impacts of the proposed action are considered minimal. The proposed action would not involve wetlands or floodplains, threatened or endangered species, or critical habitats. The proposed action would not occur in an area of cultural or historical significance, and would not affect the hydrologic or geologic characteristics of the Hanford Site. Soil and site topography in the immediate work area would be disturbed. Workers would be exposed to radiation as a result of these projects, but required and planned safety features would minimize these impacts.

  Based on preliminary estimates, potential radiation doses to the MEI, as a result of routine decommissioning operations at the 232-Z Facility, would add an estimated at 1.6×10^{-8} mrem to the 0.03 mrem dose to the hypothetical MEI reported by PNL (1995). The potential radiation dose to the MEI associated with routine operations at the

233-S Facility would add an estimated 5.94 x 10^{-6} mrem. This additional radiation dose would not be expected to cause any adverse health effects, and is conservative because adding the estimated dose to the dose calculated for existing operations assumes that the MEI is located at the same point.

- **Superconducting Magnetic Energy Storage - Engineering Test Model.** The Superconducting Magnetic Energy Storage - Engineering Test Model (SMES-ETM) would test the feasibility of storing electrical energy in the form of a direct current magnetic field in a superconducting coil (USACE 1992). The Hanford Site is one of five potential locations for the SMES-ETM. The proposed Hanford location is just northeast of the 200 East Area. The facility site would occupy less than 40 ha (100 ac) and the area defined by the perimeter of the 131-m (430-ft) superconducting coil occupying 1.2 to 1.6 ha (3 to 4 ac). Construction would require 150 to 300 workers, and operations, maintenance, and testing would require 15 to 30 workers. The design lifetime of the test facility would be 5 to 10 years.

  The primary potential impacts of the SMES-ETM are associated with potential health effects of the magnetic field. No evidence of risks to the general public or ecological receptors were identified in the EIS (USACE 1992). Potential impacts on bird navigation would be evaluated by research and monitoring during SMES-ETM testing. No significant impacts on aircraft navigation were identified. Additional habitat disturbance in the Central Plateau geographic area would be a cumulative impact associated with this project if the Hanford Site were selected.

- **Environmental Restoration Disposal Facility.** This facility has been constructed adjacent to the 200 Areas and will be in operation by September 1996 (Ecology et al. 1989). The facility provides for safe storage and disposal of waste generated during environmental restoration activities at the Hanford Site (DOE-RL 1994a). The ERDF will be the disposal facility for most of the waste excavated during remediation of waste management units at the Hanford Site. Waste generated from remediation of CERCLA past-practice units will be placed in the ERDF. Only waste that originates within the Hanford Site will be placed in the ERDF. The waste is expected to consist of dangerous waste, radioactive waste, and mixed waste. The ERDF will be expanded, as needed, ultimately covering as much as 4.1 km^2 (1.6 mi^2) on the Central Plateau southeast of the 200 West Area and southwest of the 200 East Area. Initial construction involved 65 ha (165 ac) of this area.

  Under current climate conditions, contaminants placed in the ERDF would not be expected to reach groundwater within 10,000 years. After 10,000 years, estimated human health risks for any of the alternatives are a maximum ILCR of 5 x 10^{-6} and a maximum hazard quotient for noncarcinogens of 0.2. Ecological impacts would occur at the ERDF site and at borrow sites for materials to be used in the liner and cover. The shrub-steppe habitat at the ERDF site is considered priority habitat by the State of Washington, and a number of Washington State monitored or candidate species may be affected by the ERDF. The estimated disturbed area ranges from 14 to 54 ha (35 to 133 ac) for the silt borrow area (McGee Ranch). The disturbed area at the ERDF site itself, including the trench, stockpiling areas, roads, and supporting facilities is estimated to be 260 ha (640 ac), or approximately 1 mi^2. Significant cultural resources have not been identified at the ERDF site or at the McGee Ranch. Operation of the ERDF is expected to provide up to

167 full-time positions at the Hanford Site. The total estimated capital costs for the ERDF range from $246 million to $663 million. Visual and noise impacts of ERDF construction and operation are considered negligible.

- **Spent Nuclear Fuel Management**. The DOE has developed an EIS (DOE 1995a) and issued a ROD (60 FR 28680) for the Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs. This decision establishes DOE policies for the environmentally safe transport, storage, and management of spent nuclear fuels (SNF). A large portion of the DOE-owned inventory of SNF is already stored at the Hanford Site, and has been identified as a participant in the management of spent fuel. The preferred alternative, regionalization of SNF storage by fuel type, requires management of defense production spent fuel at the Hanford Site and transport of other spent fuel currently stored at the Hanford Site to the Idaho National Engineering Laboratory.

  Land disturbance at the Hanford Site, under the preferred alternative, is estimated at 7 ha (18 ac) of shrub-steppe habitat on the Central Plateau west of the 200 East Area. Estimates of employment required for construction activities range from 176 to 1,065 during the years from 1997 to 2000. Operations would require 208 to 230 employees through 2004, with levels gradually declining to 50 to 60 workers beyond the year 2004. Many of these employees would be drawn from the existing Hanford Site workforce. Construction of the new facilities is not expected to have any significant impact on cultural resources. Solid waste generation would be a maximum of 330 m^3/yr (11,654 ft^3/yr), or approximately 4% of the 21,000 m^3/yr (740,000 ft^3/yr) currently generated at the Hanford Site. The MEI in the general population would receive a dose of 0.007 to 0.02 mrem/yr from waste processing activities. Resources, including materials, fuels, and public funds, required to implement this alternative would overlap with the time periods when the same type of resources would be required by remedial activities at the Hanford Site.

- **222-S Radioactive Liquid Waste Line Replacement and 219-S Secondary Containment Upgrade**. The DOE prepared an EA addressing replacement of the 222-S radioactive liquid waste line and 219-S facility secondary containment system that transfers liquid waste to the 241-SY Tank Farm (DOE 1995c). The action was proposed in order to bring the 222-S Laboratory (222-S) radioactive liquid waste lines into compliance with existing secondary containment and leak detection requirements specified in *Washington Administrative Code* 173-303, reduce potential risks to the environment and to worker safety, reduce the risk of laboratory shutdown caused by failure of the waste system, and upgrade the 219-S Waste Handling Facility (219-S).

  The 222-S was built in 1951 to support the 202-S Reduction-Oxidation Plant and the 200 Area tank farms. The laboratory is now used to perform analytical services on radioactive samples in support of the Tank Waste Remediation System (TWRS) Program and Hanford Site environmental restoration programs. Activities conducted at 222-S include decontamination of analytical processing and support equipment, and disposal of nonarchived radioactive samples. These activities generated low-level liquid mixed waste.

  The waste historically was transferred from 219-S through a buried pipeline to the 241-SY Tank Farm in the 200 West Area for storage. However, the current practice is to transfer waste by tanker truck from 219-S to a tank farm in the 200 East Area, because of

concerns about the integrity of the existing line between 219-S and the 241-SY Tank Farm. Ecology is now allowing this to be done on an interim basis under a RCRA Part A dangerous waste permit.

The 222-S was expected to remain in use for at least the next 30 years to serve the Hanford Site environmental remediation mission. Failure of the drain and transfer piping systems or any of the 219-S tanks would result in shutdown of the laboratory.

A FONSI was issued January 24, 1995. The proposed action is being performed in two phases. The first phase was installation of a new transfer line from the lab to the tank farms. This work is expected to be completed in December 1995. The second phase is renovation of the laboratory piping and cell interiors. The design has been completed and construction is anticipated to begin January 1996 and to be completed in March 1997.

- **Access Road from State Route 240 to the 200 West Areas.** The DOE prepared an EA addressing construction of a new access road, from State Highway 240 to Beloit Avenue in the 200 West Area, to address a potential safety concern regarding traffic congestion on the existing access to the 200 Areas (DOE 1994a). The new road is 3.5 km (2.2 mi) long and was constructed to reduce the expected traffic load by up to 30%. Construction of the road disturbed 7.2 ha (17.9 ac) of shrub-steppe habitat and could lead to habitat fragmentation, because the road divides a contiguous area of undisturbed habitat. A FONSI was issued in March 1994. The access road has been constructed and is in use.

- **Operation of Low-Level Burial Grounds.** The low-level burial grounds located in the 200 West and 200 East Areas are an active RCRA landfill and cover a total area of 225 ha (556 ac). The landfill is divided into eight burial grounds and each burial ground consists of a number of trenches that contain, or will contain, low-level radioactive and mixed waste. Six burial grounds are located in the 200 West Area and two burial grounds are located in the 200 East Area. Impacts associated with operation of the burial grounds include habitat disturbance or loss, and the potential for generation of fugitive dust.

- **Operation of the US Ecology Commercial Low-Level Radioactive Waste Landfill for Offsite Commercial Waste.** US Ecology operates a radioactive waste landfill that accepts commercially generated low-level wastes from states included in the Northwest Low-Level Radioactive Waste Compact. The US Ecology landfill is located directly east of the ERDF site. Habitat disturbance is an impact associated with the site.

- **Solid Waste Retrieval Complex, Enhanced Radioactive and Mixed Waste Storage Facility, Infrastructure Upgrades, and Central Waste Support Complex.** The DOE has prepared an EA addressing several waste management projects for the Central Plateau. These projects include the Solid Waste Retrieval Complex, Enhanced Radioactive and Mixed Waste Storage Facility, Infrastructure Upgrades, and Central Waste Support Complex. These projects will be undertaken in the 200 West Area and will involve approximately 36 ha (89 ac), or about 5% of the 777 ha (1,920 ac) in the 200 West Area. Retrieval activities will occur in previously disturbed areas. The storage facility will be constructed on relatively undisturbed land, resulting in an incremental loss of shrub-steppe habitat essential for sensitive species, such as the loggerhead shrike and sage sparrow.

  Discharges of nonradioactive liquid effluents could incrementally increase discharges of nonradioactive effluents in the 200 Areas by 43,000 m^3 (11 million gal), which would

comprise approximately 2% of the total discharge. This additional volume is not expected to produce any discernable mounding of the groundwater. Changes in the movement of underground contaminant plumes also are not expected.

Implementation of the proposed action would not be expected to produce a cumulative socioeconomic impact, and discernable changes in the radiation dose to offsite receptors would not be expected.

- **200 Area Sanitary Sewer System.** The DOE has prepared an EA proposing to replace the existing sanitary sewage septic systems in the 200 Area plateau with two modern sanitary sewage collection systems and evaporative lagoon systems for treatment and disposal. The DOE has identified a need for this proposed action to alleviate failing and overloaded sewage treatment facilities in the 200 Areas of the Hanford Site, and restrain the flow of effluent to the vadose zone.

  Approximately 50 sanitary sewage septic systems presently serve facilities on the 200 Area plateau. Many of these 30- to 40-year-old systems are failing or are overloaded. Currently, about 1,510 (400,000 gal) of sewage per month are being transported from failed 200 Area septic systems to the 100-N Area sanitary sewer lagoon. All of these septic systems discharge septic system effluent into the vadose zone. This discharge contributes to the "mounding" of groundwater below the 200 Area plateau, which drives existing below-grade contamination plumes toward the Columbia River.

  One sewage collection and lagoon system would serve the 200 West Area and surroundings, and another would serve the 200 East Area and surroundings. The proposed sewage treatment system would replace approximately 50 septic systems presently serving facilities in the 200 Area plateau. These systems would eliminate most liquid discharges to the vadose zone. Sewage dump stations in each area would allow sewage from failed septic systems in other areas to be transported to the proposed lagoon system for treatment and disposal.

- **Tank 241-C-106 Sluicing and Waste Removal.** This project addresses the need to retrieve the high-heat waste in single-shell tank (SST) 241-C-106 and transfer it to double-shell tank (DST) 241-AY-102. The removal of the waste would stabilize this tank and eliminate the need to add cooling water. An EA (DOE 1994b) and FONSI were approved in February 1995.

  This EA proposed to sluice the high-heat waste from Tank 241-C-106 to a DST through one of two proposed double encased (pipe-in-pipe design), bermed lines. The DOE has identified a need to take this action to eliminate safety concerns with the storage of high-heat waste in Tank 241-C-106, and demonstrate a tank waste retrieval technology. The system would be a closed loop, continuous sluicing process. The scope of the project is to remove 75%, at a minimum, of the high-heat waste. Sluicing of underground storage tanks involves introducing a high-volume, low-pressure stream of liquid to mobilize underground storage tank sludge waste before pumping the tank contents.

  Tank 241-C-106 is located in the 200 East Area. It has a 31-cm (10-in) -thick dished bottom, a useable waste depth of approximately 4.8 m (16 ft) at the sidewall, and is a SST. The waste in Tank 241-C-106 consists of 746,000 L (197,000 gal) of sludge that is stratified

into two layers. The top layer consists of 655,000 L (173,000 gal) of sludge, containing a sufficient amount of strontium to be considered high-heat waste, which generates approximately 32 kW of heat. The bottom layer consists of 91,000 L (24,000 gal) of low-heat producing hardened material.

5.8.1.4 All Other Areas Geographic Area. Present and reasonable foreseeable actions in the All Other Areas geographic area include the following.

- **Construction and Operation of a Laser Interferometer Gravitational-Wave Observatory on the Hanford Site.** An EA was prepared for construction and operation of a Laser Interferometry Gravitational Wave Observatory (LIGO) (NSF 1993). A FONSI was issued for this facility in December 1993. The LIGO site occupies approximately 6 km^2 (2.3 mi^2) with facilities, including a 7,600-m^2 (9100-yd^2) central building at the vertex of two 4-km (2.5-mi) arms, mid- and end-station buildings along the arms, service roads, parking areas and construction laydown areas occupy approximately 0.6 km^2 (0.23 mi^2). Service roads running the length of the 4-km (2.5-mi) arms fragment habitat that exists at the site. The facility will accommodate 10 to 20 permanent staff with an additional 10 visiting scientists. The LIGO is presently under construction.

- **Environmental Molecular Sciences Laboratory.** A FONSI for the Environmental Molecular Sciences Laboratory (EMSL) EA (DOE 1990) was issued in 1992. The EMSL would consist of an 18,500-m^2 (200,000-ft^2) building originally proposed for siting on a 12-ha (30-ac) site located within the city limits of North Richland, Washington, at the south end of the Hanford Site 300 Area. On the second day of construction, April 12, 1994, construction crews uncovered human remains thought to be those of Native Americans. The DOE immediately halted construction and proposed, consistent with the wishes of local Indian tribes and with the spirit of the *Native American Graves Protection and Repatriation Act of 1990,* and the *American Indian Religious Freedom Act of 1978*, to relocate the site of the facility. An EA was prepared addressing resiting of the facility (DOE 1994) and the FONSI was approved July 1994. The facility is under construction at the new site. Approximately 200 to 250 employees would be located at the EMSL, including permanent staff and visiting scientists. The annual effective dose equivalent to the offsite MEI would be 1×10^{-4} mrem.

- **Inert/Demolition Waste Landfill (Pit 9).** This EA proposed to construct a waste landfill (Pit 9) to accumulate inert and demolition waste for the Hanford Site (DOE 1995d). The DOE has identified a need for a convenient and economical disposal capacity of these types of waste to support the demolition activities planned for the southern areas of the Hanford Site. The current demolition waste landfill, Pit 10, located approximately 25 m (82 ft) west of Route 4S, will reach full capacity in 1995. The projected demolition activities on the Hanford Site will continue for up to 20 years; therefore, a replacement demolition landfill is required in the near term. Therefore, the DOE proposed to use an existing alluvial gravel pit, Pit 9, as a new inert and demolition waste landfill for the Hanford Site. Pit 9 is located approximately 3 km (1.9 mi) north of the 300 Area, in the 600 Area. It would be converted to use as an inert/demolition waste landfill by installing a lockable access gate at the entrance, and a fenced barrier around the entire landfill area, appropriately posted. No

other physical alterations in the Pit 9 area would be necessary. This action would support the disposal phase of various infrastructure demolition projects in the southern areas of the Hanford Site. These demolition projects would produce waste consisting of concrete, brick, incidental wood, used asphalt, and steel. Because of the large size of Pit 9, current disposal projections estimate that it would be available for the noted types of waste for 20 years. The FONSI for this action was approved May 15, 1995, and Pit 9 has been open and operational since approximately July 1995.

- **Disposition of Sodium Test Loops.** The DOE proposed to package the metallic sodium and sodium-potassium eutectic material, and associated loop hardware for shipment offsite for recycling, reuse, and/or disposal (DOE 1995e). The sodium test loops are located in the 200 and 300 Areas on the Hanford Site. Additionally, any or all loops may be packaged appropriately and transferred offsite for reuse. Residual sodium-wetted piping and associated equipment also would be packaged for recycle disposal, as appropriate. Ancillary tankage would be cleaned *in-situ* to remove residual sodium for potential reuse/disposal. Consideration would be given to allow an offsite entity to perform all, or part, of the proposed action. The FONSI for this action was approved in May 1995 and the proposed activities are proceeding as scheduled. The first of five sodium test loops have been shipped to L. M. Manufacturing under a Cooperative Research and Development Agreement. Phase two of the proposed action is to drain the sodium tanks and ship the sodium to a offsite buyer at a later date.

- **300 Area Process Sewer Piping Upgrade and 300 Area Treated Effluent Disposal Facility Discharge to the City of Richland Sewer System.** This EA was prepared to address upgrading the 300 Area process sewer piping system and to connect the Treated Effluent Disposal Facility (TEDF) discharge to the City of Richland sewage system (DOE 1995f). The FONSI for this action was issued May 25, 1995). This action addresses the need to take action to reduce, or where appropriate, eliminate untreated liquid effluents discharged to the soil in the 300 Area of the Hanford Site. This action is expected to reduce anticipated operating costs at the new 300 Area TEDF, which became operational December 1994, and improve the questionable integrity of the old piping in the existing 300 Area Process Sewer System.

  The 300 Area Process Sewer System discharges effluents to the TEDF collection sump and lift station. The construction and operation of the TEDF were addressed in a previously approved EA (DOE 1995f). The process waste liquid effluent was well below DOE requirements for radiological secondary containment, and is not considered a RCRA hazardous waste or a State of Washington *Hazardous Waste Management Act of 1976* dangerous waste.

  The proposed action includes upgrades to the existing 300 Area Process Sewer System through the construction and operation of a new collection system; and construction and operation of a combined gravity, vacuum, and pressurized collection system from the TEDF with capacity to accommodate additional buildings in the 300 Area.

- **Special Case Waste Storage Facility.** This EA addresses the transfer of nonfuel high-activity waste from 300 Area hot cells to an aboveground dry storage module in the 200 West Area.

The EA addresses construction and operation of a Special Case Material storage unit, which is the proposed high-activity remote-handled waste storage facility consists of solid waste containers, shipping casks, a transfer system, and storage modules similar to those used by the commercial nuclear power industry.

The proposed action will provide a centralized remote-handled storage facility with monitoring and retrievability capabilities in the Hanford Site's solid waste management area located in the 200 West Area. The action also will include an initial shipment of approximately (16.8 m^3) 592 ft^3 of remote-handled waste from the 324 Building B-Cell, in the 300 Area.

The EA was issued to the State of Washington, Tribes, and USFWS for comments in August 1995. Comments have been received by the DOE and responses to the comments are being prepared. The final EA is scheduled to be issued in early fiscal year 1996.

- **Fast Flux Test Facility Standby.** The DOE has prepared an EA (DOE 1995g) addressing shutdown of the Fast Flux Test Facility (FFTF). The EA proposed to permanently shutdown the FFTF by:

  - Removing fuel

  - Draining and de-energizing the systems

  - Removing the stored radioactive and hazardous materials

  - Performing other actions to place the facility in a radiologically and industrially safe shutdown state.

The action will place the FFTF in a radiologically and industrially safe shutdown condition, suitable for a long-term surveillance and maintenance phase before final decommissioning. Disposition of radioactive and hazardous materials will be necessary to place the facility in a safe shutdown condition with reduced risk to plant workers, the public, and the environment, while achieving the desired cost savings.

Appropriate surveillance and maintenance would be performed to prevent unacceptable risks to persons or the environment until final decommissioning of the facility is completed.

The FONSI was issued on May 1, 1995. The actions for permanently shutting down the FFTF include the following:

- Removing the fuel, draining and de-energizing the systems, removing the stored radioactive and hazardous materials, and performing other actions to place the facility in a radiologically and industrially safe shutdown state.

- Performing appropriate surveillance and maintenance to prevent unacceptable risks to persons or to the environment.

- Defueling the reactor core to the Interim Decay Storage and the Fuel Storage Facility by use of standard FFTF refueling equipment and operating procedures. The fuel will

be replaced with irradiated nonfuel core components, 13 new nonfuel core components, and 3 new Simulated Core Assemblies that otherwise would have been excessed.

- Appropriately dispositioning two fuel assemblies that experienced a breach in the fuel cladding during irradiation, several fuel assemblies that are known gas leakers, and seven sodium-bonded metal fuel assemblies plus sodium-bonded pins that will require slightly different disposition.

- Maintaining the metallic sodium in a molten state until the fuel assemblies can be removed from their respective storage locations and transferred to appropriate storage.

- Performing an appropriate excess evaluation of the bulk metallic sodium inventory to determine if alternative sponsors and/or uses are available.

- Maintaining the residual sodium in the main portion of the FFTF's piping and equipment after the sodium and sodium-potassium eutectic alloy systems with an inert gas atmosphere to prevent any chemical reactions during long-term surveillance and maintenance.

- Packaging the solid and liquid effluents from the shutdown activities that contain radioactive and/or hazardous materials, giving primary consideration to transportation of waste to existing Hanford Site TSD facilities. Offsite TSD facilities also will be considered, as appropriate.

The FFTF has been shut down and deactivation activities are proceeding as scheduled.

5.8.2 Other Potential Actions

A number of other proposed actions at the Hanford Site are being evaluated in environmental assessments (EA), as detailed in the *1995 Hanford Site Mission Plan, Volume 1, Site Guidance* (DOE-RL 1994c), and additional projects are likely to be proposed and evaluated in the future. Impacts of these projects cannot be considered in this analysis, because impact analyses are not complete and decisions regarding implementation of a preferred action have not been made. These projects may contribute to cumulative future impacts of proposed remedial actions in two of the four geographic areas considered in this EIS. No additional actions that may affect cumulative impacts in the Reactors on the River or Columbia River geographic areas are proposed. Actions in the All Other Areas geographic area may have indirect effects on the river.

*5.8.2.1 **Central Plateau Geographic Area.*** Actions that may contribute to cumulative impacts in the Central Plateau geographic area include the following.

- **Safe Interim Storage of Hanford Tank Wastes.** A Final EIS analyzes potential impacts of construction and operation of six new DSTs and the replacement of the cross-site waste transfer line between the 200 East and the 200 West Areas (Ecology and DOE-RL 1995). Primary potential impacts associated with the project are loss of shrub-steppe habitat and radiological air emissions.

- **Tank Waste Remediation System.** An EIS is being prepared to analyze alternatives for remediating the waste currently contained in the SSTs and DSTs in the Central Plateau geographic area, and to provide for safe storage and disposal of strontium and cesium capsules used in research projects at Hanford Site and offsite locations (DOE and Ecology 1995). DOE management has assumed that all SST waste ultimately would be removed from the tanks for immobilization and disposal. Potential impacts associated with this project are worker exposures to radiological and hazardous constituents during waste disposition, habitat disturbance, and radiological air emissions.

- **Stabilization of Plutonium Finishing Plant Radioactive Materials.** This proposed project involves stabilization of the radioactive materials present in the Plutonium Finishing Plant and subsequent safe shutdown of the facility. Potential impacts include worker exposure and radiological air emissions. A Draft EIS is in preparation.

- **Relocation and Storage of TRIGA Reactor Irradiated Fuel.** This project would relocate this irradiated fuel from the 308 Building to interim storage in the 200 West Area. An EA is in preparation (DOE 1995h).

- **Construction and Operation of a Storage Unit for Special Case Material.** The DOE is preparing an EA to address environmental impacts of constructing a facility for storing special case wastes within the fenced 200 West Area.

- **Disposal of Decommissioned, Defueled Cruiser, Los Angeles Class, and Ohio Class Naval Reactor Plants.** This EIS, to be prepared by the U.S. Navy, will evaluate the potential impacts of disposing of defueled reactor plants from decommissioned naval vessels (Navy 1995). Continued land disposal at the Hanford Site is one of the alternatives being considered. The DOE is a cooperating agency in the preparation of this EIS.

- **Hanford Spent Nuclear Fuel Management.** A DOE EIS is being prepared to follow the issuance of the ROD (60 FR 28680) for the *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Draft Environmental Impact Statement* (DOE 1995a). This EIS would address the impacts of implementing actions identified in the ROD at the Hanford Site and management of SNF from the K-Basins at the Hanford Site (DOE 1995i).

5.8.2.2 All Other Areas Geographic Area. Other actions that may contribute to cumulative impacts in the All Other Areas geographic area include the following.

- **Plutonium-Uranium Extraction Plant/Uranium Trioxide Plant Shutdown.** In 1993, the DOE directed Westinghouse Hanford Company to terminate the Plutonium-Uranium Extraction (PUREX) Plant and provided guidance to proceed with shutdown planning and terminal cleanout activities. This direction also covered the Uranium Trioxide Plant at completion of the pending shutdown campaign. An EA addressing transfer of the irradiated fuel from PUREX and the N Reactor irradiated fuel for storage at the 105-KE and 105-KW Fuel Storage Basins has been prepared (DOE 1995j).

5.8.3. Present and Reasonably Foreseeable Actions Adjacent to the Hanford Site

No major actions have been identified outside the Hanford Site boundary that would significantly contribute to environmental impacts of the proposed action. City and county planning officials were consulted to assess such potential actions. The actions identified are primarily road, bridge, and sewer system improvements that are likely to have only minor impacts themselves and that are limited compared to the large scale of actions associated with the proposed future land-use objectives. Ongoing economic and residential development in the region could contribute to cumulative socioeconomic impacts. However, as discussed in Section 5.8.4.9, there is considerable uncertainty associated with any analysis of such impacts, given available information on the scheduling of potential remedial actions.

5.8.4 Summary of Cumulative Impacts

This section summarizes potential cumulative impacts of this EIS' proposed action when added to the actions outlined above. Cumulative impacts, by their nature, generally are more clearly understood in the context of the Hanford Site as a whole. Therefore, this discussion is organized according to the resource areas of concern in this EIS, with specific geographic areas mentioned as appropriate to the discussion. In a number of cases, insufficient information is available on the potential impacts of the additional action or the scheduling of the proposed remedial action to allow a quantitative assessment of potential impacts. In these cases, the discussion focuses on identifying the primary factors likely to influence the extent and intensity of potential cumulative impacts. The likelihood and intensity of some cumulative impacts (e.g., the economy) depends on the scheduling of the many activities taking place or proposed to occur at the Hanford Site.

5.8.4.1 Geology. Potential cumulative impacts on geological resources primarily are related to the need for large quantities of borrow material that would be required to construct caps under the various Restricted Future Land-Use and Exclusive Future Land-Use Alternatives. Construction of caps for many or all of the waste sites, particularly when combined with potential source needs of other projects, such as the ERDF, could have significant cumulative impacts on the availability of materials used in the construction of the caps. Existing sources of materials could be severely depleted or completely exhausted. Section 5.10 and Appendix E provide additional information on the potential impacts and quantities of materials that will be irreversibly and irretrievably committed for cap construction.

5.8.4.2 Soils. Potential cumulative impacts on soils would be similar to impacts on ecological resources (Section 5.8.4.4), because the acreage of disturbed areas is similar in extent. The area with the greatest potential for cumulative impacts on soils is the Central Plateau geographic area, because of the large number of ground-disturbing activities proposed for the Central Plateau geographic area, including proposed projects and construction of new or expansion of existing waste management and disposal facilities. Additional activities contemplated in the Reactors on the River geographic area could have cumulative impacts. These activities (i.e., reactor decommissioning) would be widely separated in time and could culminate with restoration or rehabilitation of the reactor sites. Significant cumulative impacts on soils are not anticipated in the Columbia River and All Other Areas geographic areas.

5.8.4.3 Water Resources. No significant adverse impacts on groundwater are expected as a result of either the proposed remedial actions or the reasonably foreseeable actions. Treatment of groundwater contaminant plumes would provide a long-term beneficial impact on the water resources of the

Hanford Site. Reinjection of treated water (e.g., during pump-and-treat activities) could lead to localized temporary changes in groundwater flow patterns, but these changes would revert to the normal flow pattern once the driving source was removed at the end of the treatment phase. Reasonably foreseeable actions are expected to have either no adverse impacts or have beneficial impacts (in the case of the Columbia River Wild and Scenic designation) on surface water quality. Therefore, no cumulative impacts to water resources are anticipated.

5.8.4.4 Ecology. In the Columbia River geographic area, the increased recreational use associated with the Wild and Scenic River designation, combined with the relaxed access restrictions under the Unrestricted Future Land-Use Alternative, could result in cumulative impacts on ecological resources by disturbance of wildlife and habitats that are not accessible in the short term under the No-Action or Restricted Future Land-Use Alternatives.

In the Reactors on the River geographic area, surplus reactor decommissioning could result in some cumulative impact on shrub-steppe habitat, because reactor decommissioning would add to the areas expected to be lost under the Unrestricted Future Land-Use Alternative (40 ha [101 ac]), and Restricted Future Land-Use Alternatives (R1 and R2) (39 ha [98 ac] and 38 ha [94 ac]), respectively. However, waste management activities already have caused extensive disturbances in the area, and remediation of past-practice sites likely would be separated widely in time from the reactor decommissioning.

In the Central Plateau geographic area, significant cumulative impacts on shrub-steppe habitat would be associated with the Exclusive Future Land-Use Alternative in combination with the ERDF construction (Section 5.8.1.3.3) and SNF management (Section 5.8.1.3.4). The total cumulative area disturbed under the Exclusive Future Land-Use Alternative would be 475 ha (1,188 ac). Impacts on species of concern also would be cumulative because of the potential added loss of priority habitat used for nesting by species such as the sage sparrow, loggerhead shrike, and sage thrasher. Cumulative impacts associated with other actions proposed for the Central Plateau geographic area, but not fully evaluated at this time (e.g., TWRS), would be proportional to the amount of habitat disturbed.

Significant cumulative impacts on ecological resources in the All Other Areas geographic area currently are not anticipated, but the potential for such impacts would be reexamined as the required documentation is prepared for planned projects. Construction of access roads or haul roads would lead to fragmentation of habitats and could affect the ability of some species to utilize all available habitat. Furthermore, disturbed land along roadsides would provide opportunities for nonnative invasive species to enter the habitat.

5.8.4.5 Air Quality. The potential for cumulative impacts on air quality, as with other resource areas, is critically dependent on the timing of the proposed remedial and other reasonably foreseeable actions. As discussed in Section 5.3.5.2, which describes the impacts of the Unrestricted Future Land-Use Alternative on the Reactors on the River geographic area, remedial activities involving excavation would generate substantial amounts of airborne dust, possibly contaminated with radionuclides, and exhaust emissions from soil handling and remediation equipment. Simultaneous additional activities in the vicinity of a remediation site (i.e., ERDF and TWRS construction in the Central Plateau geographic area) could cause air quality impacts proportional to the total level of activity. However, these impacts could be prevented by appropriate mitigation measures as described in Section 5.3.5.2.2, and, therefore, are categorized as insignificant subject to mitigation.

5.8.4.6 Noise. No potentially significant noise impacts were identified for any of the alternatives considered in this EIS. Therefore, no cumulative impacts are anticipated.

5.8.4.7 Cultural Resources. Potential cumulative impacts on cultural resources would be similar in nature and extent to those on soils and ecological resources, because the cultural resource impacts are commonly associated with ground-disturbing activities. Adverse impacts would be proportional to the areal extent and the depth of the disturbance, as well as the cultural significance of the precise location. All alternatives considered in this EIS are considered to have potentially significant impacts on cultural resources, and reasonably foreseeable other actions also could have potentially significant impacts. These impacts could be mitigated through surveys, data collection, and artifact recovery to prevent the loss of the information inherent in the resources. However, these mitigation measures would unavoidably alter the site in question, which could in itself be a significant impact, particularly for sites of spiritual importance to Native Americans. Therefore, cumulative impacts on cultural resources are considered potentially significant. Mitigation through surveys and data recovery would minimize, but not eliminate, these impacts. Because the Columbia River and Reactors on the River geographic areas possess so many potentially significant cultural resources, these areas would be expected to experience significant cumulative adverse impacts to cultural resources.

5.8.4.8 Visual and Aesthetic Resources. Cumulative impacts on visual resources would be directly proportional to the extent of site activity in the short term and to the extent of viewscape alteration in the long term. The reasonably foreseeable actions in the short term are concentrated in the Central Plateau and Reactors on the River geographic areas. Long-term changes in the viewscape primarily would result from construction of the ERDF, and reactor decommissioning and removal. Cumulative impacts on the Hanford Site viewscapes could result from selection and construction of permanent caps as a remedial alternative for a large number of waste sites. As described in the visual impacts sections, these caps would be visible from a considerable distance. Similarly, the ERDF would be visible from some distance, as would the changes produced by removing the reactors from the vicinity of the Columbia River. Therefore, cumulative impacts on visual resources are considered potentially significant, but could be partially mitigated by applying the measures described in the respective visual impacts sections of this chapter.

5.8.4.9 Socioeconomic and Land-Use Impacts. The potential for cumulative socioeconomic impacts depends on the level of effort involved in reasonably foreseeable actions at the Hanford Site, and the timing of those actions. If the total effort is spread out over a long period of time, the cumulative socioeconomic impacts would be relatively small. If the total effort is concentrated in a short time span, the impacts would tend to be large and potentially disruptive. A short time span requires the hiring of additional staff, but only for a short period of time to perform the various actions simultaneously. A longer time span allows fewer workers to be hired because the same workforce can perform the various actions in sequence. Hiring a large number of workers to perform many actions at once and then dismissing those workers once the actions are completed could result in a boom-bust cycle that would have a detrimental effect on the local economy. Using a smaller number of workers over a longer time span would smooth out impacts on the local economy and minimize any disruption by allowing time for other industry to develop within the affected communities. Potential socioeconomic impacts of the remedial actions addressed in this EIS were identified as not significant or marginally significant. However, there is considerable uncertainty about the level of effort required for the reasonably foreseeable future actions, about the schedule for those actions, and about changes in total site staffing levels required to implement those actions. The potential for cumulative socioeconomic impacts is considered to be low. However, socioeconomic impacts would need to be evaluated on a continuing basis as schedules are developed for both the proposed remedial actions and the reasonably foreseeable actions not of direct concern in this EIS.

The proposed action of this EIS could lead to extensive changes in existing land uses at the Hanford Site. These changes could be significant in themselves, without considering other potentially significant decisions, such as the designation of the Hanford Reach as a Wild and Scenic River. The related issue of compatible land uses would need to be addressed as specific projects are further developed, and as land-use planning documents (i.e., the Hanford Site Comprehensive Land Use Plan) become available. The issue of compatible land uses is critical. For example, the Unrestricted Future Land-Use and Restricted Future Land-Use Alternatives for the Columbia River may not be compatible with designation of the river as wild and scenic. In the Central Plateau geographic area, the SMES-ETM, a facility not associated with waste management, may not be compatible with construction of the ERDF and other waste management facilities. A number of alternatives for various projects may conflict with tribal concerns and treaty rights. Therefore, cumulative impacts associated with land-use issues are considered potentially significant. Mitigation of these impacts would require careful and thorough coordination of remediation decisions with all potential stakeholders.

5.8.4.10 Human Health Risk. Long-term impacts of the proposed action on human health risk are all considered beneficial, because remediation of waste sites would reduce the long term risk associated with the No-Action Alternative, which is potentially significant for each geographic area. Therefore, long-term cumulative adverse impacts are not anticipated.

Short-term impacts were not considered significant for either future land-use alternatives considered for the Columbia River geographic area. The principal reasonably foreseeable action identified for the river is designation of the Hanford Reach as wild and scenic, which would have no significant impact on human health. Therefore, no short-term cumulative impacts are anticipated as a result of Columbia River remediation. Short-term impacts of remediation are considered potentially significant for the Unrestricted Future Land-Use and Restricted Future Land-Use (R1) Alternatives for the Reactors on the River geographic area; the Exclusive Future Land-Use Alternative for the Central Plateau geographic area; and the Restricted Future Land-Use (R1) Alternative for the All Other Areas geographic area. Cumulative short-term health impacts to the offsite population would not be significant, because the location of the offsite MEI would be unique for different projects and adverse health effects would not be expected even when the impacts (e.g., radiation dose) from each project are summed.

5.8.4.11 Occupational Impacts. Occupational impacts are directly proportional to the scale of site activity, assuming a constant relative level of effort dedicated to preventing accidents and exposures to radiological and chemical hazards. Therefore, potential cumulative impacts would be considered potentially significant, but could be mitigated by maintaining and improving existing safety programs.

5.9 Unavoidable Adverse Impacts

This section describes potential unavoidable adverse environmental impacts associated with implementation of the future land-use alternatives. Unavoidable adverse impacts are impacts that would occur after implementation of all feasible mitigation measures.

Remedial activities required for several of the alternatives include excavating large volumes of soil. Remediation efforts would result in soil disturbances through compaction and potential increased soil erosion. Excavation in and near the Columbia River could result in downstream siltation and sedimentation. The most significant unavoidable adverse impacts on soils occur in the Central Plateau

geographic area under the Exclusive Future Land-Use Alternative. Approximately 475 ha (1,174 ac) of soils would be affected by this alternative.

The Hanford Site has an abundance of significant cultural resources. Proposed waste site excavation could result in the disturbance of human remains and Native American sites. Significant prehistoric or historic resources could be lost. These resources are considered irreplaceable. The extent of cultural resources that would be disturbed cannot be assessed until the significance and boundaries of known site areas are established. Some resource locations will be more significant than others, and each cultural resource location must be individually assessed. Mitigation measures would be implemented, but some unavoidable adverse impacts are anticipated.

Physical impacts on terrestrial resources and sensitive habitats (i.e., aquatic habitat, wetlands, shrub-steppe habitat) would be unavoidable under all except the No-Action Alternative. Permanent loss of habitat for some species of concern could occur, and could result in population declines. Reclamation would restore some habitat, but would not fully replace diverse plant communities that have developed over long time periods. The most significant adverse impacts on shrub-steppe habitat, and the impacts most likely to be unavoidable, could occur in the Central Plateau geographic area under the Exclusive Future Land-Use Alternative. Approximately 6% of shrub-steppe habitat in the Central Plateau geographic area would be affected by this alternative.

Application of caps over waste sites would permanently alter the existing landscape. These caps would stand out visually within the landscape of the relatively flat Hanford Site, particularly in the Columbia River and the Reactors on the River geographic areas. Caps would be noticeable to users of the Columbia River and from vantage points along State Routes 24 and 240.

5.10 Irreversible and Irretrievable Commitments of Resources

Irreversible and irretrievable resource commitments are related to use of nonrenewable resources and the effects that consumption of the resources would have on future generations. Irreversible effects occur as a result of use or destruction of a resource (e.g., energy and minerals) that cannot be replaced within a reasonable time frame. Irretrievable resource commitments involve the loss in value of an affected resource that cannot be restored (e.g., extinction of a species or disturbance of a cultural site). Identification of irreversible and irretrievable commitments of resources is required by NEPA. The discussion also is intended to secure the exclusion of liability for natural resource damages discussed in Section 107(f)(1) of the CERCLA statute. This provision of the CERCLA states that there is no liability for natural resource injuries if those injuries are specifically identified as irreversible and irretrievable commitments of resources in an EIS or comparable document.

Geologic resources required for cap construction would be irreversibly and irretrievably committed. Geologic resources required for cap construction consist of gravel, sand, silt, and crushed basalt. These materials would be obtained from two borrow pit sites (McGee Ranch and Pit 30) and a basalt quarry site as discussed in Appendix E. Conservatively estimated quantities of geologic materials from each of the three sites are shown in Table 5-53. Reserves totaling approximately 36.1 million m^3 (47.3 million yd^3) of fine-grained material are available at the McGee Ranch site (Lindberg 1994; Skelly 1992). Cap construction could require a significant percentage of the McGee Ranch reserves. The total available reserves at Pit 30 and the basalt quarry site have not been determined. Requirements for cap materials (see Table 5-53) would be expected to significantly deplete, but not exhaust, the available resources at these sites. The estimated requirement for the basalt quarry site may be artificially high because of the assumption that the site would provide

asphalt base and asphalt, in addition to basalt, and the cap was assumed to be comparable to the reference cap discussed in Appendix E. This estimate of irreversibly and irretrievably committed geologic resources is conservative, because the number of waste sites that would be capped and the type of cap that would be selected for each site is not presently known.

Table 5-53. Estimated Volumes of Materials Required to Implement Capping Alternatives from Three Primary Sources of Geologic Materials.[a]

Geographic Area	Alternative	McGee Ranch[b] million m^3 (yd^3)	Pit 30[c] million m^3 (yd^3)	Basalt Quarry[d] million m^3 (yd^3)
Columbia River	Restricted	0.1 (0.2)	0.04 (0.05)	0.2 (0.2)
Reactors on the River	Restricted (R2)	7.3 (9.6)	2.1 (2.8)	9.4 (12.3)
Central Plateau	Exclusive	5.6 (7.3)	11.9 (15.6)	34.5 (45.2)
All Other Areas	Restricted (R2)	3.4 (4.4)	1.0 (1.3)	4.3 (5.7)
Total		16.4 (21.5)	15.1 (18.8)	48.4 (63.4)

[a]Based on volumes presented in Table H-14, Appendix H.
[b]Assumed source of fine-grained materials (silt) required for caps.
[c]Assumed source of gravel and sand.
[d]Assumed source of basalt used in caps, asphalt base, and asphalt.

The cultural resources of the Hanford Site are extensive and not reproducible. Cultural resources of value to Native Americans and others may be disturbed or destroyed at borrow areas and at waste sites that are excavated or covered. Losses of cultural resources would be irreversible and irretrievable. Mitigation measures would be implemented; these measures should reduce, but not prevent, the loss of cultural resources.

Implementation of remedial activities required to accommodate future land-use objectives of each geographic area would result in habitat disturbance as a consequence of waste site stabilization, waste removal, and construction of support and treatment facilities. Disturbed areas would be regraded and planted with native vegetation. Successful restoration of the habitat is uncertain and the habitat disturbance could lead to permanent changes, as well as displacement or loss of wildlife. Areas and types of habitat that would be disturbed under each alternative for each geographic area are provided in Table 5-54. Selection of the alternative with the greatest amount of disturbance in each area would temporarily or permanently alter 500 ha (1,236 ac) of shrub-steppe habitat, 28 ha (69 ac) of wetlands, and 20 ha (50 ac) of aquatic habitat.

Resources that would be committed include large expenditures of public funds for conducting remedial actions. Approximate expenditures required under the various alternatives are given in Table 5-55. Significant expenditures also would be required under the No-Action Alternative. The estimated cost of monitoring and maintenance over a 100-year period is estimated to be greater than $2.4 billion. Expenditures for remedial activities also would be required by the No-Action Alternative, but these costs could only be estimated as remedial activities and remediation levels will be established for each individual operable unit based on site-specific decision processes.

Remedial activities would require the consumption of fuel for operation of construction equipment and transport of waste and capping materials. Estimated quantities of fuel that would be required to accommodate future land-use alternatives are given in Table 5-56. Actual quantities of fuel consumed will depend on the exact nature of actions implemented under CERCLA and the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1994), and on the fuel efficiency of machinery used to implement those actions.

5.11 Conflict with Land-Use Plans of Other Federal, State, and Tribal Agencies

This discussion addresses possible conflicts between the proposed future and other potential future land-uses for each geographic area.

5.11.1 Columbia River Geographic Area

Some stipulations of the Restricted Future Land-Use and Unrestricted Future Land-Use Alternatives of the Columbia River geographic area could be considered inconsistent with the proposed Wild and Scenic River and NWR designations. These uses could include controlled and/or unlimited recreation uses. Under the Wild and Scenic River and NWR designation, recreation access would be improved, but not expanded; damming and major dredging would be prohibited; corridor development would be controlled; and off-road vehicle use would be prohibited in unauthorized areas (NPS 1994). Proposed recreational uses that would involve expanded access, damming, major dredging, corridor development, and/or off-road activity could be incompatible with the proposed Wild and Scenic River designation, and these activities are inconsistent with the protection of the resources intended by the designation. Congressional action is required to designate the Hanford Reach as a Wild and Scenic River.

Tribal treaty rights on the Hanford Site could be maintained under the Restricted Future Land-Use Alternative by controlling new recreational uses and preventing encroachment on traditional tribal fishing, hunting, and gathering sites, and cultural properties. The Unrestricted Future Land-Use Alternative, with unlimited recreation, could encroach on and impact these traditional sites. Encroachment on the traditional tribal areas could be interpreted by the tribes as an abrogation of the 1855 Treaties.

The Unrestricted Future Land-Use Alternative would allow complete access to natural resources by consumptive and nonconsumptive users. Increased recreational use would be expected under the Unrestricted Future Land-Use Alternative. Expanded access would directly conflict with the Wild and Scenic River designation.

The Restricted Future Land-Use Alternative would not significantly affect water-based recreation. Current restrictions on land-based recreation (e.g., hunting, wildlife observation, nature study, and similar activities) could continue.

Table 5-54. Habitat Areas Disturbed under Each Land-Use Alternative for Each Geographic Area.

Geographic Area	No Action	Unrestricted	Restricted (R1)	Restricted (R2)	Exclusive
Columbia River	None	23 ha (57 ac) wetlands 20 ha (50 ac) aquatic 36 ha (90 ac) shrub-steppe	<0.4 (1 ac) of each habitat	NA	NA
Reactors on the River	3 ha (7 ac) shrub-steppe	5 ha (12 ac) wetlands 40 ha (101 ac) shrub-steppe	4 ha (11 ac) wetlands 39 ha (98 ac) shrub-steppe	3 ha (8 ac) wetlands 38 ha (94 ac) shrub-steppe	NA
Central Plateau	280 ha (692 ac) shrub-steppe	NA	NA	NA	475 ha (1,173 ac) shrub-steppe
All Other Areas	5 ha (12 ac) shrub-steppe	NA	115 ha (287 ac) shrub-steppe	134 ha (329 ac) shrub-steppe	NA

NA = Not applicable.

Table 5-55. Estimated Expenditures for Each Alternative Depending on Transportation Option.

Geographic Area	Alternative	Truck Transport (million $)	Rail Transport (million $)
Columbia River	Unrestricted Restricted	4,691 93	2,678 46
Reactors on the River	Unrestricted Restricted (R1) Restricted (R2)	5,152 3,766 5,543	4,127 3,037 2,954
Central Plateau	Exclusive	1,807	--
All Other Areas	Restricted (R1) Restricted (R2)	1,029 3,156	670 792

Table 5-56. Estimated Fuel Consumed for Each Alternative Depending on Transportation Option.

Geographic Area	Alternative	Truck Transport million L (gal)	Rail Transport million L (gal)
Columbia River	Unrestricted Restricted	82.9 (21.9) 1.51 (0.4)	82.9 (21.9) 1.14 (0.3)
Reactors on the River	Unrestricted Restricted (R1) Restricted (R2)	150.2 (39.7) 105.6 (27.9) 152.2 (40.2)	109.0 (28.8) 76.5 (20.2) 76.8 (20.3)
Central Plateau	Exclusive	NA	--
All Other Areas	Restricted (R1) Restricted (R2)	42.0 (11.1) 100.3 (26.5)	27.6 (7.3) 35.2 (9.3)

NA = Not available.

The Unrestricted Future Land-Use and Restricted Future Land-Use Alternatives do not appear to be inconsistent with the *Wahluke 2000 Plan* proposed by the Wahluke 2000 Committee. The plan seeks to avoid significant environmental and scenic impacts on the Columbia River, while proposing recreational designations (Wahluke 2000 Plan).

The No-Action Alternative could preclude implementation of portions of the *Wahluke 2000 Plan*. The plan proposes recreational designations along the river (Wahluke 2000 Plan). The control of access and recreation under the No-Action Alternative could prevent or restrict new recreational uses along the river.

The No-Action Alternative would maintain the existing conditions. Both river access and recreation activities would remain controlled. The river would remain unremediated, and potential environmental impacts would continue. However, these impacts are low, as described in Section 5.2. This alternative would not be inconsistent with any existing land-use planning documentation. Controlled access to the river could diminish passive use and value that would accompany the proposed Wild and Scenic River and NWR designations. This alternative would maintain restrictions on the use of traditional fishing, hunting, and gathering sites, and cultural properties of value to Native Americans in some locations.

5.11.2 Reactors on the River Geographic Area

The proposed remediation of the Reactors on the River geographic area would result in increased construction vehicle traffic, construction noise, and dust in the nearby area. There are no immediately adjacent residential or agricultural uses to be affected by the remedial activities. The adjacent county lands are separated from the Reactors on the River geographic area by the Columbia River and the North Slope.

As with the Columbia River, the Unrestricted Future Land-Use Alternative for the Reactors on the River geographic area could allow unlimited recreation along the river. Any use that included expanded river access, damming, major dredging, corridor development, and/or off-road activity could be incompatible with the proposed Wild and Scenic River and NWR designations. Encroachment on traditional tribal areas would be interpreted by the tribes as an abrogation of the 1855 Treaties.

Restricted Future Land-Use Alternatives (R1 and R2) are similar from a land-use perspective. Unless the proposed restricted uses are located well away from the shores of the river, industrial development could be inconsistent with the proposed Recreational River and NWR designations for the river and North Slope. Development along the river corridor would be controlled (NPS 1994), and industrial development could be interpreted as development that is too intensive and/or out of scale. The Restricted Future Land-Use Alternatives (R1 and R2) would not significantly affect water-based recreation. Certain land-based recreation, such as hunting and camping, could continue to be restricted. Restricted use of the Rectors on the River might not be consistent with Native American wishes to exercise their treaty-reserved rights on the Hanford Site, as prescribed by the 1855 Treaties.

The No-Action Alternative would continue the restrictions on the use of the traditional fishing, hunting, and gathering sites, and cultural properties of the Native Americans, and would not be consistent with Native American wishes to exercise their treaty-reserved rights on the Hanford Site as prescribed by the 1855 Treaties.

5.11.3 Central Plateau Geographic Area

The proposed use within the Central Plateau (200 Areas), under either the No-Action or Exclusive Future Land-Use Alternatives, involves waste management.

Exclusive use of the Central Plateau geographic area would not affect the proposed Recreational River and NWR designations.

The Exclusive Future Land-Use Alternatives for the Central Plateau geographic area would not be consistent with Native American wishes to exercise their reserved rights on the Hanford Site as prescribed by the 1855 Treaties. The No-Action Alternative would continue current waste management activities in this area, and would conflict with Native American wishes to exercise rights reserved by the 1855 Treaties.

5.11.4 All Other Areas Geographic Area

Restricted uses for the All Other Areas geographic area include Restricted Future Land-Use Alternatives (R1 and R2). These alternatives do not differ appreciably from a land-use perspective. The Restricted Future Land-Use Alternatives (R1 and R2) propose industrial development, research, waste management, wildlife habitat, and controlled recreation. Should proposals including industrial development, waste management, or anything other than ecological research occur within 0.4 km (1/4 mi) of the Columbia River, these proposals would be inconsistent with the Recreational River and NWR designations along the river (NPS 1994). Industrial development, research, waste management, and controlled recreation uses could encroach on the traditional tribal fishing, hunting, and gathering sites and cultural properties. Encroachment on the traditional tribal areas could be interpreted by the tribes as an abrogation of the 1855 Treaties.

The No-Action Alternative would maintain controlled industrial development, compatible research, waste management, and wildlife uses in their current locations, and would not include remediation. This alternative would continue restrictions on use of traditional fishing, hunting, and gathering sites and cultural properties of value to Native Americans.

Future actions on the Hanford Site would include coordination with Tribal governments to protect the treaty-reserved rights of the Native Americans on the Hanford Site. Coordination with federal resource agencies (National Park Service and USFWS) and local planning agencies (i.e., Benton, Franklin, Grant, and Adams counties; and the cities of Richland, West Richland, Pasco, and Kennewick) would be maintained, especially during the preparation of comprehensive plans by agencies or local governments.

5.12 Environmental Justice

In February 1994, Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (59 FR 32), was released to federal agencies. This Executive Order deals with the issue of environmental justice and directs federal agencies to consider environmental justice during the NEPA process, and to incorporate environmental justice as part of the agency mission. Federal agencies are specifically directed to identify and address disproportionately high and adverse human health or environmental effects of programs, policies, and activities on minority and low-income populations.

The Executive Order also directed the Administrator of the EPA to convene a Federal Working Group on Environmental Justice. The Working Group was directed to provide guidance to federal agencies on criteria for identifying disproportionately high and adverse human health or environmental effects on minority populations and low-income populations and to coordinate with each federal agency in developing an environmental justice strategy for application to proposed agency activities. In coordination with the Working Group, the DOE has developed draft internal guidance to implement the Executive Order. Because the DOE and the Working Group are still in the process of developing guidance, and because scoping for this EIS occurred before issuance of the Executive Order, the environmental justice analysis presented in this EIS may depart somewhat from the implementation guidance that will eventually be issued.

The following discussion addresses environmental justice as related to future land uses of the DOE Hanford Site. The analysis identifies minority and low-income populations in the vicinity of the

Hanford Site. Subsequent to identification, the analysis provides a qualitative discussion of the impacts that future land-use alternatives might have on these populations.

5.12.1 Demographics

Demographic information obtained from the U.S. Bureau of Census was used to identify minority populations and low-income communities within an 80-km (50-mi) radius surrounding the Hanford Site. For Environmental Justice analysis purposes, the area defined by this 80-km (50-mi) radius is considered the zone of potential impact.

5.12.1.1 Definitions. The demographic analysis used the following definitions to develop community characteristics:

- *Census Tract*--An area defined for the purpose of monitoring census data that is usually comprised of between 2,500 and 8,000 persons, with 4,000 persons being ideal. When first delineated, census tracts are designed to be homogeneous with respect to population characteristics, economic status, and living conditions. Census tracts do not cross county boundaries. Spatial census tract size varies widely depending on the density of settlement. Census tract boundaries are delineated with the intention of being maintained over a long period of time so that statistical comparisons can be made from census to census.

- *Census Block Group*--An area defined for the purpose of monitoring census data that generally consists of between 250 and 550 housing units.

- *Minority Population*--A group of people and/or communities experiencing common conditions of exposure or impact that consists of persons classified by the U.S. Bureau of the Census as Negro/Black/African American, Hispanic, Asian and Pacific Islander, American Indian, Eskimo, Aleut, and other non-White persons, based on self-classification by the people according to the race with which they most closely identify. For purposes of analysis, minority populations are defined as those census tracts within the zone of impact where the percent minority population exceeds the percentage minority population within the entire zone of impact. Census tracts where the percent minority population exceeds 50% also are considered minority populations. In the case of migrant or dispersed populations, a minority population consists of a group that is greater than 50% minority.

- *Low-Income Community*--An area where the median household income is 80% or more below the median household income for the metropolitan statistical area (urban) or county (rural). The 80% threshold was used based on definitions used by the U.S. Department of Housing and Urban Development.

- *Population Base*--Census tracts were included in the analysis if 50% of the geographic area of the tract fell within the 80-km (50-mi) radius of the Hanford Site.

*5.12.1.2 **Minority and Low-Income Populations Near Hanford.*** Demographic maps were prepared using 1990 census data resolved to the census tract group level (USBC 1992).

A total population of approximately 384,000 people reside within an 80-km (50-mi) radius of the Hanford Site. The minority population within the area of impact consists of approximately 95,000 people and represents approximately 25% of the population in the assessment area. The ethnic

composition of the minority population is primarily Hispanic (approximately 80%) and American Indian (8%). Census tracts where the percentage of minority persons within the population exceeds 20% are located to the southwest and northeast of the Hanford Site and within the City of Pasco, Washington (Cushing 1995).

The low-income population within the 80-km (50-mi) area of impact represents approximately 42% of households in the area of impact. Census tracts where the percentage of the population consisting of low-income households exceeds 25% are principally located to the southwest and north of the Hanford Site and within the City of Pasco, Washington (Cushing 1995).

Considerable overlap between low-income populations and minority populations exists in the vicinity of the Hanford Site.

*5.12.1.3 **Limitations of Demographic Data.*** Characterization of minority and low-income populations residing within a geographical area is sensitive to the basic definitions and assumptions used to identify those populations. Consequently, the number of individuals identified as minority and/or low-income individuals within the population around a particular site may vary from analysis to analysis. Both the Interagency Working Group and the DOE are in the process of developing final guidelines for use in the evaluation of environmental justice, and several different approaches to identification of minority and low-income populations have been used in recent DOE EISs. The approach presented in this EIS is consistent with the approach used in Cushing (1995). Other demographic studies may use different assumptions and, consequently, report a different total population, minority population, or low-income population depending on the assumptions used to identify each population.

5.12.2 Environmental Justice Analysis

Analysis of environmental justice concerns was based on a qualitative assessment of the impacts reported in other sections of this chapter. The analysis was performed to identify any disproportionately high and adverse human health or environmental impacts on minority or low-income populations in the vicinity of the Hanford Site. The evaluation considered potential impacts arising under each of the major disciplines evaluated in the EIS, including land use, socioeconomics, water resources, air resources, ecology, health and safety, and cultural resources.

The following definitions were used in the assessment:

- *Disproportionately High and Adverse Human Health Effects.* Adverse health effects are measured in risks and rates that could result in LCFs, as well as other fatal or nonfatal impacts to human health. Disproportionately high and adverse human health effects occur when the risk or rate for a minority population or low-income population from exposure to an environmental hazard significantly exceeds the risk or rate to the general population and, where available, to other appropriate comparison groups.

- *Disproportionately High and Adverse Environmental Impacts*. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds the impact on the larger community.

This EIS considers the environmental impacts associated with future land-use alternatives for various geographic areas within the Hanford Site. Anticipated environmental impacts from remedial activities that would enable each future land-use scenario are evaluated with respect to health risks and environmental damage resulting from the scenario.

5.12.2.1 Human Health Impacts. Potential human health effects and environmental impacts were evaluated with respect to environmental justice issues. Health effects from normal operations associated with the proposed action and from accident conditions were reviewed and special exposure pathways, such as subsistence consumption of fish and game, were considered.

5.12.2.1.1 Health Impacts from Hanford Operations. Impacts to human health from Hanford operations for both workers and the general public are minimal. The calculated dose to the MEI for 1994 was determined to be 5.1×10^{-2} mrem (PNL 1995). An avid sportsman would receive an additional radiation dose caused by consumption of large quantities of wild game and fish. Although the magnitude of the exposure would depend on the actual quantity of fish and game consumed, adverse health effects would not be expected even if the majority of the meat and fish consumed by the individual came from these sources.

5.12.2.1.2 Health Impacts from Natural Motive Forces. Prevailing winds on the Hanford Site are from the northwest. The second most common winds are from the southwest, particularly in the spring and fall. Most surface water runoff, if any, would drain to the Columbia River and the rest would drain to the Yakima River, which joins the Columbia River below the Hanford Site. Groundwater systems underlying the Hanford Site tend to flow toward the Columbia River in a southwest and northeast direction.

The risk of impacts to surrounding populations from routine operations at the Hanford Site is so small that propagation by natural motive forces is essentially of no consequence. The consequences of a accident would depend on the random conditions at the time of occurrence, but the impacts from the accidents evaluated in this EIS would not be expected to produce unacceptable health effects in the population surrounding the Hanford Site. Consequently, disproportionately high and adverse health effects to minority or low-income populations would not be expected to occur as a result of natural motive forces.

5.12.2.1.3 Health Impacts from Subsistence Consumption of Fish and Wildlife. The human health calculations presented in PNL (1995) estimate dose and risk to a member of the public based on site-specific agricultural data and parameters describing a typical dietary pattern.

Subsistence consumption of fish and wildlife is not explicitly addressed by the analysis. However, calculations used in arriving at risk to human health use several conservative assumptions. The calculations assume that a very high proportion of the diet is based on locally grown produce and locally grazed livestock produced at locations representing the highest concentrations of radioactive contamination. In addition, the diet of the hypothetical MEI includes fish caught from the Columbia River. Consumption of fish was determined to be a major contributor to the dose received by the hypothetical MEI. The radiation dose received by a person who was subsisting on wild game and fish

would be higher than the 5.1 x 10^{-2} mrem reported by PNL (1995). However, this additional dose would be unlikely to be sufficiently high to cause adverse health effects. Furthermore, no human population in the immediate vicinity of the Hanford Site is known to subsist entirely on locally harvested fish or wildlife. Remediation activities conducted in support of future land uses also would reduce exposure of a person who was subsisting on fish and game.

Game species, locally grazed livestock, fish, locally grown foodstuffs, and native plants around the Hanford Site are routinely sampled for radionuclides as part of the ongoing environmental monitoring program. Data from monitoring programs are reported annually in an environmental report (PNL 1995). Monitoring has not indicated that excessive health risks would be associated with consumption of fish and game. Hanford operations and remedial activities are unlikely to result in disproportionately high human health effects in minority or low-income populations from consumption of fish and game.

5.12.2.2 Environmental Impacts to Low-Income and Minority Populations. Environmental Justice impacts that could affect low-income and minority populations in the vicinity of the Hanford Site consist of potential socioeconomic impacts and impacts to biological and cultural resources valued by Native Americans.

5.12.2.2.1 Environmental Justice Impacts to Low-Income Populations. Low-income individuals and populations would be affected by employment levels and government spending at the Hanford Site. Funding and employment levels are linked with future land use at the Hanford Site. Greater levels of remedial activity would require greater expenditures in the short term. This money trickles through the regional economy, and creates services and opportunities that benefit economically deprived individuals located close to the Hanford Site. These effects would be highly localized and largely restricted to geographic areas where a large number of Hanford Site employees reside. Populations in many areas identified as low-income in the demographic analysis are unlikely to be impacted by current or future government spending at the Hanford Site.

Declining federal spending would reduce revenue available to support local services in communities adjacent to the Hanford Site. Local tax rates could rise in an attempt to make up for lost revenue. Low-income individuals residing in the Tri-Cities would be affected by changes in spending at the Hanford Site.

5.12.2.2.2 Environmental Justice Impacts to Native Americans. Substantial Native American populations are located in five census tracts within the 80-km (50-mi) assessment area. These census tracts are located on the Yakama Indian Reservation in Yakima County, Washington. However, other Native American populations located outside of the assessment area also have an interest in the Hanford Site based on treaty rights.

In 1855, treaties with the Confederated Tribes and Bands of the Yakama Indian Nation and the Confederated Tribes of the Umatilla Indian Reservation resulted in the ceding of lands that currently comprise the Hanford Site. Treaties reserved certain tribal rights to the ceded lands. A separate 1855 Treaty with the Nez Perce Tribe reserved rights regarding traditional uses of the Columbia River Basin for the tribe. Although only the Confederated Tribes and Bands of the Yakama Indian Nation reside within the 80-km (50-mi) assessment area, impacts to other tribes also must be considered. In addition to the three federally recognized tribes, the Wanapum Band also maintains an active interest in the Hanford Site. This Band, which was not a signatory of the 1855 Treaties and is not currently a federally recognized Tribal Nation, resided on the Hanford Site before relocation to the vicinity of Priest Rapids Dam in the 1940s.

Reserved treaty rights include access to open and unclaimed portions of the lands ceded in the 1855 Treaties. Specific treaty rights included rights to exercise cultural and religious activities, and to hunt, fish, and gather plants in usual and accustomed locations. Since 1943, the tribes have had limited access to traditional use areas because of safety and national security concerns at the Hanford Site. Furthermore, the DOE does not necessarily consider the lands to be open and unclaimed. Nevertheless, the tribes desire to exercise specific rights to use of the Hanford Site established by the 1855 Treaties.

Regardless of access issues, reserved treaty rights are dependent upon the health of the ecosystems upon which the resources depend. The tribes assert that a treaty right to hunt, fish, or gather plants is diminished (if not voided) if the fish, wildlife, or plants have vanished or are contaminated to the extent that they threaten human health. These resources, particularly the resources with cultural and religious connotations, do not have equivalent value for the general population. Consequently, impacts to these resources represent an environmental justice impact to Native American populations.

Cultural and biological resources valued by Native Americans have, in effect, been preserved by the presence of the Hanford Site. In the absence of government control, these resources would likely have been damaged or destroyed through land development practices similar to land development of the surrounding areas. Furthermore, impacts to these resources are likely to occur if the DOE relinquishes control of the Hanford Site in the future.

Environmental justice impacts to Native American populations are likely to occur under all alternatives for future land-use objectives at the Hanford Site. The nature of the impacts to cultural and biological resources that are valuable to Native Americans will vary depending on the nature and extent of remedial activities that are actually implemented.

Restricted Future Land-Use and Exclusive Future Land-Use Alternatives would result in impacts by denying access to some or all geographic areas. However, these alternatives also would function to protect cultural and biological resources that are located in the restricted areas.

The Unrestricted Future Land-Use Alternative may allow access to the geographic areas. However, damage to resources would likely result from the remediation activities that would be required to enable the unrestricted use. Furthermore, upon completion of remedial activities, the DOE might relinquish control of the land and subsequent development could further damage cultural and biological resources.

From an engineering perspective, basalt outcrops immediately west of Gable Butte have been identified as one of the most viable sources of the basalt required for remedial activities (e.g., capping). Gable Butte also has been considered as a possible source of basalt. These sites are sacred to Native Americans, but are of less significance to the general population. Environmental justice impacts, consisting of damage to a cultural resource valued by Native Americans, would occur if Gable Butte or Gable Mountain is selected as a source of basalt. The magnitude of the impacts would depend on the quantity of basalt required by remedial activities.

5.13 Relationship Between Near-Term Use and Long-Term Productivity of the Environment

Near-term is defined for purposes of this EIS as the period when remedial actions would take place. These actions would be concentrated in the next 30 years, when most construction, ground disturbance, and associated direct impacts would occur. *Long-term* is defined as the period following most active remediation, with the exception of long-term remediation activities (e.g., groundwater treatment).

The near-term uses of the Hanford Site under the proposed and alternative actions would be consistent with current industrial and waste management uses. Remediation would result in increased ground disturbance, vehicle traffic and noise, construction, and overall Hanford Site activity. The net effect of remedial actions would be to enhance the overall long-term productivity of the Hanford Site by increasing the range of potential permissible uses. All four of the geographic areas currently have at least partial restrictions on some uses. With one exception, all of the remediation alternatives would permit some of these restrictions to be relaxed, if not eliminated. The exception is the Exclusive Future Land-Use Alternative for the Central Plateau geographic area. This alternative would dedicate the Central Plateau geographic area to waste management and, thus, preclude its long-term use for other purposes.

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Consultations, Laws, & Requirements

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6.0 Consultations, Laws, and Requirements

This chapter summarizes the major laws, regulations, Executive Orders, and U.S. Department of Energy (DOE) orders that may apply to future land use and remedial actions conducted on the Hanford Site, and identifies the federal, tribal, state, and local agencies that will be consulted by the DOE during the preparation of this Environmental Impact Statement (EIS).

6.1 Federal Environmental Statutes and Regulations

This section discusses relevant federal statutes and regulations that might be applicable to the implementation of the alternatives at the Hanford Site and the remedial activities necessary to facilitate future land-use objectives.

6.1.1 National Environmental Policy Act of 1969, as amended

The *National Environmental Policy Act of 1969* (NEPA) establishes a national policy that encourages awareness of the environmental consequences of human activities and promotes consideration of those environmental impacts during the planning and implementing stages of a project. The NEPA requires that federal agencies prepare detailed statements to address the environmental effects of proposed major federal actions that significantly may affect the quality of the human environment. This EIS has been prepared in response to these NEPA requirements and policies, and discusses reasonable alternatives and the potential environmental consequences of the alternatives. This EIS has been prepared in accordance with the Council on Environmental Quality (CEQ) Regulations implementing the procedural provisions of the NEPA, 40 *Code of Federal Regulations* (CFR) 1500-1508, and the DOE regulation for implementing NEPA (10 CFR 1021).

6.1.2 Clean Air Act of 1970, as amended

The *Clean Air Act of 1970* (CAA), as amended, is intended to "protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population." Section 118 of the CAA requires each federal agency, with jurisdiction over properties or facilities that might result in the discharge of air pollutants, to comply with all federal, state, interstate, and local requirements with regard to the control and abatement of air pollution.

Under the CAA, the U.S. Environmental Protection Agency (EPA) is required to establish National Ambient Air Quality Standards that protect public health from known or anticipated adverse effects of a regulated pollutant. The CAA also requires the establishment of national performance standards for new or modified stationary sources of atmospheric pollutants; specific emission increases must be evaluated in order to prevent significant deterioration of air quality. Hazardous air pollutants, including radionuclides, are regulated separately. Emissions of air pollutants are regulated by the EPA through 40 CFR 50-99, and radionuclide emissions and hazardous air pollutants are regulated specifically under the National Emission Standards for Hazardous Air Pollutants Program, contained in 40 CFR 61 and 40 CFR 63.

6.1.3 Safe Drinking Water Act of 1974, as amended

The primary objective of the *Safe Drinking Water Act of 1974* (SDWA) is to protect the quality of the public water supply and sources of drinking water. In the State of Washington, the EPA has been given the authority to implement regulations to establish standards applicable to public water systems. These regulations further establish the maximum contaminant levels (MCL), including maximum levels of radioactivity allowed for drinking water systems. MCLs often are used as goals for remedial actions taken under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). The EPA has promulgated the SDWA requirements in 40 CFR 100-149, which specify that the average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 mrem/yr. Revisions to the limits regulating radionuclides have been proposed by the EPA.

Other programs established by the SDWA include the Sole Source Aquifer Program, the Wellhead Protection Program, and the Underground Injection Control Program.

6.1.4 Clean Water Act of 1977, as amended

The *Clean Water Act of 1977* (CWA) was enacted to "restore and maintain the chemical, physical and biological integrity of the Nation's water." The CWA prohibits "discharge of toxic pollutants in toxic amounts" to navigable waters of the United States. Section 313 of the CWA requires all branches of the Federal Government engaged in any activity that might result in a discharge or runoff of pollutants to surface waters to comply with federal, state, interstate, and local requirements.

In addition to setting water quality standards for waterways, the CWA provides guidelines and limitations for effluent discharges from point sources and gives authority for the EPA to implement the National Pollutant Discharge Elimination System (NPDES) Permitting Program. The NPDES Program is administered by the Water Management Division of the EPA through 40 CFR 122.

In 1987, the CWA was amended, and requires the EPA to establish regulations for issuing permits for stormwater discharges associated with industrial activity. Stormwater discharges are permitted through the NPDES Program, and general permit requirements are published in 40 CFR 122.

6.1.5 Resource Conservation and Recovery Act of 1976, as amended

Treatment, storage, and/or disposal (TSD) of hazardous and nonhazardous waste is regulated under the *Resource Conservation and Recovery Act of 1976* (RCRA) and the *Hazardous and Solid Waste Amendments of 1984*. Any state that seeks to administer and enforce a hazardous waste program pursuant to RCRA may apply for EPA authorization of the state program. The EPA regulations implementing RCRA, found in 40 CFR 260-280, define hazardous wastes, and specify the transportation, handling, and TSD requirements of these wastes.

Regulations imposed on waste generators for TSD facilities vary according to the type and quantity of material and/or waste that is generated, treated, stored, or disposed of. The method of TSD also influences the extent and complexity of the requirements.

6.1.6 Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended

The CERCLA provides a statutory framework for the cleanup of waste sites containing hazardous substances and, as amended by the *Superfund Amendments and Reauthorization Act of 1986*, an emergency response program in the event a release (or threat of a release) of a hazardous substance to the environment occurs. Using a Hazard Ranking System, federal and private sites are ranked and may be included on the National Priorities List (NPL). The CERCLA requires federal facilities with contaminated sites to undertake investigations and remediation, as necessary. The CERCLA also includes requirements for reporting releases of certain hazardous substances (in excess of specified amounts) to state and federal agencies.

6.1.7 Emergency Planning and Community Right-to-Know Act of 1986, also known as Superfund Amendments and Reauthorization Act of 1986 (SARA Title III)

Under Subtitle A of the *Emergency Planning and Community Right-to-Know Act of 1986*, federal facilities are required to provide information regarding the inventories of chemicals used or stored at a site, and releases from that site, to the State Emergency Response Commission and the Local Emergency Planning Committee, to ensure that emergency plans are sufficient to respond to unplanned releases of hazardous substances. Implementation of provisions in the *Emergency Planning and Community Right-to-Know Act of 1986* began voluntarily in 1987; inventory and emissions reporting began in 1988 based on 1987 activities and information. The requirements of the *Emergency Planning and Community Right-to-Know Act of 1986* were promulgated by the EPA in 40 CFR 350-372. The DOE requires compliance with SARA Title III as agency policy.

6.1.8 Toxic Substances Control Act of 1976

The *Toxic Substances Control Act of 1976* (TSCA) provides the EPA with the authority to require testing of chemical substances, both new and old, entering the environment and, where necessary, to regulate those chemicals. The law complements and expands other toxic substance laws, such as Section 112 of the CAA and Section 307 of the CWA. The TSCA was enacted because there were no federal regulations requiring evaluation of potential environmental or health effects from the thousands of chemicals being developed and released to the public or commerce annually. The TSCA also regulates TSD of toxic substances (e.g., polychlorinated biphenyls, chlorofluorocarbons, asbestos, dioxins, certain metal-working fluids, and hexavalent chromium).

6.1.9 Pollution Prevention Act of 1990

The *Pollution Prevention Act of 1990* (PPA) establishes a national policy for waste management and pollution control. The PPA focuses first on source reduction, followed sequentially by environmentally safe recycling, treatment, and disposal as a last resort. The DOE has committed to participation in Section 313 of SARA, and the EPA's 33/50 Pollution Prevention Program. The goal for facilities involved in Section 313 compliance is a 33% reduction in releases of 17 priority chemicals by 1997 (based on a 1993 baseline). On August 3, 1993, Executive Order 12856 was issued. This Executive Order expands the 33/50 Pollution Prevention Program and requires the DOE to reduce total releases of all toxic chemicals by 50% by December 31, 1999; therefore, each DOE

site is establishing site-specific goals to reduce generation of all waste types.

6.1.10 Federal Facilities Compliance Act of 1992

The *Federal Facilities Compliance Act of 1992* (FFCA), enacted on October 6, 1992, waives sovereign immunity for fines and penalties for RCRA violations at federal facilities. A provision of the FFCA postpones fines and penalties for 3 years for mixed waste storage prohibition violations at DOE sites, and requires the DOE to prepare plans for developing the required treatment capacity for mixed waste stored or generated at each facility. Each plan must be approved by the host state or the EPA, after consultation with other affected states, and a consent order requiring compliance with the plan must be issued by the regulator. The FFCA also states that the DOE will not be subject to fines and penalties for land disposal restriction storage prohibition violations for mixed waste as long as the DOE is in compliance with an approved plan and consent order, and meets all other applicable regulations.

6.1.11 National Historic Preservation Act of 1966, as amended

The *National Historic Preservation Act of 1966* (NHPA) requires nomination for and placement of sites with significant national historic value on the National Register of Historic Places. Permits and certifications are not required under the NHPA; however, consultation with the Advisory Council on Historic Preservation is required if a federal action may impact a historic property resource. This consultation generally results in a Memorandum of Agreement that includes stipulations to minimize adverse impacts to the historic resource. Coordination with the State Historic Preservation Officer is undertaken to ensure that potentially significant sites are properly identified and appropriate mitigation measures are implemented.

6.1.12 Archaeological Resources Protection Act of 1979, as amended

The *Archaeological Resources Protection Act of 1979* requires a permit for any excavation or removal of archaeological resources from public or Indian lands. Excavations must be undertaken for the purpose of furthering archaeological knowledge in the public interest, and resources removed are to remain the property of the United States. Consent must be obtained from the Indian tribe owning the land on which a resource is located before issuance of a permit; the permit must contain terms and conditions requested by the tribe.

6.1.13 Native American Graves Protection and Repatriation Act of 1990

The *Native American Graves Protection and Repatriation Act of 1990* directs the Secretary of Interior to guide responsibilities in repatriation of federal archaeological collections and collections held by museums receiving federal funding that are affiliated culturally to Native Americans. Major actions to be taken include: establishing a review committee with monitoring and policymaking responsibilities; developing regulations for repatriation, including procedures for identifying lineal descent or cultural affiliation needed for claims; oversight of museum programs designed to meet inventory requirements and deadlines of the law; and developing procedures to handle unexpected discoveries of graves or grave goods during activities on federal or tribal land.

6.1.14 American Indian Religious Freedom Act of 1978

The *American Indian Religious Freedom Act of 1978* reaffirms Native American religious freedom under the First Amendment, and sets United States policy to protect and preserve the inherent and constitutional right of American Indians to believe, express, and exercise traditional religions. This Act also requires that federal actions avoid interfering with access to sacred locations and traditional resources that are integral to the practice of religion.

6.1.15 Religious Freedom Restoration Act of 1993

The *Religious Freedom Restoration Act of 1993* prohibits the government, including federal departments, from substantially burdening the exercise of religion, unless the government demonstrates a compelling governmental interest, and the action furthers a necessary government interest and is the least restrictive means of furthering that interest.

6.1.16 Endangered Species Act of 1973, as amended

The *Endangered Species Act of 1973* (ESA) is intended to prevent further decline of endangered and threatened species and restore those species and their habitats. The ESA is jointly administered by the Departments of Commerce and Interior. Section 7 of the ESA requires agencies to consult with the U.S. Fish and Wildlife Service (USFWS) to determine whether endangered and threatened species or critical habitats are known to be in the vicinity of a proposed action. The ESA also requires consultation to determine whether an action will adversely affect listed species.

6.1.17 Migratory Bird Treaty Act of 1918, as amended

The *Migratory Bird Treaty Act of 1918* is intended to protect birds that have common migration patterns between the United States and Canada, Mexico, Japan, and Russia. The law regulates the harvest of migratory birds by specifying factors such as the mode of harvest, hunting seasons, and bag limits. This Act stipulates that, except as permitted by regulations, it is unlawful at any time, by any means, or in any manner to "kill...any migratory bird." The DOE is required to consult with the USFWS regarding impacts to migratory birds and to evaluate ways to avoid or minimize impacts in accordance with the USFWS Migration Policy.

6.1.18 Bald and Golden Eagle Protection Act of 1972, as amended

The *Bald and Golden Eagle Protection Act of 1972* makes it unlawful to take, pursue, molest, or disturb bald and golden eagles, their nests, or their eggs anywhere in the United States. A permit must be obtained from the U.S. Department of Interior to relocate a nest that interferes with resource development or recovery operations.

6.1.19 Wild and Scenic Rivers Act of 1968, as amended

The *Wild and Scenic Rivers Act of 1968* protects certain selected rivers of the Nation. These rivers possess outstanding scenic, recreational, geological, fish and wildlife, historical, cultural, or other similar values. These rivers are to be preserved in a free-flowing condition to protect water

quality and other vital national conservation purposes. This Act also instituted a national wild and scenic rivers system, designated the initial rivers within the system, and developed standards for the addition of new rivers in the future.

6.1.20 Nuclear Waste Policy Act of 1982, as amended

The *Nuclear Waste Policy Act of 1982* authorizes federal agencies to develop a geologic repository for the permanent disposal of Spent Nuclear Fuel (SNF) and radioactive high-level waste. This Act also specifies the process for selecting a repository site and constructing, operating, closing, and decommissioning the repository, and establishes programmatic guidance for these activities.

6.1.21 Atomic Energy Act of 1954, as amended

The *Atomic Energy Act of 1954* (AEA) authorizes the DOE to establish standards to protect health or minimize dangers to life or property with respect to activities under DOE jurisdiction. The DOE has used a series of orders to establish an extensive system of standards and requirements to ensure safe operation of facilities.

The AEA and related statutes give the EPA responsibility and authority for developing generally applicable environmental standards for protection of the general environment from radioactive material. The EPA has promulgated several regulations under this authority.

6.1.22 Occupational Safety and Health Act of 1970, as amended

The *Occupational Safety and Health Act of 1970* establishes standards to enhance safe and healthy working conditions in places of employment throughout the United States. The *Occupational Safety and Health Act of 1970* is administered and enforced by the Occupational Safety and Health Administration (OSHA), an agency under the U.S. Department of Labor. Although the OSHA and the EPA both have a mandate to limit exposures to toxic substances, the jurisdiction of the OSHA is limited to safety and health conditions in the workplace. In general, it is the duty of each employer to furnish a place of employment free of recognized hazards likely to cause death or serious physical harm to all employees. Employees have a duty to comply with OSHA standards and with all rules, regulations, and orders issued under the *Occupational Safety and Health Act of 1970*. OSHA regulations establish specific standards telling employers what must be done to achieve a safe and healthy working environment. The DOE places emphasis on compliance with these regulations at DOE facilities. The DOE prescribes, through DOE orders, that contractors shall meet OSHA standards applicable to work at government-owned, contractor-operated facilities (see DOE Orders 5480.1B, 5483.1A in Table 6-1). The DOE maintains, and makes available, the various records of minor illnesses, injuries, and work-related deaths as required by OSHA regulations.

6.2 State Laws and Regulations

State and local statutes also apply to activities at the Hanford Site because (1) federal law delegates enforcement or implementation authority to state or local agencies, or (2) the state requirement is more stringent than the federal requirement.

6.2.1 Washington State Environmental Policy Act of 1971, as amended

The Washington legislature enacted the *State Environmental Policy Act of 1971* (SEPA). The statute was amended in 1983, and new implementing regulations (the SEPA rules) were adopted and codified by the Washington State Department of Ecology (Ecology) in 1984 as *Washington Administrative Code* (WAC) 197-11. The purpose and policy sections of the statute are extremely broad, including recognition by the legislature that "each person has a fundamental and inalienable right to a healthful environment...." The SEPA contains a substantive mandate that "policies, regulations, and laws of the State of Washington shall be interpreted and administered in accordance with the policies set forth in [SEPA]." The SEPA applies to all branches of state government, including state agencies, municipal and public corporations, and counties, and requires each agency to develop procedures implementing and supplementing SEPA requirements and rules. Although the SEPA does not apply directly to federal actions, the term "government action" with respect to state agencies is defined to include the issuance of licenses, permits, and approvals. Thus, as in the NEPA, proposals (federal, state, or private) are evaluated and may be conditioned or denied through the permit process based on environmental considerations. The SEPA does not create an independent permit requirement, but overlays all existing agency permitting activities.

6.2.2 Washington Hazardous Waste Management Act of 1976

The Washington hazardous waste program is managed jointly by the EPA and the Ecology. The federal RCRA program allows state enforcement if the state program is consistent with the federal program and at least as stringent. The Ecology has enacted hazardous waste regulations that are consistent with and as stringent as, or more stringent than, the federal program. Washington has been delegated authority to implement RCRA and *Hazardous and Solid Waste Amendments of 1984* programs. Regulated parties must comply with the requirements of both the federal program, pursuant to regulations in 40 CFR 260-272, and the state program, pursuant to the requirements of the *Washington Hazardous Waste Management Act of 1976* and WAC 173-303, *Dangerous Waste Regulations*.

6.2.3 Washington Model Toxics Control Act of 1989

The State of Washington has adopted a statutory "Superfund" scheme for identifying and responding to releases of hazardous substances. Known as the *Washington Model Toxics Control Act of 1989* (MTCA), the Washington law supplements CERCLA. The MTCA requires the Ecology to investigate and prioritize hazardous waste release sites, provide technical assistance to "potentially liable parties" desiring to perform cleanups, set cleanup standards for hazardous substances, undertake cleanups where appropriate, require and assist in or perform cleanups, provide opportunities for public involvement, establish a scientific advisory board, and regularly report to the legislature. The statute empowers the Ecology to gain access to property; enter into settlements, either through administrative orders or consent decrees; file actions or issue orders to compel cleanups; and impose civil penalties and seek recovery of state cleanup costs.

6.2.4 Washington Water Pollution Control Act of 1945

The *Washington Water Pollution Control Act of 1945* establishes a permit system to license and control the discharge of pollutants into waters of the state. Under the permit system, dischargers

must reduce releases to a level determined to be technologically and economically achievable, regardless of the condition of the receiving water. Dischargers also must maintain or improve the condition of the receiving water. The state has a general policy prohibiting degradation of existing water quality; a variety of approaches are used to address the problem of toxic pollutants. Permits are required for both point source and nonpoint source discharges.

6.2.5 Washington Growth Management Act of 1989

In 1989, the Washington State Legislature enacted the *Growth Management Act of 1989* (GMA), which is a broad strategy for managing problems associated with rapid growth and development. The GMA creates new roles and responsibilities for planning at the local, regional, and state level. Before passage of the GMA, local governments were responsible for land-use planning, and the state played a limited role. Local governments had statutory authority to engage in land-use planning, but were not required to plan. As a result, local governments largely limited land-use planning to traditional zoning, shorelines, environmental review, and transportation planning. The GMA significantly changed the system by establishing a statewide planning framework and requiring many local governments to plan.

6.2.6 Washington Air Quality Regulations

Most of the provisions of the *Washington Clean Air Act of 1991* (WCAA) mirror the requirements of the *Federal Clean Air Act Amendments of 1990* (Federal CAAA). The Federal CAAA establishes a minimum or "floor" for Washington's air quality programs. The WCAA authorizes Ecology and local air pollution control authorities to implement programs consistent with the Federal CAA (i.e., the WCAA authorizes an operating permit program, enhanced civil penalties, new administrative enforcement provisions, motor vehicle inspections, and provisions addressing ozone and acid rain).

Washington also has an extensive set of regulations governing toxic air pollutants (TAP) (WAC 173-460). These regulations are similar to the programs for regulating Hazardous Air Pollutants (HAP) required by the Federal CAA. In contrast to the Federal CAA HAPs program, which applies to new and existing emission sources, the TAP rules apply only to new sources of TAPs, including any modification of an existing source where the modification will increase TAP emissions. Furthermore, the Ecology refers to a list of over 450 individual chemicals that are deemed to be TAPs. The list overlaps with the Federal CAA list of HAPs, but is considerably longer. The TAP rules are implemented under the New Source Review Program and the Regulatory Standard for TAPs is "best available control technology."

The Washington State Department of Health regulations in WAC 246-247, "Radiation Protection-- Air Emissions," contain standards and permit requirements for the emission of radionuclides to the atmosphere from DOE facilities based on the Ecology standards in WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides."

The local air authority, Benton County Clean Air Authority, enforces regulations pertaining to detrimental effects, fugitive dust, incineration products, odor, opacity, asbestos, and sulfur oxide emissions. The Benton County Clean Air Authority has also been delegated authority to enforce EPA asbestos regulations.

6.3 Executive Orders

This section identifies Presidential Executive Orders that clarify environmentally related issues of national policy and provide guidelines for federal actions.

6.3.1 Executive Order 12088, Federal Compliance with Pollution Control Standards

Executive Order 12088 was issued on October 13, 1978 and amended by Executive Order 12580 issued on January 23, 1987. The order directs federal agencies to comply with applicable administrative and procedural pollution control standards established by, but not limited to, the CWA, the CAA, the SDWA, the TSCA, and the RCRA.

6.3.2 Executive Order 11593, National Historic Preservation

Executive Order 11593 was issued on May 13, 1971. The order directs federal agencies to locate, inventory, and nominate properties under agency jurisdiction or control to the National Register of Historic Places if those properties qualify. This process requires the DOE to provide the Advisory Council on Historic Preservation with the opportunity to comment on impacts of proposed actions on potentially eligible or listed resources.

6.3.3 Executive Order 11514, Protection and Enhancement of Environmental Quality

Executive Order 11514 directs federal agencies to continually monitor and control agency activities to protect and enhance the quality of the environment and to develop procedures to ensure the fullest practicable provision of timely public information and understanding of the federal plans and programs with environmental impact in order to obtain the views of interested parties. The DOE has issued regulations and orders for compliance with this Executive Order (10 CFR 1021, DOE Order 5440.1E).

6.3.4 Executive Order 11988, Floodplain Management

Executive Order 11988 directs federal agencies to establish procedures to ensure that the potential effects of flood hazards and floodplain management are considered for actions undertaken in a floodplain. The Executive Order further directs that floodplain impacts are to be avoided to the extent practicable.

6.3.5 Executive Order 11990, Protection of Wetlands

Governmental agencies are directed by Executive Order 11990 to avoid, to the extent practicable, any short- and long-term adverse impacts on wetlands wherever there is an practicable alternative.

6.3.6 Executive Order 12344, Naval Nuclear Propulsion Program

Executive Order 12344 was enacted as law by Public Law 98-525, and prescribes the authority and responsibility of the Naval Nuclear Propulsion Program, a joint Navy/DOE organization, for matters pertaining to Naval nuclear propulsion. Organizational responsibilities include all environmental and occupational safety and health aspects of the program.

6.3.7 Executive Order 12580, Superfund Implementation

Executive Order 12580 delegates to the heads of executive departments and agencies the responsibility for undertaking remedial actions for releases, or threatened releases, that are not on the NPL and removal actions where the release is from a facility under the jurisdiction or control of executive departments and agencies.

6.3.8 Executive Order 12856, Right-to-Know Laws and Pollution Prevention Requirements

Executive Order 12856 directs federal agencies to reduce and report toxic chemicals entering any wastestream; improve emergency planning, response, and accident notification; and encourage clean technologies and testing of innovative prevention technologies. The Executive Order also provides that federal agencies are persons for purposes of the *Emergency Planning and Community Right-to-Know Act of 1986* (SARA Title III), which obliges agencies to meet the requirements of that Act.

6.3.9 Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations

Executive Order 12898 directs all federal agencies to achieve environmental justice by identifying and addressing disproportionately high and adverse human health or environmental effects of agency programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions. The Executive Order creates an Interagency Working Group on Environmental Justice and directs each federal agency to develop strategies to identify and address environmental justice concerns. The Executive Order further directs each federal agency to collect, maintain, analyze, and make available information on the race, national origin, income level, and other readily accessible and appropriate information for areas surrounding facilities or sites expected to have a substantial environmental, human health, or economic effect on the surrounding populations, when such facilities or sites become the subject of a substantial federal environmental administrative or judicial action.

6.4 U.S. Department of Energy Regulations and Orders

This section identifies a series of DOE orders implementing statutory environmental, health, and safety protection responsibilities and requirements that must be met by operating contractors.

The DOE is responsible for establishing a comprehensive health, safety, and environmental program for its facilities, as authorized by the AEA. The regulatory mechanisms used by the DOE to manage its facilities are the promulgation of regulations and issuance of DOE orders.

DOE regulations are found generally in Title 10 of the CFR. These regulations address such areas as energy conservation, administrative requirements and procedures, nuclear safety, and classified information. For purposes of this EIS, relevant regulations include the following:

- 10 CFR 820, "Procedural Rules for DOE Nuclear Activities"
- 10 CFR 830.120, "Quality Assurance Requirements"
- 10 CFR 834, "Radiation Protection of the Public and the Environment" (proposed)
- 10 CFR 835, "Occupational Radiation Protection"
- 10 CFR 1021, "Compliance with the National Environmental Policy Act"
- 10 CFR 1022, "Compliance with Floodplain/Wetlands Environmental Review Requirements."

DOE orders generally set forth policies, and the programs and internal procedures for implementing the policies. Major DOE orders that may pertain to Hanford Site remedial activities are listed in Table 6-1.

6.5 Consultations

NEPA and CEQ Regulations require consultation with federal, tribal, state, and local agencies with jurisdiction or special expertise regarding any environmental impact. Agencies involved include those with authority to issue applicable permits, licenses, and other regulatory approvals, as well as those responsible for protecting significant resources (e.g., endangered species, critical habitats, or historic resources). Federal and state agencies and Native American governments have been, and will continue to be, consulted during the development of this EIS. Agencies and tribes that will be consulted are identified in Table 6-2. Representatives of federal, tribal, state, and local agencies were involved in the development of future land-use alternatives and scoping of this EIS through involvement in the Hanford Future Site Uses Working Group. Consultations undertaken by the DOE will be identified in the final EIS.

Table 6-1. U.S. Department of Energy Orders Pertaining to Remedial Activities at the Hanford Site. (2 sheets)

DOE Order	Subject
1300.2A	U.S. Department of Energy Technical Standards Program (5-19-92)
1360.2B	Unclassified Computer Security Program (5-18-92)
1540.2	Hazardous Material Packaging for Transport-Administrative Procedures (9-30-86; Chg. 1, 12-19-88)
3790.1B	Federal Employee Occupational Safety and Health Program (1-7-93)
430.1	Life-Cycle Asset Management (8-24-95)
4330.4B	Maintenance Management Program (2-10-94)
5000.3B	Occurrence Reporting and Processing of Operations Information (1-19-93; Chg. 1, 7-2-93)
5400.1	General Environmental Protection Program (11-9-88; Chg. 1, 6-29-90)
5400.2A	Environmental Compliance Issue Coordination (1-31-89; Chg. 1, 1-7-93)
5400.4	Comprehensive Environmental Response, Compensation, and Liability Act Requirements (10-6-89)
5400.5	Radiation Protection of the Public and the Environment (2-8-90; Chg. 2, 1-7-93)
5440.1E	National Environmental Policy Act Compliance Program (11-10-92)
5480.1B	Environment, Safety, and Health Program for DOE Operations (9-23-86; Chg. 5, 5-10-93)
5480.3	Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes (7-9-85)
5480.4	Environmental Protection, Safety, and Health Protection Standards (5-15-84; Chg. 4, 1-7-93)
5480.7A	Fire Protection (2-17-93)
5480.8A	Contractor Occupational Medical Program (6-26-92; Chg. 1, 10-19-92)
5480.9A	Construction Project Safety and Health Management (4-13-94)
5480.10	Contractor Industrial Hygiene Program (6-26-85)
5480.11	Radiation Protection for Occupational Workers (12-21-88; Chg. 3, 6-17-92)
5480.15	U.S. Department of Energy Laboratory Accreditation Program for Personnel Dosimetry (12-14-87)
5480.17	U.S. Department of Energy Site Safety Representatives (10-5-88)
5480.18B	Nuclear Facility Training Accreditation Program (8-31-94)
5480.19	Conduct of Operations Requirements for DOE Facilities (7-9-90; Chg. 1, 5-18-92)

Table 6-1. U.S. Department of Energy Orders Pertaining to Remedial Activities at the Hanford Site. (2 sheets)

DOE Order	Subject
5480.20A	Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities (11-15-94)
5480.21	Unreviewed Safety Questions (12-24-91)
5480.22	Technical Safety Requirements (2-25-92; Chg. 1, 9-15-92)
5480.23	Nuclear Safety Analysis Reports (4-10-92; Chg. 1, 3-10-94)
5480.24	Nuclear Criticality Safety (8-12-92)
5480.28	Natural Phenomena Hazards Mitigation (1-15-93)
5480.31	Startup and Restart of Nuclear Facilities (9-15-93)
5481.1B	Safety Analysis and Review System (9-23-86; Chg. 1, 5-19-87)
5482.1B	Environment, Safety, and Health Appraisal Program (9-23-86; Chg. 1, 11-18-91)
5483.1A	Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned, Contractor-Operated Facilities (6-22-83)
5484.1	Environmental Protection, Safety, and Health Protection Information Reporting Requirements (2-24-81; Chg. 7, 10-17-90)
5500.1B	Emergency Management System (4-30-91; Chg. 1, 2-27-92)
5500.2B	Emergency Categories, Classes, and Notification and Reporting Requirements (4-30-91; Chg. 1, 2-27-92)
5500.3A	Planning and Preparedness for Operational Emergencies (4-30-91; Chg. 1, 2-27-92)
5500.4A	Public Affairs Policy and Planning Requirements for Emergencies (6-8-92)
5500.7B	Emergency Operating Records Protection Program (10-23-91)
5500.10	Emergency Readiness Assurance Program (4-30-91; Chg. 1, 2-27-92)
5630.11B	Safeguards and Security Program (8-2-94)
5630.12A	Safeguards and Security Inspection and Assessment Program (6-23-92)
5700.6C	Quality Assurance (8-21-91)
5820.2A	Radioactive Waste Management (9-26-88)
6430.1A	General Design Criteria (4-6-89)

DOE = U.S. Department of Energy.

Table 6-2. Agency Consultations.

Subject Area	Legislation	Agency
Endangered Species	*Endangered Species Act of 1973*	USFWS
Migratory Birds	*Migratory Bird Treaty Act of 1918*	USFWS
Eagles	*Bald and Golden Eagle Protection Act of 1972*	USFWS
Archaeological, Historical, and Cultural Resources	*National Historic Preservation Act of 1966; Archaeological Resources Protection Act of 1979; American Antiquities Preservation Act of 1906; American Indian Religious Freedom Act of 1978; Native American Graves Protection and Repatriation Act of 1990*	Washington Department of Community Development; Office of Archaeology and Historic Preservation; State Historic Preservation Officer; U.S. Advisory Council on Historic Preservation; Yakama Indian Nation; Confederated Tribes of the Umatilla Indian Reservation; Nez Perce Tribe; Wanapum Band
Discharge of Pollutants to Waters	*Clean Water Act of 1977; Safe Drinking Water Act of 1974*	EPA; Ecology
Work in Navigable Waters	*Clean Water Act of 1977; Safe Drinking Water Act of 1974*	USACE
Prime and Unique Farmlands	*Farmland Protection Policy Act of 1981*	Soil Conservation Service; U.S. Department of Agriculture
Floodplains	Executive Order 11988; *Fish and Wildlife Coordination Act of 1934*; 10 CFR 1022, "Compliance with Floodplain/Wetlands Environmental Review Requirements"	USFWS; USACE; Grant, Benton, and Franklin County Planning Departments
Wetlands	10 CFR 1022, "Compliance with Floodplain/Wetlands Environmental Review Requirements;" Executive Order 11990; *Fish and Wildlife Coordination Act of 1934; Clean Water Act of 1977*, Section 404	USFWS; USACE; EPA; Ecology
Alterations to Bodies of Water	*Fish and Wildlife Coordination Act of 1934*	USFWS
Columbia River	*Wild and Scenic Rivers Act of 1968; Comprehensive Conservation Study of the Hanford Reach of the Columbia River; Anadromous Fish Conservation Act of 1965*	U.S. Department of Interior, National Park Service
Air Pollution	*State and Federal Clean Air Acts of 1991 and 1970, respectively*	EPA; Ecology; Benton County Clean Air Authority; Washington State Department of Health
Water Use and Availability	*Water Resources Planning Act of 1965; Safe Drinking Water Act of 1974*	EPA, Office of Water Policy; Ecology
Noise Issues	*Noise Pollution and Abatement Act of 1970; Noise Control Act of 1972*	EPA; Grant, Benton, and Franklin County Planning Departments
Siting and Planning	*Grant, Benton, and Franklin County Zoning Regulations and Land Use Plans*	Grant, Benton, and Franklin County Planning Departments
Waste Management and Transportation	*Resource Conservation and Recovery Act of 1976; Hazardous and Solid Waste Amendments of 1984; Comprehensive Environmental Response, Compensation and Liability Act of 1980; Emergency Planning and Community Right-to Know Act of 1986; Superfund Amendments and Reauthorization Act of 1986; Toxic Substances Control Act of 1976; Federal Insecticide, Fungicide, and Rodenticide Act of 1975*	EPA; U.S. Department of Transportation; Ecology

USACE = U.S. Army Corps of Engineers.
USFWS = U.S. Fish and Wildlife Service.

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8.0 References

Chapter 1 References

40 CFR 1506.1, 1978, "Limitation of Actions During the NEPA Process," *Code of Federal Regulations*, as amended.

57 FR 37959, 1992, "Intent to Prepare the Hanford Remedial Action Environmental Impact Statement, Richland, Washington," *Federal Register*, Vol. 57, p. 37959 (August 21).

59 FR 4052, 1994, "Intent to Prepare the Hanford Tank Wastes Remediation System Environmental Impact Statement, Richland, Washington," *Federal Register*, Vol. 28, p. 4052 (January 28).

59 FR 53969, 1994, "Notice of Intent to Prepare the Plutonium Finishing Plant Environmental Impact Statement," *Federal Register*, Vol. 59, p. 53969 (October 27).

60 FR 28680, 1995, "Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs, Final Environmental Impact Statement," *Federal Register*, Vol. 60, p. 28680 (June 1).

CEQ, 1993, *Incorporating Biodiversity Considerations into Environmental Impact Analysis Under the National Environmental Policy Act*, Council on Environmental Quality, Washington, D.C. (January).

Comprehensive Conservation Study of the Hanford Reach of the Columbia River, 1988 (Public Law 100-605).

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq.

Cushing, 1995, *Hanford Site National Environmental Policy Act (NEPA) Characterization*, PNL-6415, Rev. 7, Pacific Northwest Laboratory, Richland, Washington.

DOE, 1987, *Final Environmental Impact Statement: Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes*, DOE/EIS-0113, U.S. Department of Energy, Washington, D.C.

DOE, 1988, *Radioactive Waste Management*, DOE Order 5820.2A, U.S. Department of Energy, Washington, D.C.

DOE, 1992, *Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington, Environmental Impact Statement*, DOE/EIS-0019F, U.S. Department of Energy, Washington, D.C.

DOE, 1994a, *Draft U.S. Department of Energy Public Participation Guidance for Environmental Justice Activities*, U.S. Department of Energy, Washington, D.C. (July 25).

DOE, 1994b, *Predecisional Draft: U.S. Department of Energy Proposed Environmental Justice Strategy, Executive Order 12898*, U.S. Department of Energy, Washington, D.C.

DOE, DOA, and DOI, 1994, *Columbia River System Operation Review Draft Environmental Impact Statement*, DOE/EIS-0170, U.S. Department of Energy, U.S. Department of the Army, and the U.S. Department of the Interior, Portland, Oregon (July).

DOE, 1995a, *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs, Final Environmental Impact Statement*, DOE/EIS-0203-F, U.S. Department of Energy, Washington, D.C.

DOE, 1995b, *Draft Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*, DOE/EIS-0200-D, U.S. Department of Energy, Washington, D.C. (August)

DOE, 1995c, *Management of Spent Nuclear Fuel from the K Basins at the Hanford Site, Richland, Washington*, DOE/EIS-0245D, U.S. Department of Energy, Washington, D.C. (October).

DOE and Ecology, 1995, *Preliminary Draft for the Tank Waste Remediation System*, DOE/EIS-0189, U.S. Department of Energy, Washington State Department of Ecology, Richland, Washington (August).

DOE-RL, 1990, *Hanford Site Development Plan*, DOE/RL-89-15, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993, *Hanford Mission Plan, Volume 1, Site Guidance*, DOE/RL-93-08, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1994a, *Remedial Investigation and Feasibility Study Report for the Environmental Restoration Disposal Facility*, DOE/RL-93-99, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1994b, *NEPA Roadmap for the Environmental Restoration Disposal Facility Regulatory Package*, DOE/RL-94-41, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington (June).

DOE-RL, 1995, *Implementation Plan for the Hanford Remedial Action Environmental Impact Statement, Richland, Washington*, DOE/RL-93-66, U.S. Department of Energy, Richland, Washington.

Ecology and DOE-RL, 1995, *Final Environmental Impact Statement: Safe Interim Storage of Hanford Tank Wastes*, DOE/EIS-0212, Washington State Department of Ecology and U.S. Department of Energy, Richland Operations Office, Richland, Washington (October).

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, as amended, Document No. 89-10, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy.

EPA, 1995, "Declaration of the CERCLA Record of Decision for the USDOE Hanford Environmental Restoration Disposal Facility, Hanford Site, Benton County, Washington," (January 20).

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, Washington, D.C. (February 11).

Gerber, M. S., 1992, *Legend and Legacy: Fifty Years of Defense Production at the Hanford Site*, WHC-MR-0293, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

Hazardous and Solid Waste Amendments of 1984, Public Law 98-616, et seq.

HFSUWG, 1992, *The Future for Hanford: Uses And Cleanup, The Final Report of the Hanford Future Site Uses Working Group*, Hanford Future Site Uses Working Group, Richland, Washington.

National Environmental Policy Act of 1969, 42 USC 4321, et seq.

Navy, 1995, *Disposal of Decommissioned, Defueled Cruiser, Los Angeles Class and Ohio Class, Naval Reactor Plants Environmental Impact Statement*, Draft, U.S. Department of Navy, Washington, D.C. (August).

NPS, 1994, *Hanford Reach of the Columbia River, Comprehensive River Conservation Study and Environmental Impact Statement Final - June 1994*, National Park Service, Pacific Northwest Regional Office, Seattle, Washington.

PNL, 1995, *Hanford Site Environmental Report for Calendar Year 1994*, PNL-10574, Pacific Northwest Laboratory, Richland, Washington.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

State Environmental Policy Act of 1971, RCW Chapter 43.21C, et seq.

USACE, 1992, *Superconducting Magnetic Energy Storage – Engineering Test Model (SMES-ETM) Environmental Impact Statement*, U.S. Army Corps of Engineers, Mobile, Alabama.

Chapter 2 References

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9701, et seq.

Ecology, EPA, and DOE, 1994, *Hanford Federal Facility Agreement and Consent Order*, 89-10, Rev. 3, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

National Environmental Policy Act of 1969, 42 USC 4321, et seq.

Chapter 3 References

40 CFR 1500-1508, "Council on Environmental Quality Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act," *Code of Federal Regulations*, as amended.

58 FR 48509, 1993, *Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington, Environmental Impact Statement* (September 16).

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq.

DOE, 1985, *Environmental Assessment, Decommissioning of the Strontium Semiworks Facility, Building 201-C, Hanford Site, Richland, Washington*, DOE/EA-0259, U.S. Department of Energy, Washington, D.C.

DOE, 1992, *Addendum: Final Environmental Impact Statement) Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington*, DOE/EIS-0119F, U.S. Department of Energy, Washington, D.C. (December).

DOE, 1993, *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements*, U.S. Department of Energy, Washington, D.C. (May).

DOE-RL, 1991, *Hanford 300 Area Development Plan*, DOE/RL-91-09, U.S. Department of Energy, Richland Operations Office, Richland, Washington (September).

DOE-RL, 1992, *Environmental Restoration and Waste Management Site-Specific Plan for the Richland Field Office, Hanford Site Five-Year Plan Fiscal Years 1994-1998*, DOE/RL-92-27, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993a, *Hanford Site Development Plan*, DOE/RL-93-19, U.S. Department of Energy, Richland Operations Office, Richland, Washington (May).

DOE-RL, 1993b, *200 East Groundwater Aggregate Area Management Study Report*, DOE/RL-92-19, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington (April).

DOE-RL, 1993c, *200 West Groundwater Aggregate Area Management Study Report*, DOE/RL-92-16, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington (January).

DOE-RL, 1994b, *100 Area Feasibility Study, Phases 1 and 2*, DOE/RL-92-11, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington (February).

DOE-RL, 1994a, *Implementation Plan for the Hanford Remedial Action Environmental Impact Statement*, DOE/RL-93-66, U.S. Department of Energy, Richland Operations Office, Richland, Washington (June).

DOE-RL, 1994c, *Fiscal Year 1995 Hanford Mission Plan, Volume 1, Site Guidance*, DOE/RL-93-102, U.S. Department of Energy, Richland Operations Office, Richland, Washington (March).

Ecology, 1993, *Hanford Land Transfer, A Report Prepared by the Washington State Department of Ecology*, Washington State Department of Ecology, Olympia, Washington (March).

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, as amended, Document No. 89-10, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy.

Ecology, EPA, and DOE, 1993, *Record of Decision, USDOE Hanford 1100 Area, Hanford Site, Richland, Washington*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Richland, Washington (September).

HFSUWG, 1992, *The Future For Hanford: Uses And Cleanup, A Final Report of the Hanford Future Site Uses Working Group*, Hanford Future Site Uses Working Group, Westinghouse Hanford Company, Richland, Washington (December).

National Environmental Policy Act of 1969, 42 USC 4321, et seq.

Navy, 1984, *Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled Submarine Reactor Plants*, U.S. Department of the Navy, Washington, D.C.

NPS, 1994, *Hanford Reach of the Columbia River, Comprehensive River Conservation Study and Final Environmental Impact Statement*, National Park Service, Pacific Northwest Regional Office, Seattle, Washington (June).

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

WHC, 1992, *Site Evaluation Report for the Environmental Restoration Storage and Disposal Facility*, WHC-SD-EN-EV-009, Westinghouse Hanford Company, Richland, Washington.

WHC, 1994, *Safeguards and Security Program: 1994 Fiscal Year Work Plan*, WHC-SP-1045, Westinghouse Hanford Company, Richland, Washington.

WHC and USACE, 1994a, *100 D&D Subproject Baseline Summary*, Westinghouse Hanford Company, Richland, Washington and U.S. Army Corps of Engineers, Arlington, Virginia (March).

WHC and USACE, 1994b, *RARA/UST Subproject Baseline Summary*, Westinghouse Hanford Company, Richland, Washington and U.S. Army Corps of Engineers, Arlington, Virginia (March).

Winship, R. A., and M. C. Hughes, 1992, *Surplus Facilities Program Plan, Fiscal Year 1993*, WHC-EP-0231-5, Westinghouse Hanford Company, Richland, Washington (September).

Chapter 4 References

10 CFR 1022, 1979, "Compliance with Floodplain/Wetlands Environmental Review Requirements," *Code of Federal Regulations*, as amended.

29 CFR 1910, 1974, "U.S. Department of Labor, Occupational Safety and Health Administration (OSHA)," *Code of Federal Regulations*, as amended.

36 CFR 800.9, 1986, "Protection of Historic and Cultural Properties," *Code of Federal Regulations*, as amended.

40 CFR 52, 1972, "Prevention of Significant Deterioration of Air Quality," *Code of Federal Regulations*, as amended.

40 CFR 60.1, 1971, "Standards of Performance for new Stationary Sources: Applicability," *Code of Federal Regulations,* as amended.

50 CFR 17, 1975, "Endangered and Threatened Wildlife and Plants," *Code of Federal Regulations*, as amended.

American Indian Religious Freedom Act of 1978, 42 USC 1996, et seq.

Archaeological Resources Protection Act of 1979, 16 USC 470aa-47011, et seq.

CEQ, 1993, *Incorporating Biodiversity Considerations into Environmental Impact Analysis Under the National Environmental Policy Act*, Council on Environmental Quality, Washington, D.C. (January).

Clean Air Act of 1970, 33 USC 1251, et seq.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9701, et seq.

Cowardin, L. M., Carter,V., Golet, F. C., and LaRoe, E. T., 1979, *Classification of Wetlands and Deepwater Habitats of the United States*, U.S. Fish and Wildlife Service, Washington, D.C.

Cushing, C. E., 1992, *Hanford Site National Environmental Policy Act (NEPA) Characterization*, PNL-6415, Rev. 5, Pacific Northwest Laboratory, Richland, Washington.

Cushing, C. E., 1995, *Hanford Site National Environmental Policy Act (NEPA) Characterization*, PNL-6415, Rev. 7, Pacific Northwest Laboratory, Richland, Washington.

DOE, 1990, "General Environmental Protection Program," DOE Order 5400.1, U.S. Department of Energy, Washington, D.C.

DOE, 1993, "Radiation Protection of the Public and the Environment," DOE Order 5400.5, U.S. Department of Energy, Washington, D.C.

DOE, 1987, *Final Environmental Impact Statement: Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes*, DOE/EIS-0113, Vol. 1 of 5, U.S. Department of Energy, Washington, D.C.

9613470.0552

DOE, 1988, *Consultation Draft Site Characterization Plan, Volumes 1-9*, DOE/RW-0164, Office of Civilian Radioactive Waste Management, U.S. Department of Energy, Washington, D.C.

DOE, 1995, *Final Environmental Impact Statement: Department of Energy Programmatic Spent Nuclear Fuel management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs,* U.S. Department of Energy, Idaho Operations Office, Idaho Falls, Idaho (April).

DOE-RL, 1990a, *Hanford Site Development Plan*, DOE/RL-89-15, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1990b, *Hanford Site Infrastructure Plan*, DOE/RL-89-31, U.S. Department of Energy, Richland Operations Office, Richland, Washington (January).

DOE-RL, 1991, *Hanford Site Environmental Monitoring Plan*, DOE/RL-91-50, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1994, *Hanford Site Development Plan*, DOE/RL-94-13, U.S. Department of Energy, Richland Operations Office, Richland, Washington (May).

ERDA, 1975, *Waste Management Operations, Hanford Reservation, Richland, Washington: Final Environmental Statement*, ERDA-1538, Vol. 1, U.S. Energy Research & Development Administration, Washington, D.C. (December).

Fitzner, R. E., and R. H. Gray, 1991, "The Status, Distribution, and Ecology of Wildlife on the U.S. DOE Hanford Site: A Historical Overview of Research Activities," *Environmental Monitoring and Assessment*, 18: 173-202.

Franklin, J. F., and Dyrness, C. T., 1988, *Natural Vegetation of Oregon and Washington*, Oregon State University Press, Corvallis, Oregon.

Hajek, B. F., 1966, *Soil Survey Hanford Project in Benton County Washington*, BNWL-243, Pacific Northwest Laboratory, Richland, Washington.

HFSUWG, 1992, *The Future for Hanford: Uses and Cleanup, The Final Report of the Hanford Future Site Uses Working Group*, Hanford Future Site Uses Working Group (December).

Hoitink, D. L. and Burk, K. W., 1994, *Climatological Data Summary 1993 with Historical Data,* PNL-9809, Pacific Northwest Laboratory, Richland, Washington.

National Historic Preservation Act of 1966, 16 USC 470-470w-6, et seq.

Native American Graves Protection and Repatriation Act of 1990, 25 USC 3001, et seq.

NPS, 1994, *Hanford Reach of the Columbia River, Comprehensive River Conservation Study and Environmental Impact Statement Final - June 1994*, National Park Service, Seattle, Washington (June).

Parker, P. L., and King, T. F., 1990, *Guidelines for Evaluating and Documenting Traditional Cultural Properties*, National Register Bulletin No. 38, U.S. Department of Interior, National Park Service, Interagency Resources Division, Washington, D.C.

PNL, 1977, *Ecology of the 200-Area Plateau Waste Management Environs: A Status Report*, PNL-2253, Pacific Northwest Laboratory, Richland, Washington (October).

PNL, 1981, *Raptors of the Hanford Site and Nearby Areas of Southcentral Washington*, PNL-3212, Pacific Northwest Laboratory, Richland, Washington (May).

PNL, 1984, *Environmental Characterization of Two Potential Locations at Hanford for a New Production Reactor*, PNL-5275, Pacific Northwest Laboratory, Richland, Washington (September).

PNL, 1987, *The Economic and Community Impacts of Closing Hanford's N Reactor and Nuclear Materials Production Facilities*, PNL-6295, Pacific Northwest Laboratory, Richland, Washington (August).

PNL, 1989, *Hanford Cultural Resources Management Plan*, PNL-6942, Pacific Northwest Laboratory, Richland, Washington (June).

PNL, 1990a, *Spawning and Abundance of Fall Chinook Salmon (Oncorhynchus tshawytscha) in the Hanford Reach of the Columbia River, 1948-1988*, PNL-7289, Pacific Northwest Laboratory, Richland, Washington (March).

PNL, 1990b, *Archaeological Survey of the 200-East and 200-West Areas, Hanford Site, Washington*, PNL-7264, Pacific Northwest Laboratory, Richland, Washington (March).

PNL, 1991a, *A Study Plan for Determining Recharge Rates at the Hanford Site using Environmental Tracers*, PNL-7626, Pacific Northwest Laboratory, Richland, Washington (February).

PNL, 1991b, *An Evaluation of the Chemical, Radiological, and Ecological Conditions of West Lake on the Hanford Site*, PNL-7662, Pacific Northwest Laboratory, Richland, Washington (March).

PNL, 1993a, *Hanford Site Environmental Report for Calendar Year 1992*, PNL-8682, Pacific Northwest Laboratory, Richland, Washington (June).

PNL, 1993b, *Habitat Types on the Hanford Site: Wildlife and Plant Species of Concern*, PNL-8942, Pacific Northwest Laboratory, Richland, Washington (December).

PNL, 1995a, *Hanford Site Environmental Report for Calendar Year 1994*, PNL-10574, Pacific Northwest Laboratory, Richland, Washington (June).

PNL, 1995b, *Hanford Site Ground-Water Monitoring for 1994,* PNL-10698, Pacific Northwest Laboratory, Richland, Washington (August).

RHO, 1984, *An Assessment of Aquifer Intercommunication Within B Pond-Gable Mountain Pond Area of the Hanford Site*, RHO-RE-ST-12P, Rockwell Hanford Operations, Richland, Washington (March).

Rice, D. G., 1980, *Cultural Resources Assessment of the Hanford Reach of the Columbia River, State of Washington*, Contract DACW 67-M-80-1193, submitted to U.S. Army Corps of Engineers, Seattle District, Seattle, Washington.

Rickard, W. H., and L. D. Poole, 1989, "Terrestrial Wildlife of the Hanford Site: Past and Future," *Northwest Science* 63 (4): 183-193.

Schuller, C. A., Rickard, W. H., Sargeant, G. A., 1993, "Conservation of Habitats for Shrub-Steppe Birds," *Environmental Conservation*, 20(1): 57-64.

TNC, 1995, *"Biodiversity Inventory and Analysis of the Hanford Site, 1994 Annual Report*," prepared by The Nature Conservancy for the U. S. Department of Energy, Richland, Washington (May).

WAC 173-216, 1995, "State Waste Discharge Permit Program," *Washington Administrative Code*, as amended.

WHC, 1991a, *Geologic Setting of the 200-West Area: An Update*, WHC-SD-EN-TI-008, Rev. 0, Westinghouse Hanford Company, Richland, Washington (January).

WHC, 1991b, *Geology and Hydrology of the Hanford Site: A Standardized Text for use in Westinghouse Hanford Company Documents and Reports*, WHC-SD-ER-TI-003, Westinghouse Hanford Company, Richland, Washington (September).

WHC, 1992a, *Geology of the Northern Part of the Hanford Site: An Outline of Data Sources and the Geologic Setting of the 100 Areas*, WHC-SE-EN-TI-011, Rev. 0, Westinghouse Hanford Company, Richland, Washington (March).

WHC, 1992b, *Geologic Setting of the 200-East Area: An Update*, WHC-SD-EN-TI-012, Rev. 0, Westinghouse Hanford Company, Richland, Washington (March).

WHC, 1992c, *Phase I Hydrogeologic Summary of the 300-FF-5 Operable Unit, 300 Area*, WHC-SD-EN-TI-052, Rev. 0, Westinghouse Hanford Company, Richland Washington (February).

WHC, 1992d, *Fiscal Year 1991, 100 Areas CERCLA Ecological Investigation*, WHC-EP-0448, Westinghouse Hanford Company, Richland, Washington (April).

WHC, 1992e, *Vascular Plants of the Hanford Site*, WHC-EP-0554, Westinghouse Hanford Company, Richland, Washington (July).

WHC, 1992f, *Status of Birds at the Hanford Site in Southeastern Washington*, WHC-EP-0402, Rev. 1, Westinghouse Hanford Company, Richland, Washington (June).

WHC, 1992g, *A Synthesis of Ecological Data from the 100 Areas of the Hanford Site*, WHC-EP-0601, Westinghouse Hanford Company, Richland, Washington (October).

WHC, 1992h, *Biological Assessment for Rare and Endangered Plant Species Related to CERCLA Characterization Activities*, WHC-EP-0526, Westinghouse Hanford Company, Richland, Washington (April).

WHC, 1992i, *Biological Assessment for State Candidate and Monitor Wildlife Species Related to CERCLA*, WHC-SD-EN-EE-009, Rev. 0, Westinghouse Hanford Company, Richland, Washington (August).

WHC, 1993, *Vegetation Communities Associated with the 100-Area and 200-Area Facilities on the Hanford Site*, WHC-SD-EN-TI-216, Rev. 0, Westinghouse Hanford Company, Richland, Washington (January).

Chapter 5 References

10 CFR 1022, 1979, "Compliance with Floodplain/Wetlands Environmental Review Requirements," *Code of Federal Regulations*, as amended.

29 CFR 1910, 1974, "Occupational Safety and Health Standards," *Code of Federal Regulations*, as amended.

40 CFR 50-99, 1970, "National Primary and Secondary Ambient Air Quality Standards," *Code of Federal Regulations, as amended.*

40 CFR 264, 1980, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.

40 CFR 300, 1990, "National Oil and Hazardous Substances Pollution Contingency Plan," *Code of Federal Regulations*, as amended.

40 CFR 1500-1508, 1978, "Council on Environmental Quality Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act," *Code of Federal Regulations*, as amended.

56 FR 23363, 1991, "U.S. Nuclear Regulatory Commission (NRC) Standards for the Protection Against Radiation," *Federal Register*, Vol. 56, p. 23363 (May 21).

58 FR 178, 1993, "Record of Decision: Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington," *Federal Register*, Vol. 58, p. 178 (September).

59 FR 32, 1994, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," Executive Order 12898, *Federal Register*, White House Office, p. 7629 (February 16).

60 FR 28680, 1995, "Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs," *Federal Register*, Vol. 60, p. 28680 (June 1).

American Indian Religious Freedom Act of 1978, 42 USC 1996, et seq.

Barnes, H. H., Jr., 1967, *Roughness Characteristics of Natural Channels: U.S. Geological Water-Supply Paper 1849*, U.S. Government Printing Office, Washington, D.C.

BHI, 1995, *Draft Baseline Planning Documents*, Bechtel Hanford, Inc., Richland, Washington.

Bolick, B., 1994, personal communication (May), Soil Conservation Service (SCS), U.S. Department of Agriculture, Pasco, Washington.

Brincken, E., 1994, personal communication, Soil Conservation Service (SCS), U.S. Department of Agriculture, Pasco, Washington (May).

Chatters, J. C., 1989, *Hanford Cultural Resources Management Plan*, PNL-6942, Pacific Northwest Laboratory, Richland, Washington.

Clean Water Act of 1977, 33 USC 1251, et seq.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq.

Cushing C. E., 1995, *Hanford Site National Environmental Policy Act* (NEPA) *Characterization*, PNL-6415, Rev. 7, Pacific Northwest Laboratory, Richland, Washington.

DOE, 1990, *Environmental and Molecular Sciences Laboratory at the Hanford Site, Richland, Washington*, DOE/EA-0429, U.S. Department of Energy, Washington, D.C. (September).

DOE, 1991, *Hanford Environmental Compliance Project*, DOE/EA-0383, U.S. Department of Energy, Washington, D.C. (November).

DOE, 1992, *Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington, Environmental Impact Statement*, DOE/EIS-0119F, U.S. Department of Energy, Washington, D.C.

DOE, 1993, *Radiation Protection of the Public and the Environment*, DOE Order 5400.5, U.S. Department of Energy, Washington, D.C.

DOE, 1994a, *Access Road from State Route 240 to the 200 West Area, Hanford Site, Richland, Washington*, DOE/EA-0904, U.S. Department of Energy, Washington, D.C. (March).

DOE, 1994b, *Tank 241-C-106 Past-Practice Sluicing Waste Retrieval, Hanford Site, Richland, Washington,* DOE/EA-0933, U.S. Department of Energy, Washington, D.C. (February).

DOE, 1994c, *Resiting, Construction and Operation of the Environmental and Molecular Sciences Laboratory at the Hanford Site, Richland, Washington*, DOE/EA-0959, U.S. Department of Energy, Washington, D.C.

DOE, 1995a, *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Draft Environmental Impact Statement*, DOE/EIS-02-3-D, U.S. Department of Energy, Idaho Falls, Idaho.

DOE, 1995b, *Deactivation of N Reactor Facilities, Hanford Site, Richland, Washington*, DOE/EA-0984, U.S. Department of Energy, Richland, Washington (May).

DOE, 1995c, *222-S Radioactive Liquid Waste Line Replacement and 219-S Secondary Containment Upgrade, Hanford Site, Richland, Washington*, DOE/EA-0944, U.S. Department of Energy, Washington, D.C. (January).

DOE, 1995d, *Inert/Demolition Waste Landfill (Pit 9) Hanford Site, Richland, Washington*, DOE/EA-0983, U.S. Department of Energy, Washington, D.C. (May).

DOE, 1995e, *Disposition of Alkali Metal Test Loops, Hanford Site, Richland, Washington*, DOE/EA-0987, U.S. Department of Energy, Washington, D.C. (May).

DOE, 1995f, *300 Area Process Sewer Piping Upgrade and 300 Area Treated Effluent Disposal Facility Discharge to the City of Richland Sewer System, Hanford Site, Richland, Washington*, DOE/EA-0980, U.S. Department of Energy, Washington, D.C. (May).

DOE, 1995g, *Shutdown of the Fast Flux Test Facility, 400 Area, Hanford Site, Richland, Washington*, DOE/EA-0993, U.S. Department of Energy, Washington, D.C. (May).

DOE, 1995h, *Relocation and Storage of TRIGA Reactor Irradiated Fuel, Hanford Site, Richland, Washington*, DOE/EA-0985, U.S. Department of Energy, Washington, D.C. (August).

DOE, 1995i, *Management of Spent Nuclear Fuel from the K-Basins at the Hanford Site, Richland, Washington*, DOE/EIS-0245D, U.S. Department of Energy, Washington, D.C.

DOE, 1995j, *Transfer of Plutonium-Uranium Extraction Plant and N Reactor Irradiated Fuel for Storage at the 105-KE and 105-KW Fuel Storage Basins, Hanford Site, Richland, Washington*, DOE/EA-0988, U.S. Department of Energy, Washington, D.C. (July).

DOE and Ecology, 1995, *Preliminary Draft for the Tank Waste Remediation System*, DOE/EIS-0189, U.S. Department of Energy, Washington State Department of Ecology, Richland, Washington (August).

DOE-RL, 1993a, *Hanford Site Baseline Risk Assessment Methodology (HSBRAM)*, DOE/RL-91-45, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993b, *200-East Groundwater Aggregate Area Management Study Report*, DOE/RL-92-19, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1994a, *Remedial Investigation and Feasibility Study Report for the Environmental Restoration Disposal Facility*, DOE/RL-93-99, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1994b, *100 Area Feasibility Study, Phases 1 and 2*, DOE/RL-92-11, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1994c, *1995 Hanford Site Mission Plan, Volume 1, Site Guidance*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1995, "unpublished data from the Human Resources Services Division," Sharon Hall, U.S. Department of Energy, Richland Operations Office, Richland, Washington (July 14).

DOT, 1982, *Noise Barrier Cost Reduction Procedure STAMINA 2.0/OPTIMA: User's Manual*, FHWA-DP-58-1, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C.

Droppo, J. G. Jr., 1991, *Multimedia Environmental Pollutant Assessment System (MEPAS) Application Guidance, Volume 1 - Users Guide and Volume 2 - Guidelines for Evaluating MEPAS Input Parameters*, PNWD-1857, Pacific Northwest Laboratory, Richland, Washington.

Durbin, T. J., 1978, *Calibration of a Mathematical Model of the Antelope Valley Ground-Water Basin, California*, Geological Survey Water Supply Paper 2046, U.S. Geological Survey, Washington, D.C.

Ecology and DOE-RL, 1995, *Environmental Impact Statement, Safe Interim Storage of Hanford Tank Wastes, Hanford Site*, DOE/EIS-0212, Washington State Department of Ecology and U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, as amended, Document No. 89-10, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Washington, D.C.

EG&G, 1993, *Occupational Injury and Property Damage Summary*, DOE/EH/01570-H3, U.S. Department of Energy, Idaho Falls, Idaho (January-June).

Endangered Species Act of 1973, 16 USC 1531, et seq,

EPA, 1985, *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources*, NTIS PB86-124906, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

EPA, 1988a, *Air/Superfund National Technical Guidance Study Series, Volume II – Estimation of Baseline Air Emissions at Superfund Sites*, EPA-450/1-89-002, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina.

EPA, 1988b, *Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake And Air Concentration and Dose Conversion Factors For Inhalation, Submersion And Ingestion*, EPA-520/1-88-020, Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, D.C.

Fitzner, R. E., Weiss, S. G., and Stegen, J. A., 1994, *Biological Assessment for Threatened and Endangered Wildlife Species*, WHC-EP-0513, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Gilmore, T. J., Borghese, J. V., and Newcomer, D. R., 1991, "Letter Report: Evaluation of the Effects of the Columbia River on the Unconfined Aquifer Beneath the 100-N Area/Phase 3," *Evaluations of the Effects of the Columbia River on the Unconfined Aquifer Beneath the 100-N Area*, PNL-7646, Pacific Northwest Laboratory, Richland, Washington.

Hazardous Waste Management Act of 1976, RCW 70.105D, et seq.

IAEA, 1992, *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards*, Technical Reports Series No. 332, International Atomic Energy Agency, Vienna, Austria.

Lindberg, J. W., 1994, *Geology of the McGee Ranch Site, Area B: Phase II Characterization*, WHC-SD-EN-TI-206, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Model Toxics Control Act of 1989, RCW Chapter 70.105D, et seq.

National Environmental Policy Act of 1969, 42 USC 4321, et seq.

NSC, 1993, *Accident Facts, 1993 Edition*, National Safety Council, Itasca, Illinois.

Native American Graves Protection and Repatriation Act of 1990, 25 USC 3001, et seq.

Navy, 1995, *Disposal of Decommissioned, Defueled Cruiser, Los Angeles Class and Ohio Class, Naval Reactor Plants Environmental Impact Statement*, Draft, U.S. Department of Navy, Washington, D.C. (August).

NCRP, 1989, *Comparative Carcinogenicity of Ionizing Radiation and Chemicals*, NCRP 96, National Council on Radiation Protection and Measurements, Bethesda, Maryland.

NCRP, 1991, *Effects of Ionizing Radiation on Aquatic Organisms*, NCRP 109, National Council on Radiation Protection and Measurements, Bethesda, Maryland.

NPS, 1994, *Hanford Reach of the Columbia River, Comprehensive River Conservation Study and Final Environmental Impact Statement-June 1994*, National Park Service, Seattle, Washington.

NSF, 1993, *Environmental Assessment for Construction and Operation of a Laser Interferometer Gravitational-Wave Observatory on the Hanford Site*, National Science Foundation, Richland, Washington.

PNL, 1993, *Hanford Site Environmental Report for Calendar Year 1992*, PNL-8682, Pacific Northwest Laboratory, Richland, Washington.

PNL, 1995, *Hanford Site Environmental Report for Calendar Year 1994*, PNL-10574, Pacific Northwest Laboratory, Richland, Washington.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

Skelly, W. A., 1992, *Characterization Plan for Fine-Textured Soils in the McGee Ranch Site Vicinity*, WHC-SD-EN-AP-051, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

USACE, 1992, *Superconducting Magnetic Energy Storage – Engineering Test Model (SMES-ETM) Environmental Impact Statement*, U.S. Army Corps of Engineers, Mobile, Alabama.

USACE, 1994, *Preconceptual Baseline Cost Estimates for the Remediation of Hanford Past Practices*, U.S. Army Corps of Engineers, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

USBC, 1992, *1990 Census of Population and Housing*, Summary Tape File 3 on CD-ROM, U.S. Department of Commerce, U.S. Bureau of Census, Washington, D.C.

WAC-173-303, 1993, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

WHC, 1994, *Safeguards and Security Program: 1994 Fiscal Year Work Plan*, WHC-SP-1045, Westinghouse Hanford Company, Richland, Washington.

WHC and USACE, 1994a, *100 D&D Subproject Baseline Summary*, Westinghouse Hanford Company U.S. Army Corps of Engineers, Richland, Washington.

WHC and USACE, 1994b, *RARA/UST Subproject Baseline Summary*, Westinghouse Hanford Company and U.S. Army Corps of Engineers, Richland, Washington.

Chapter 6 References

10 CFR 820, 1993, "Procedural Rules for U.S. Department of Energy Nuclear Activities," *Code of Federal Regulations*, as amended.

10 CFR 830.120, 1994, "Quality Assurance Requirements," *Code of Federal Regulations*, as amended.

10 CFR 834, 1993, "Radiation Protection of the Public and the Environment" (proposed), *Code of Federal Regulations*, as amended.

10 CFR 835, 1993, "Occupational Radiation Protection," *Code of Federal Regulations*, as amended.

10 CFR 1021, 1992, "Compliance with the National Environmental Policy Act (DOE)," *Code of Federal Regulations*, as amended.

10 CFR 1022, 1979, "Compliance with Floodplain/Wetlands Environmental Review Requirements," *Code of Federal Regulations*, as amended.

40 CFR 1500-1508, 1978, Regulations for Implementing the Procedural Provisions of the National EPA (CEQ), *Code of Federal Regulations*, as amended.

American Antiquities Preservation Act of 1906, 16 USC 431, et seq.

American Indian Religious Freedom Act of 1978, 42 USC 1996, et seq.

Anadromous Fish Conservation Act of 1965, Public Law 89-304, as amended.

Archaeological Resources Protection Act of 1979, 16 USC 470aa, et seq.

Atomic Energy Act of 1954, 42 USC 2011, et seq.

Bald and Golden Eagle Protection Act of 1972, 16 USC 668-668d, et seq.

Clean Air Act of 1970, 42 USC 7401, et seq.

Clean Water Act of 1977, 33 USC 1251, et seq.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq.

Emergency Planning and Community Right-to-Know Act of 1986, 42 USC 11001, et seq.

Endangered Species Act of 1973, 16 USC 1531, et seq.

Executive Order 11514, *Protection and Enhancement of Environmental Quality*, issued May 24, 1977

Executive Order 11593, *National Historic Preservation*, issued May 13, 1971

Executive Order 11988, *Floodplain Management*, issued May 24, 1977

Executive Order 11990, *Protection of Wetlands*, issued May 24, 1977

Executive Order 12088, *Federal Compliance with Pollution Control Standards*, issued October 13, 1978

Executive Order 12344, *Naval Nuclear Propulsion Program*, issued February 1, 1982 (see also Public Law 98-525).

Executive Order 12580, Superfund Implementation, issued January 23, 1987

Executive Order 12856, *Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements*, issued August 3, 1993

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations*, issued February 11, 1994

Farmland Protection Policy Act of 1981, 7 USC 4201 to 4209, et seq.

Federal Facilities Compliance Act of 1992, 42 USC 6901, et seq.

Federal Insecticide, Fungicide, and Rodenticide Act of 1975, 7 USC 136, et seq.

Federal Water Pollution Control Act of 1948, as amended.

Fish and Wildlife Coordination Act of 1934, 16 USC 661, et seq.

Hazardous and Solid Waste Amendments of 1984, 42 USC 6901, et seq.

Migratory Bird Treaty Act of 1918, 16 USC 703, et seq.

National Environmental Policy Act of 1969, 42 USC 4321, et seq.

National Historic Preservation Act of 1966, 16 USC 470, et seq.

Native American Graves Protection and Repatriation Act of 1990, 25 USC 3001, et seq.

Noise Control Act of 1972, 42 USC 4901 to 4918, et seq.

Noise Pollution and Abatement Act of 1970, 42 USC 1858, et seq.

Nuclear Waste Policy Act of 1982, 42 USC 10101-10270, et seq.

Occupational Safety and Health Act of 1970, 29 USC 651, et seq.

Pollution Prevention Act of 1990, 42 USC 13101, et seq.

Religious Freedom Restoration Act of 1993, 42 USC 2000bb, et seq.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

Safe Drinking Water Act of 1974, 42 USC 300(f), et seq.

Solid Waste Disposal Act of 1965, 42 USC 3251 to 3259, et seq.

State Environmental Policy Act of 1971, RCW Chapter 43.21C, et seq.

Superfund Amendments and Reauthorization Act of 1986, 42 USC 9671, et seq.

Toxic Substances Control Act of 1976, 15 USC 2601-2671, et seq.

WAC 173-303, 1995, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

WAC 173-460, 1991, "Controls for New Sources of Toxic Air Pollutants," *Washington Administrative Code*, as amended.

WAC 173-480, 1986, "Ambient Air Quality Standards and Emission Limits for Radionuclides," *Washington Administrative Code*, as amended.

WAC 197-11, 1984, "State Environmental policy Act," *Washington Administrative Code*, as amended.

WAC 246-247, 1994, "Radiation Protection--Air Emissions," *Washington Administrative Code*, as amended.

Washington Clean Air Act of 1991, RCW Chapter 70.94, et seq.

Washington Growth Management Act of 1989, RCW 36.70A, et seq.

Washington Hazardous Waste Management Act of 1976, RCW Chapter 70.105, et seq.

Washington Model Toxics Control Act of 1989, RCW Chapter 70.105D, et seq.

Washington Water Pollution Control Act of 1945, RCW 90.48, et seq.

Water Quality Act of 1987, 33 USC 1251, et seq.

Water Resources Planning Act of 1965, 42 USC 1962, et seq.

Wild and Scenic Rivers Act of 1968, 16 USC 1271, et seq., 71:8301, et seq.