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Draft Hanford Remedial Action Environmental Impact Statement and Comprehensive Land Use Plan

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Title: *Draft Hanford Remedial Action Environmental Impact Statement and Comprehensive Land Use Plan*

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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 determined 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* and the *Resource Conservation and Recovery Act of 1976.*

To facilitate the establishment of future land-use objectives, the Hanford Site was divided into four geographic areas: (1) Columbia River, (2) Reactors on the River, (3) Central Plateau, (4) All Other Areas. The future land-use alternatives considered in detail 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: The Draft Environmental Impact Statement is available for review and comment on the internet at http://www.hanford.gov/eis/hraeis/hraeis.htm. A Public Hearing on the Draft Environmental Impact Statement will be announced in August of 1996. Written and oral comments on the Draft Environmental Impact Statement will be accepted until November 1, 1996, at the Washington State addresses or internet address provided above. The U.S. Department of Energy will consider these public comments in preparing the Final Environmental Impact Statement.

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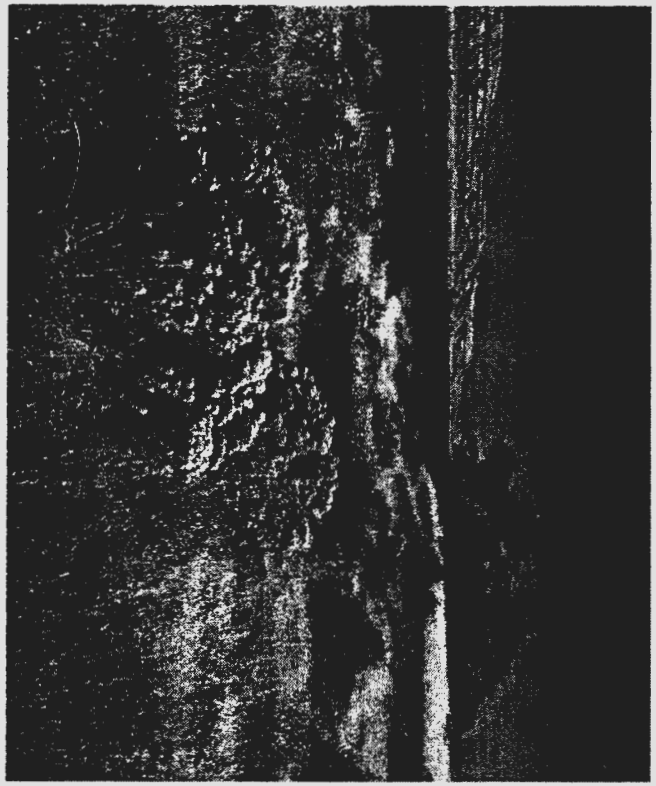

Acronyms and Helpful Information

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Acronyms and Initialisms

219-S	219-S Waste Handling Facility
222-S	222-S Laboratory
ACGIH	American Conference of Government Industrial Hygienists
AEA	*Atomic Energy Act of 1954*
AEC	U.S. Atomic Energy Commission
ALARA	As Low As Reasonably Achievable
ALE	Fitzner/Eberhardt Arid Lands Ecology (Reserve)
BCM	bank cubic meter
BCY	bank cubic yard
BHI	Bechtel Hanford, Inc.
BLM	Bureau of Land Management
BOR	Bureau of Reclamation
BPA	Bonneville Power Administration
Bq	becquerel
CAA	*Clean Air Act of 1970*
CBC	Columbia Basin College
CEQ	Council on Environmental Quality
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
Ci	curies
Corps	U.S. Army Corps of Engineers
CWA	*Clean Water Act of 1977*
DCG	derived concentration guide
DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
DST	double-shell tank
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
EMSL	Environmental and Molecular Sciences Laboratory
EPA	U.S. Environmental Protection Agency
EPZ	Emergency Planning Zone
ER	Environmental Restoration
ERDA	U.S. Energy Research and Development Administration
ERDF	Environmental Restoration Disposal Facility
EUZ	Exclusive Use Zone
Federal CAAA	*Federal Clean Air Act Amendments of 1990*
FFCA	*Federal Facilities Compliance Act of 1992*
FFTF	Fast Flux Test Facility
FONSI	Finding of No Significant Impact
FR	*Federal Register*
FTE	full-time equivalent
GIS	geographic information system

GMA	*Washington Growth Management Act of 1990*
HA	Hazard Assessment
HAMMER	Hazardous Materials Management and Emergency Response (Facility)
Hanford Reach	Hanford Reach of the Columbia River
HAP	hazardous air pollutant
HSRAM	*Hanford Site Risk Assessment Methodology*
HI	Hazard Index
HLW	high-level waste
HMS	Hanford Meteorological Station
HRA-EIS	*Hanford Remedial Action Environmental Impact Statement and Comprehensive Land Use Plan*
HSWA	*Hazardous and Solid Waste Amendments of 1984*
IAEA	International Atomic Energy Agency
ILCR	incremental lifetime cancer rate
IP	Implementation Plan
LCF	latent cancer fatality
LCM	loose cubic meter
LCY	loose cubic yard
LIGO	Laser Interferometer Gravitational-Wave Observatory
LLMW	low-level mixed waste
LLW	low-level waste
MAP	Mitigation Action Plan
MEI	maximally exposed individual
MCL	maximum contaminant level
MEPAS	Multimedia Environmental Pollutant Assessment System
MMI	Modified Mercalli Intensity
MOA	Memorandum of Agreement
MTCA	*Model Toxics Control Act of 1989*
NAAQS	National ambient air quality standards
National Register	*National Register of Historic Places*
N Reactor	105-N Reactor
NCRP	National Council on Radiation Protection and Measurements
NEPA	*National Environmental Policy Act of 1969*
NHPA	*National Historic Preservation Act of 1966*
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPPC	Northwest Power Planning Council
NRC	U.S. Nuclear Regulatory Commission
NRCS	National Resource Conservation Service (until recently, known as the soil conservation service)
NWR	National Wildlife Refuge
OSHA	*Occupational Safety and Health Act of 1970*
PCB	polychlorinated biphenyl
PEL	permissible exposure limit
PFP	Plutonium Finishing Plant
PFP-EIS	*Plutonium Finishing Plant Environmental Impact Statement*
PM_{10}	particulate matter nominally 10 microns or less
PNNL	Pacific Northwest National Laboratory (until October 1995, known as Pacific Northwest Laboratory or PNL)

1	PPA	*Pollution Prevention Act of 1990*
2	PSD	Prevention of Significant Deterioration
3	PUREX	Plutonium-Uranium Extraction
4	R&D	Research and Development
5	RCRA	*Resource Conservation and Recovery Act of 1976*
6	RI/FS	Remedial Investigation/Feasibility Study
7	RL	U.S. Department of Energy, Richland Operations Office
8	ROD	Record of Decision
9	SAR	Safety Analysis Report
10	SARA	*Superfund Amendments and Reauthorization Act of 1986*
11	SEPA	*State Environmental Policy Act of 1971*
12	SHPO	Washington State Historic Preservation Office
13	SI	International System of Units
14	SMES-ETM	Superconducting Magnetic Energy Storage - Engineering Test Model

Helpful Information

Definition of Terms

100-Year Flood. A flood event of a magnitude that occurs, on average, once every 100 years, and equates to a 1-percent probability of occurring in any given year.

500-Year Flood. A flood event of a magnitude that occurs, on average, once every 500 years, and equates to a 0.2-percent probability of occurring in any given year.

Absorbed Dose. The energy imparted by ionizing radiation per unit mass of irradiated material. The unit of absorbed dose is the rad.

Acute Exposure. A single exposure to a toxic or radioactive substance that may result in severe biological harm or death. Acute exposures normally are characterized as lasting no longer than one day.

Affected Environment. In an Environmental Impact Statement, a description of the existing environment covering information that directly relates to the scope of the proposed action and alternatives that are analyzed in the impact analysis. The Affected Environment provides a baseline and must include sufficient detail to support the impact analysis, including cumulative impacts. Environmentally sensitive resources, such as Floodplains and wetlands, threatened and endangered species, prime and unique agricultural lands, and historic and cultural resources, must be identified.

Air Quality Standards. Legally prescribed levels of constituents in the ambient air that cannot be exceeded during a specific time in a specific area.

ALARA. See As Low as Reasonably Achievable.

Alpha-Emitter. A radioactive substance that decays by releasing an alpha particle.

Alpha Low-Level Waste. Waste that was previously classified as transuranic waste, but has a transuranic concentration lower than the currently established limit for transuranic waste.

Alpha Particle. A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. An alpha particle is identical to a helium nucleus that has a mass number of 4 and an electrostatic charge of +2.

Alternative. In an Environmental Impact Statement, one of a range of reasonable means of accomplishing the purpose and need identified by the agency. Reasonable alternatives must be practical or feasible from a common sense, technical, and economic standpoint. In addition, the *National Environmental Policy Act of 1969* requires evaluation of a "No Action" alternative.

Anadromous Fish. Fish that migrate from the ocean or sea up a river to spawn (e.g., salmon and some species of trout).

Anticline. A fold in the rock structure with strata sloping downward on both sides from a common crest; opposite of syncline.

Aquifer. A saturated, permeable geologic formation that contains and is capable of transmitting water.

Aquitard. Less-permeable beds in a stratigraphic sequence that tend to impede the movement of water in an aquifer.

As Low As Reasonably Achievable (ALARA). Provides an approach to manage and control exposures to hazardous or radiological materials. ALARA is not a dose limit but a process which has the objective of attaining doses as far below the applicable limits as is reasonably achievable.

Atmospheric Stability. A measure of the amount of mixing and turbulence in the atmosphere.

Attainment Area. Any area that is designated, pursuant to 42 USC 7407(d) of the *Clean Air Act of 1970*, as having ambient conditions equal to or less than national primary or secondary ambient air quality standards for a particular air pollutant or a group of air pollutants.

Background Radiation. Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material); consumer products containing nominal amounts of radioactive material or producing nominal amounts of radiation; and global fallout that exists in the environment (e.g., from the testing of nuclear explosive devices).

Bank Cubic Meters/Yard. The volume of material at an excavation site prior to excavation (i.e., in the bank).

Barrier. Manmade components of a waste management system designed to prevent or impede the release of radionuclides or other contaminants to the biosphere. Barriers can include the waste form, waste container, and materials placed over, under, or around these containers or wastes. For example, an engineered cap constructed over a waste site is a barrier.

Basalt. A dark grey to black, fine grained igneous rock composed primarily of calcium feldspar and pyroxene, with or without olivine. This material underlies the Hanford Site, and may be quarried for use as riprap in the construction of caps to prevent the migration of contaminants in surface soils and burial grounds by preventing infiltration of precipitation.

Benthic. Living on or at the bottom of a body of water.

Biodiversity. The diversity of ecosystems, species, and genes, and the variety and variability of life. Biodiversity also is a qualitative measure of the richness and abundance of ecosystems and species in a given area.

Bounding. Represents the maximum reasonably foreseeable event or impact. All other reasonably foreseeable events or impacts would have fewer and/or less severe environmental impacts.

Buffer Zone. An area designated to separate and/or protect human health and safety. In the context of this EIS, buffer zones in which access is restricted would be maintained around disposal sites and active facilities to protect public health and safety.

By-Product Material. Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or utilizing special nuclear material. The tailings or wastes produced by the extraction and/or concentration of uranium or thorium from any ore processed primarily for its source material content. By-product material is exempt from regulation under the *Resource Conservation and Recovery Act of 1976.*

Candidate Species. A plant or animal species that is under consideration by the U.S. Fish and Wildlife Service or Washington Department of Fish and Wildlife for listing as either Threatened or Endangered.

Cap. Construction of an engineered barrier over the top of a waste site in order to prevent or impede the release of radionuclides or other waste material into the environment.

Carcinogen. Any substance or agent that is capable of producing cancer.

Characterization. The determination of contaminants at a waste site by review of process knowledge, nondestructive examination or assay, or sampling and analysis. Characterization is generally undertaken to determine appropriate remedial action and appropriate waste storage, treatment, handling, transportation, and disposal requirements.

Chronic Exposure. The absorption or intake of hazardous material over a long period of time (e.g., over a lifetime).

Class I Area. Under the *Clean Air Act of 1970*, the designation applies to pristine areas, such as national parks and wilderness areas, where substantial growth is effectively precluded in order to avoid degradation of air quality. Goat Rocks Wilderness Area is the closest Class I area to the Hanford Site, located approximately 90 miles northwest.

Class II Area. A designation for areas under the *Clean Air Act of 1970* where moderate degradation of air quality is permissible. The Hanford Site and its immediate vicinity are in a Class II Area.

Closure. Deactivation, stabilization, and surveillance of a waste management unit, landfill, or other facility. Closure often refers to the process under the *Resource Conservation and Recovery Act of 1976* involving the preparation and approval of a closure plan.

Cofferdam. A temporary watertight enclosure constructed in water-logged soil or under water and pumped dry so that construction or repairs (or remediation) can proceed under normal conditions.

Cold War. Intense economic, political, military, and ideological rivalry between nations just short of military conflict. Major expansions in the production of nuclear materials for military applications were undertaken at the Hanford Site so that the Nation could maintain an overwhelming arsenal of nuclear weapons. In the context of this EIS, the Cold War refers to the period from the end of World War II to 1989 (when the Berlin Wall was dismantled).

Collective Dose. The sum of total effective dose equivalents of all individuals in a specified population. Collective dose is expressed in units of person-rem.

Committed Dose Equivalent. The dose equivalent to organs or tissues that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

Confined Aquifer. An aquifer bounded above and below by less permeable layers. Groundwater in the confined aquifer is under a pressure greater than atmospheric pressure.

Controlled Area. An area to which access is controlled to protect individuals from exposure to radiation or radioactive and/or hazardous materials.

Contamination. The presence of unwanted radioactive and/or hazardous materials above background concentrations in environmental media (air, soil, water) or on the surfaces of structures, objects, or personnel.

Criteria Pollutants. Substances for which national ambient air quality standards have been established by the EPA.

Critical Habitat. Any air, land, or water area determined (through a regulatory action under the *Endangered Species Act of 1973*) to be essential to the survival of a population of an endangered or threatened species or habitat deemed to be necessary for the recovery of a threatened or endangered species. Critical habitat has not been designated on the Hanford Site.

Cumulative Impact. The impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably-foreseeable, future actions. Cumulative impacts can result from individually minor, but collectively significant actions taking place over a period of time.

Cultural Resources. Areas or objects that are of cultural significance to human history at the national, state, or local level. Generally includes archaeological, historic, and prehistoric resources, as well as resources of traditional use or religious value to Native Americans.

Curie (Ci). The basic unit used to describe the intensity of radioactivity in a sample of material. One curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of 1 gram of radium. A curie also is the quantity of any radionuclide that decays at a rate of 37 billion disintegrations per second.

Dangerous Waste. Those solid wastes designated in *Washington Administrative Code* 173-303-070 through 173-303-100 as dangerous, or extremely hazardous, or mixed waste.

Decay, Radioactive. A decrease in the amount of any radioactive material with the passage of time caused by the spontaneous emission from the atomic nuclei of either alpha or beta particles, which are often accompanied by gamma radiation (see also half-life, radioactive).

Decommissioning. The process of removing a facility from operation, followed by decontamination, entombment, dismantlement, or conversion to another use.

Decontamination. The actions taken to reduce or remove substances that pose a substantial present or potential hazard to human health or the environment, (e.g., removing radioactive contamination from facilities, soil, or equipment by washing, chemical action, mechanical cleaning, or other techniques).

Defense Waste. Radioactive waste from any activity performed in whole or in part in support of U.S. Department of Energy atomic energy defense activities; excludes waste from U.S. Department of Energy nondefense activities, waste under the purview of the U.S. Nuclear Regulatory Commission, or waste generated by the commercial nuclear power industry.

DOE Orders. Requirements internal to the U.S. Department of Energy that establish agency policy and procedures, including procedures for compliance with applicable laws.

Derived Concentration Guides. Concentrations of radionuclides in air and water that an individual could continuously consume, inhale, or be immersed in at average annual rates without receiving an effective dose equivalent greater than 100 mrem/yr.

Disposal. Emplacement of waste in a manner that ensures protection of human health and the environment within prescribed limits for the foreseeable future with no intent of retrieval, and that requires deliberate action to regain access to waste.

Dose (or radiation dose). A generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent. Relates to a chemical to which an organism is exposed; generally denotes the quality of radiation or energy that is absorbed by the organism.

Dose Conversion Factor. Any factor used to change an environmental measurement to dose in units of concern.

Ecosystem. The interacting system of a biological community and its physical environment, considered as a unit in nature.

Effective Dose Equivalent (EDE). The sum of the products of the dose equivalents to the organ or tissue and the weighing factors applicable to each of the irradiated body organs or tissues. The EDE includes the dose from radiation sources internal and/or external to the body, and is expressed in units of roentgen-equivalent man (rem).

Effective Porosity. Interconnected pore volumes that permit the flow of water in a porous medium.

Emergency Planning Zone. 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 and public health and safety in the event of an operational emergency.

Emission Standards. Legally enforceable limits on the quantities and/or kinds of air pollutants that can be emitted into the atmosphere.

Endangered Species. Animals, birds, fish, plants, or other living organisms threatened with extinction by man-made or natural changes in their environment. Requirements for declaring a species endangered are contained in the *Endangered Species Act of 1973*.

Environmental Justice. The fair treatment of people of all races, cultures, and income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Executive Order 12898 required federal agencies to identify and address any potentially disproportionately high and adverse human health and environmental effects of agency policies, programs, and activities on minority and low-income populations.

Evapotranspiration. The combined processes by which water is transferred from the surface of the Earth to the atmosphere, including evaporation of liquid or solid water, and transpiration from plants.

Exclusive Land Use. A remediation scenario under which potential health risks limit use and require strict control 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 DOE. Exclusive use areas could include buffer zones around active facilities.

Exclusive Use Zone. An area around a facility extending from the facility fence line to a point where the threat posed to the public from routine and accidental releases diminishes to the point where routine public access can be allowed.

Exposure Scenario. A set of facts, assumptions, and inferences about how exposure takes place that aids the exposure assessor in evaluating, estimating, or quantifying exposures.

Facility Area. An area within the Hanford Boundary immediately surrounding a facility or group of facilities that functions under process safety management and a common emergency response plan.

Feasibility Study (FS). A step in the environmental restoration process specified by the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*. The objectives of the FS are to identify alternatives for remediation and describe a remedial action that satisfies applicable or relevant and appropriate requirements for mitigating confirmed environmental contamination. The FS presents a series of specific engineering or construction alternatives for remediating a site. A detailed analysis is presented for each alternative and includes costs, effects, engineering feasibility, and environmental impacts. The FS is based on information provided in the remedial investigation. Successful completion of an FS should result in a Record of Decision, which selects a remedial action alternative and subsequent development of a remedial design for implementation of the selected remedial action.

Fission Products. The lighter atomic nuclides (fission fragments) formed by the fission of heavy elements; also refers to the nuclides formed by radioactive decay of the fission fragments.

Floodplain. The portion of a river valley that becomes covered with water when the river overflows its banks at flood stage.

Food Chain. The pathways by which any material entering the environment passes from the first absorbing organism through plants and animals, including humans.

Fugitive Dust. The particulate matter that is stirred up and released into the atmosphere during excavation or construction activities.

Gamma-Emitter. A radioactive substance that decays by releasing gamma radiation.

Gamma Radiation. A high energy, short wavelength electromagnetic radiation (a packet of energy) emitted from the nucleus. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating, and are best stopped by dense materials, (e.g., lead or uranium). Gamma rays are similar to x-rays, but are usually more energetic.

Geologic Repository. A deep (greater than 600 m), underground mined array of tunnels used for the disposal of radioactive waste or spent nuclear fuel. A geologic repository includes the geologic repository operations area and the portion of the geologic setting that provides isolation.

Groundwater. The supply of water below the land surface in the zone of saturation.

Groundwater Mounds. A hydrologic condition, often caused by artificial recharge of an aquifer, in which "mounds" of groundwater are created. These mounds have been known to alter the natural hydraulic gradients and drainage patterns of an aquifer. The pressure and weight of the groundwater mounds can increase the hydrostatic head so that all nearby groundwater, and any associated contaminant plume, could move more rapidly toward a receptor.

Grouting. The process of immobilizing or fixing solid or liquid forms of waste to enable safe storage or disposal. Generally, grout is a fluid mixture of cementitious materials and waste that sets up as a solid mass.

Half-life. The time in which half the atoms of a particular radioactive substance disintegrate to a different nuclear form. Used as a measure of the persistence of radioactive materials; each radionuclide has a characteristic, constant half-life. Measured half-lives vary from millionths of a second to billions of years.

Hanford Federal Facility Agreement and Consent Order. A binding agreement, negotiated pursuant to Section 120 of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980,* and other regulations signed by DOE, the U.S. Environmental Protection Agency Region 10, and the State of Washington Department of Ecology, to organize responsibilities for remediation of the Hanford Site and to establish milestones by which the remediation will be accomplished. Normally referred to as the Tri-Party Agreement, this agreement commits the three agencies to a long-term cooperative program to remediate the contaminated sites at Hanford. The Tri-Party Agreement contains a blueprint for remediation and uses enforceable milestones to keep the program on schedule.

Hazard Classification. A safety classification based on potential onsite consequences. Criteria for this classification are discussed in DOE Order 5480.23 (Nuclear Safety Analysis Reports).

Hazardous Air Pollutant. Any air pollutant subject to a standard promulgated under 42 USC Section 7412 or other requirements established under 42 USC Section 7412 of the Clean Air Act, including 42 USC Section 7412 (g), (j), and (r) to the Clean Air Act. The State of Washington regulates similar pollutants as "toxic air pollutants." However, state regulations apply only to new sources; Federal regulations apply to new and existing sources. The list of chemicals regulated by the state overlaps with the Federal list, but is considerably longer.

Hazardous Material. A substance or material, including a hazardous substance, that has been determined by the U. S. Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce.

Hazardous Substance. Any substance that, when released to the environment in an uncontrolled or unpermitted fashion, becomes subject to the reporting and possible response provisions of the *Clean Water Act of 1977* and the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*

Hazardous Waste. Those wastes that are identified as hazardous pursuant to 40 CFR 261.

High-Efficiency Particulate Air (HEPA) Filter. A filter with an efficiency of at least 99.95 percent that is used to separate particles from exhaust streams prior to release into the atmosphere.

High-Level Waste. The highly radioactive waste material that results from processing or reprocessing spent nuclear fuel, including liquid waste produced directly from reprocessing and any solid waste derived from the liquid that contains a combination of transuranic and fission product nuclides in quantities that require permanent isolation. High-level waste may include other highly radioactive material that the U.S. Nuclear Regulatory Commission, consistent with existing law, determines by rule to require permanent isolation.

Historic Resources. The sites, districts, structures, and objects that are considered limited and nonrenewable because of an association with historic events, persons, or social or historic movements.

Hydraulic Conductivity. The capacity of a porous medium to transport water. The parameter relating the volumetric flux to the driving force in flow through a porous medium (particularly water through soil); a function of both the porous medium and the properties of the fluid.

Hydraulic Gradient. The slope of the water table.

Impact. The effect, influence, alteration, or imprint of an action. Impacts may be beneficial or detrimental.

Inadvertent Intrusion. The inadvertent or unanticipated disturbance of a disposal facility by a person that could result in the release of contaminants or waste or exposure of personnel.

Infrastructure. The basic facilities, equipment, utilities, and installations supporting the function of a system.

Institutional Control. Control of waste management facilities through human institutions. Institutional controls include such measures as access restrictions, deed restrictions, or restrictions on activities or site uses.

Interim Action (CERCLA). A remedial action undertaken to clean up or contain a potential threat to human health and the environment that can or should be addressed in a short time frame. The study associated with an interim action may be completed within an "umbrella" remedial investigation/feasibility study. Interim actions are completed on an accelerated schedule and generally deal with well-defined contamination problems that present a significant, although not immediate, threat to human health and the environment.

Interim Action (NEPA). An action that may be undertaken while work on a required program EIS is in progress, and the action is not covered by an existing program statement. An interim action may not be undertaken unless such action: (a) is justified independently of the program; (b) is itself accompanied by an adequate EIS or has undergone other NEPA review; and (c) will not prejudice the ultimate decision on the program (i.e., interim action prejudices the ultimate decision on the program when the action tends to determine subsequent development or limits alternatives).

Ion Exchange. The reversible interchange of ions of like charge within a medium.

Isotope. A variation of an element that has the same atomic number but a different number of neutrons in the nucleus. Thus, carbon-12, carbon-13, and carbon-14 are isotopes of the element carbon. Isotopes have nearly the same chemical properties, but often have different physical properties (e.g., carbon-12 and carbon-13 are stable and carbon-14 is radioactive).

Land-Use Planning. A decisionmaking process to determine the future or end use of a parcel of land, considering such factors as current land use, public expectations, cultural considerations, local ecological factors, legal rights and obligations, technical capabilities, and cost.

Latent Cancer Fatalities. Deaths occurring at later years from radiation-induced cancers.

Leachate. The solution formed after percolation of a solvent through a material.

Life Cycle Costs. All costs, except the cost of personnel occupying a facility, from the time that the space requirement is defined until the facility passes out of government hands.

Loose Cubic Meters/Yards. The volume of unconsolidated excavated material.

Low-Level Waste. Waste that contains radioactivity and is not classified as high-level waste, transuranic waste, or spent nuclear fuel. Test specimens of fissionable material irradiated for research and development, and not for the production of power or plutonium, may be classified as low-level waste if the concentration of transuranic elements is less than 100 nanocuries per gram of waste. The U. S. Department of Energy, U. S. Environmental Protection Agency, and U.S. Nuclear Regulatory Commission share the responsibility for managing low-level waste.

Manhattan Project. The code name for the large-scale national project that developed the first atomic bomb.

Maximally Exposed Individual (MEI). An hypothetical person who lives near the Hanford Site who, by virtue of location and living habits, could receive the highest possible radiation dose.

Maximum Contaminant Level (MCL). Under the *Safe Drinking Water Act of 1974*, the maximum permissible concentrations of specific constituents in drinking water that is delivered to any user of a public water system that serves 15 or more connections and 25 or more people. The standards take into account the feasibility and cost of attaining the standard. In this EIS, MCLs are referred to as *Drinking Water Standards*.

Milestone. An important or critical event that must occur in order to achieve the objectives of the Tri-Party Agreement.

millirem (mrem). One thousandth (10^{-3}) of a rem (see also, rem).

Mitigation. Those actions that avoid impacts altogether, minimize impacts, rectify impacts, reduce or eliminate impacts, or compensate for impacts.

Mixed Waste. Waste containing both radioactive and hazardous components as defined by the *Atomic Energy Act of 1954* and the *Resource Conservation and Recovery Act of 1976*, respectively.

National Ambient Air Quality Standards (NAAQS). Air quality standards established by the *Clean Air Act of 1970*. Primary NAAQS are intended to protect public health with an adequate margin of safety. Secondary NAAQS are intended to protect the public welfare from any known or anticipated adverse effects of a pollutant.

National Environmental Research Parks. Outdoor laboratories set aside for ecological research to study the environmental impacts of energy developments and for informing the public of environmental and land use options. The parks were established under the U.S. Department of Energy to provide protected land areas for research and education in the environmental sciences and to demonstrate the environmental compatibility of energy technology development and use.

National Priorities List (NPL). A formal listing of the most hazardous waste sites in the nation, as established under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, that have been identified for remediation.

National Register of Historic Places. A list maintained by the National Park Service of architectural, historic, archaeological, and cultural sites of local, state or national significance.

Nearest Public Access Location. For facility accident analysis, the location of the nearest point where members of the public could be present, such as on an uncontrolled public highway that crosses the Hanford Site.

Nitrogen Oxides (NO_x). Gases formed from atmospheric nitrogen and oxygen when combustion takes place under high temperature and high pressure. Nitrogen oxides include nitric oxide (NO) and nitrogen dioxide (NO_2). Nitrogen oxides are considered to be a major air pollutant and are regulated under the Clean Air Act. In the presence of sunlight, nitric oxide combines with atmospheric oxygen to form nitrogen dioxide, which can cause lung damage at high concentrations.

Nonattainment Area. An area which is shown by monitoring data to exceed any national primary or secondary ambient air quality standard for a pollutant.

NO_x. A generic term used to describe oxides of nitrogen (see nitrogen oxides).

Nuclear Fuel. Materials that are fissionable and can be used in nuclear reactors for the production of energy.

Nuclide. A generic term referring to all known isotopes, both stable and unstable, of the chemical elements.

Offsite. Any place outside the Hanford Site boundary.

Onsite. Within the Hanford Site boundary.

Operable Unit. A discrete set of one or more release sites that are considered together for assessment and remedial activities. Criteria for placement of release sites into an operable unit include geographic proximity, similarity of waste characteristics and site types, and the possibilities for economy of scale.

Outfall. The end of a drain or pipe that carries waste water or other effluents into a ditch, pond, or river.

Past-Practice Waste Sites. Sites previously used for disposal of radioactive and/or hazardous wastes by means that may no longer be considered to be environmentally acceptable methods of disposal.

Permeability. The degree of ease with which water can pass through a rock or soil.

Person-rem. The unit of collective radiation dose applied to populations or groups of individuals. The product of the average individual dose in a population multiplied by the number of individuals in the population.

Physiographic Province. An extensive portion of the landscape, normally encompassing many hundred square miles, which portrays similar qualities of soil, rock, shape, and vegetation of the same geomorphic origin.

Plume. The cloud of a pollutant in air, surface water, or groundwater formed after the pollutant is released from a source.

Plutonium. A manmade fissile element. Pure plutonium is a silvery metal that is heavier than lead. Plutonium-239 has a half-life of 24,000 years.

PM-10. All particulate matter in the ambient air with an aerodynamic diameter less than or equal to ten (10) micrometers.

Polychlorinated Biphenyls (PCB). A class of chemical substances formerly manufactured for use as an insulating fluid in electrical equipment. These chemical substances are highly toxic to aquatic life, persist in the environment, and accumulate in animal tissues.

Population Dose. The overall dose to the offsite population, also known as collective dose.

Porosity. The ratio of the volume of pores of a material to the volume of its mass.

Prehistoric Resources. All evidence of human activity that pre-dates recorded history and can be used to reconstruct lifeways and cultural history of past peoples, including artifacts and the contexts in which the artifacts occur.

Probable Maximum Flood. The largest flood for which there is any reasonable expectancy in a specific area. The probable maximum flood is normally several times larger than the largest flood of record.

Process Knowledge. The set of information used by trained and qualified individuals who are cognizant of the origin, use, and location of waste-generating materials and processes in sufficient detail to certify the identity of the waste.

Processing (of irradiated nuclear fuel). Applying a chemical or physical process designed to alter the characteristics of the nuclear fuel matrix or to recover a particular material.

Production Reactor. A nuclear reactor that is used to irradiate target material to produce special nuclear material or by-product material.

Public. Anyone outside the U.S. Department of Energy site boundary during normal operations or at the time of an accident.

PUREX. An acronym for Plutonium-Uranium Extraction, the name of the chemical process used to reprocess spent nuclear fuel and irradiated targets. Often refers to the Hanford PUREX Facility, where this extraction process was implemented.

rad. The unit of absorbed dose of ionizing radiation. One rad is equal to an absorbed dose of 100 ergs/gram.

Radiation (ionizing radiation). Alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. In the context of this EIS, radiation does not include nonionizing radiation such as radiowaves, microwaves, or visible, infrared, or ultraviolet light.

Radioactive Waste. Any waste which contains radioactive material in concentrations that exceed those listed in 10 CFR 20.

Radioisotope. An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation in the process. Approximately 5,000 natural and artificial radioisotopes have been identified. Usually synonymous with *radionuclide*.

Raptor. A bird of prey (hawk, eagle, etc.).

Recharge. Replenishment of water to an aquifer.

Record of Decision (ROD). A public document that records the final decision(s) concerning a proposed action. The ROD is based in whole or in part on information and technical analysis generated either during the CERCLA process or the NEPA process, both of which consider public comments and community concerns during the decisionmaking process.

Redd. The spawning ground or nest of various fish species; the term usually refers to salmon nests.

Region of Influence. The region in which the direct and indirect principal socioeconomic and environmental justice effects of actions are likely to occur and are expected to be of consequence to local jurisdictions.

rem. The dosage of ionizing radiation that will cause the same biological effect as 1 roentgen of x-ray or gamma ray exposure. Acronym for roentgen-equivalent man.

Remedial Investigation (RI). The *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* process of determining the extent of hazardous substance contamination and, as appropriate, conducting treatability investigations. The RI provides the site-specific information required to develop remedial action alternatives in the feasibility study (FS).

Remediation. The process of remediating a site where a release of a hazardous substance has occurred.

Reprocessing (of nuclear fuel). Processing of reactor irradiated nuclear material (primarily spent nuclear fuel) to recover fissile and fertile material, in order to recycle the materials, primarily for defense purposes. Historically, reprocessing has involved aqueous chemical separations of desired elements (typically uranium or plutonium) from undesired elements in the fuel.

Restricted Land Use. A remediation scenario under which residual contamination precludes some human uses. Restrictions could apply to surface soils, subsurface soils, surface water, or groundwater.

Retrieval. The process of recovering wastes that have been stored or disposed, so that the wastes may be appropriately characterized, treated, and disposed.

Reverse-well Injection. Process in which solutes are injected in an underlying geologic formation through wells. During the early years of Hanford, waste solutions were pumped into reverse wells as a method of waste disposal.

Riparian Habitat. A specialized form of wetland restricted to areas along, adjacent to, or contiguous with perennially flooded and intermittently flowing rivers and streams. Also, periodically flooded lake and reservoir shore areas.

Riprap. A loose assemblage of stones that may be used in cap construction. In caps, riprap is used as a capillary break to retard downward migration of water and to limit biointrusion.

Risk. Quantitative expression of possible loss that considers both the probability that a hazard causes harm and the consequences of that event.

Safety Analysis Report. A report, prepared in accordance with DOE Orders 5481.1B and 5480.23, that summarizes the hazards associated with the operation of a particular facility and defines minimum safety requirements.

Sanitary Waste. Liquid or solid wastes that are not considered hazardous or radioactive, generated as a result of routine operations of a facility.

Saturated Zone. A subsurface area in which all pores are filled with water under pressure equal to or greater than atmospheric pressure.

Scope. In an Environmental Impact Statement, the range of actions, alternatives, and impacts to be considered.

Scoping Process. An early and open public participation process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action.

Sedimentary Interbeds. Rock layers composed of materials, such as sand or gravel, which are derived from the breakdown of various rocks and are layered between other rock types.

Seismicity. The phenomenon of earth movements; seismic activity. Seismicity is related to the location, size, and rate of occurrence of earthquakes.

Sensitive Species. A Washington State category for plant species considered vulnerable or declining, that could become endangered or threatened without active management or removal of threats. Also sometimes used as a generic term for any plant and wildlife species that are threatened or endangered, rare, vulnerable or declining, or monitored by state or Federal agencies.

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Shrub-steppe. Typically a treeless area covered by grasses and shrubs and having a semiarid climate. Precipitation is typically very slight, but sufficient to support the growth of sparse grass and other plants adapted to living in conditions where water is scarce. Washington State Department of Fish and Wildlife considers shrub-steppe a priority habitat.

Solid Waste. Any garbage, refuse, or sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including, solid liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations and from community activities. Solid waste does not include solid and dissolved material in domestic sewage, or solid or dissolved materials in irrigation return flows, or industrial discharges which are point sources subject to permits under Section 402 of the *Federal Water Pollution Control Act, as amended*, or source, special nuclear, or by-product material as defined by the *Atomic Energy Act of 1954*, as amended.

Source Term. The estimated quantities of radionuclides or hazardous materials released to, or available in, the environment for exposure of biological receptors.

SO_x. A generic term used to describe oxides of sulfur. The combination of sulfur oxides with water vapor produces acid rain (see also, sulfur oxides).

Stabilization (of waste sites). Actions taken to reduce the environmental hazards associated with an area used for disposal of hazardous and/or radioactive materials.

Stakeholder. Any person or organization with an interest in or affected by U.S. Department of Energy activities. Stakeholders may include representatives from Tribal governments, Federal agencies, state agencies, Congress, unions, educational groups, industry, environmental groups, other groups, and members of the general public.

Storativity. The ratio of the volume of water that a given unconfined aquifer mass will yield by gravity to the volume of that mass. Specifically defined as the volume of water that an aquifer releases from storage per unit surface area of aquifer per unit decline in the component of hydraulic head normal to that surface.

Sulfur Oxides. Pungent, colorless gases formed primarily by the combustion of fossil fuels. Sulfur oxides are considered to be major air pollutants and may damage the respiratory tract and vegetation (see also, SO_x).

Superfund. The common name used for the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* and its amendments.

Surface Water. All waters that are open to the atmosphere and subject to surface runoff (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors that are directly influenced by surface water.

Surplus facility. Any facility or site (including equipment) that has no identified programmatic use and may or may not be contaminated with radioactive or hazardous materials to levels that require controlled access.

Syncline. A fold in the rock structure inclining upward on both sides of a median axis as in a downward fold of rock strata; opposite of anticline.

Threatened Species. Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant part of its range.

Transuranic Waste. Waste containing more that 100 nanocuries of alpha-emitting transuranic isotopes, which have half-lives greater than 20 years, per gram of waste, except for (a) high-level radioactive waste; (b) waste that the U.S. Department of Energy has determined, with concurrence of the Administrator of the U.S. Environmental Protection Agency, does not need the degree of isolation required by 40 CFR 191; or (c) waste that the U.S. Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR 61.

Transmissivity. A measure of the capacity of a water-bearing unit to transmit fluid. The product of the thickness and the average hydraulic conductivity of a unit. Also, the rate at which water is transmitted through an aquifer under a specific hydraulic gradient at a prevailing temperature and pressure.

Treatment. Any method, technique, or process designed to change the physical or chemical character of a waste to render the waste less hazardous, safer to transport, store or dispose, or reduced in volume.

Tritium. A radioactive isotope of the element hydrogen, with two neutrons and one proton (H-3).

Unconfined Aquifer. An aquifer that has a water table or surface at atmospheric pressure. At Hanford, the unconfined aquifer is the uppermost aquifer and is the most susceptible to contamination from Hanford Site operations.

Unrestricted Land Use. A remediation scenario under which no human uses are precluded because of contamination. Under this land use, certain uses may be prohibited for other reasons, such as physical hazards, cultural resource protection, or habitat protection.

Vadose Zone. The area between the land surface and the top of the water table. Saturated bodies, such as perched groundwater, may exist in the vadose zone. The vadose zone is also known as the zone of aeration and the unsaturated zone.

Vegetation Type. A classification of the plant community on a site based on the dominant plant species in the community.

Volatile Organic Compound (VOC). Chemical containing mainly carbon, hydrogen, and oxygen that readily evaporates at ambient temperature. Exposure to some organic compounds can produce toxic effects on biological tissues and processes.

Waste Management. The planning, coordination, and direction of functions related to the generation, handling, treatment, storage, transport, and disposal of waste, as well as associated surveillance and maintenance activities.

Waste Minimization. An action that economically avoids or reduces the generation of waste by source reduction, reducing the toxicity of hazardous waste, improving energy usage, or recycling. These actions are consistent with the general goal of minimizing present and future threats to human health, safety, and the environment.

Water Level (water table). The top elevation of the groundwater.

Wetland. Those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in a saturated soil environment. These areas are frequently transitional between terrestrial and aquatic systems.

Wilderness Area. An area formally designated by Act of Congress as part of the National Wilderness Preservation System.

Wild and Scenic River. A portion of a river that has been designated by Congress as part of the *National Wild and Scenic Rivers Act of 1968.*

Wind Rose. Star shaped diagram that depicts the frequency and direction of winds of various speeds.

Worker. Any person whose day-to-day activities are controlled by process safety management programs and a common emergency response plan. When evaluating the potential consequences of an accident, the worker is defined as an individual located 100 m (328 ft) downwind of the facility location where the accident occurs.

Scientific Notation

Scientific notation is used in this EIS 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 traditional number requires moving the decimal point either left or right. If the value given is 2.0×10^3, the decimal point should be moved three positions (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 positions to the **LEFT** of its present location. The result would be 0.00002. An alternative form of scientific notation is used in some tables in this EIS. In this form, 2.0×10^3 (2,000) is written 2.0 E+03. To translate to the traditional form, the decimal point is again moved three positions to the right, adding zeros as necessary. Similarly, 2.0×10^{-5} (0.00002) is written as 2.0 E-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 standard American equivalents in parentheses in most locations. Table 1 summarizes and defines the terms and corresponding 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 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 rads 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. Jacquish, 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 ($\geq$ or $\leq$), 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.

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})
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 meter
BCY	bank cubic yard
cm^3	cubic centimeter
ft^3	cubic foot
gal	gallon
L	liter
LCM	loose cubic meter
LCY	loose cubic yard
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 Celsius
°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
Weight	
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 (37 billion disintigrations/s)
cpm	counts per minute
mCi	millicurie (1 x 10^{-3} Ci)
μCi	microcurie (1 x 10^{-6} Ci)
nCi	nanocurie (1 x 10^{-9} Ci)
pCi	picocurie (1 x 10^{-12} Ci)
aCi	attocurie (1 x 10^{-18} Ci)
Bq	becquerel (1 disintigration/s)

Table 3. Names and Symbols for Units of Radiation Dose.

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

Table 4. Radionuclide Nomenclature and Half-Lives.

Symbol	Radionuclide	Half-Life
Am-241	americium-241	432 yr
Ar-41	argon-41	1.8 h
Ba-133	barium-133	10.7 yr
Be-7	beryllium-7	53.4 d
Bi-212	bismuth-212	61 min
C-14	carbon-14	5,730 yr
Ce-144	cerium-144	284 d
Co-57	cobalt-57	270.9 d
Co-60	cobalt-60	5.3 yr
Cr-51	chromium-51	27.7 d
Cs-134	cesium-134	2.1 yr
Cs-137	cesium-137	30 yr
Eu-152	europium-152	13.3 yr
Eu-154	europium-154	8.8 yr
Eu-155	europium-155	5 yr
H-3	tritium	12.3 yr
I-129	iodine-129	1.6 x 10^{7} yr
I-131	iodine-131	8 d
K-40	potassium-40	1.3 x 10^{8} yr
Kr-85	krypton-85	10.7 yr
Mn-54	manganese-54	312 d
Mo-99	molybdenum-99	66 h
Na-22	sodium-22	2.6 yr
Nb-95	niobium-95	35 d
Ni-63	nickel-63	96 yr
Np-239	neptunium-239	2.4 d
Pb-212	lead-212	10.6 h
Pm-147	promethium-147	2.6 yr
Po-212	polonium-212	0.3 x 10^{-6} s
Po-216	polonium-216	0.15 s
Pu-238	plutonium-238	87.7 yr
Pu-239	plutonium-239	2.4 x 10^{4} yr
Pu-240	plutonium-240	6.5 x 10^{3} yr
Pu-241	plutonium-241	14.4 yr
Ra-226	radium-226	1,600 yr
Ra-228	radium-228	5.8 yr
Rn-220	radon-220	56 s
Rn-222	radon-222	3.8 d
Ru-103	ruthenium-103	39.3 d
Ru-106	ruthenium-106	368 d
Sb-125	antimony-125	2.8 yr
Sr-89	strontium-89	50.5 d
Sr-90	strontium-90	21.1 yr
Tc-99	technetium-99	2.1 x 10^{5} yr
Th-232	thorium-232	1.4 x 10^{10} yr
Ti-208	thallium-208	3.1 min
U or uranium[a]	uranium total	--
U-234	uranium-234	2.4 x 10^{5} yr
U-235	uranium-235	7 x 10^{8} yr
U-236	uranium-236	2.3 x 10^{7} yr
U-238	uranium-238	4.5 x 10^{9} yr
Zn-65	zinc-65	243.9 d
Zr-95	zirconium-95	64 d

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

Conversion Table

Multiply	By	To Obtain
°C	(°C x 9/5) + 32	°F
°F	(°F - 32) + 9/5	°C
acres	0.405	ha
BCM	1.308	BCY
BCY	0.765	BCM
becquerel	2.7×10^{-11}	curie
Ci/m^3	10^{12}	pCi/m^3
cm	0.394	in.
curie	3.7×10^{10}	becquerel
ft	0.305	m
ft^2	0.093	m^2
ft^3	0.028	m^3
g	.035	oz
gal	3.785	L
gray	100	rad
ha	2.47	acres
in	2.54	cm
kg	2.205	lb
km	0.621	mi
km^2	0.386	mi^2
L	.0264	gal
lb	0.454	kg
LCM	1.308	LCY

Multiply	By	To Obtain
LCY	0.765	LCM
m	3.28	ft
m^2	10.76	ft^2
m^3	35.7	ft^3
m^3	1.308	yd^3
mCi/cm^3	10^{15}	pCi/m^3
mCi/km^2	1.0	nCi/m^2
mi	1.61	km
mi^2	2.59	km^2
nCi	0.001	pCi
nCi/m^2	1.0	mCi/km^2
oz	28.349	g
pCi	1,000	nCi
pCi/L-	10^{-9}	μCi/mL
pCi/m^3	10^{-15}	mCi/cm^3
pCi/m^3	10^{-12}	Ci/m^3
ppb	0.001	ppm
ppm	1,000	ppb
rad	0.01	gray
rem	0.01	sievert
sievert	100	rem
μCi/mL	10^9	pCi/L
yd^3	0.765	m^3

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Elemental and Chemical Constituent Nomenclature

Symbol	Constituent
Ag	silver
Al	aluminum
As	arsenic
B	boron
Ba	barium
Be	beryllium
Br	bromine
C	carbon
Ca	calcium
CaF_2	calcium fluoride
CCl_4	carbon tetrachloride
Cd	cadmium
$CHCl_3$	trichloromethane
Cl^-	chloride
CN^-	cyanide
Co	cobalt
CO_3^{-2}	carbonate
Cr	chromium (total)
Cr VI	hexavalent chromium
Cu	copper
F-	fluoride
Fe	iron
HCO_3^-	bicarbonate
Hg	mercury

Symbol	Constituent
K	potassium
LiF	lithium fluoride
Mg	magnesium
Mn	manganese
Mo	molybdenum
N	nitrogen
Na	sodium
NH_3	ammonia
NH_4^+	ammonium
Ni	nickel
NO_2^-	nitrite
NO_3^-	nitrate
P	phosphorus
Pb	lead
PO_4^{-3}	phosphate
Sb	antimony
Se	selenium
Si	silicon
SO_4^{-2}	sulfate
Sr	strontium
Ti	titanium
Tl	thallium
V	vanadium
Zn	zinc

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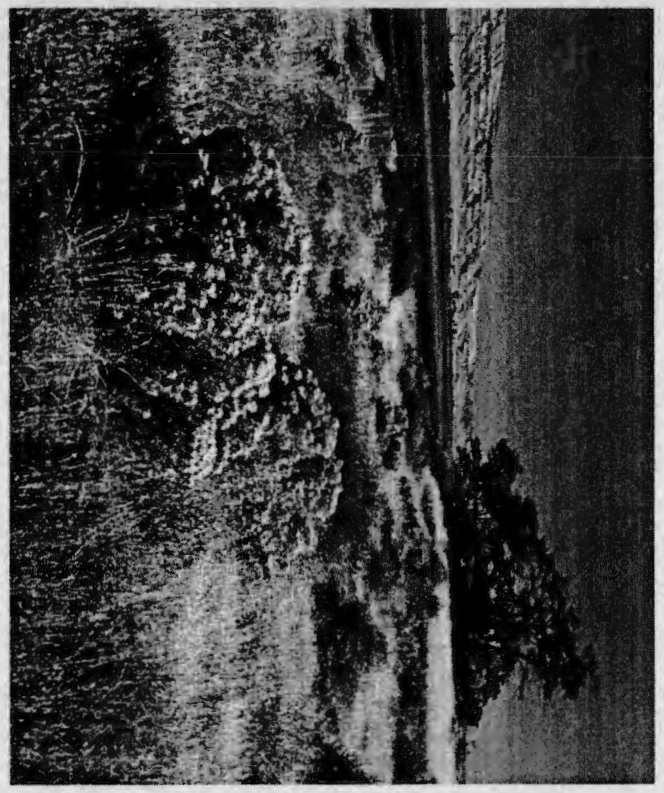

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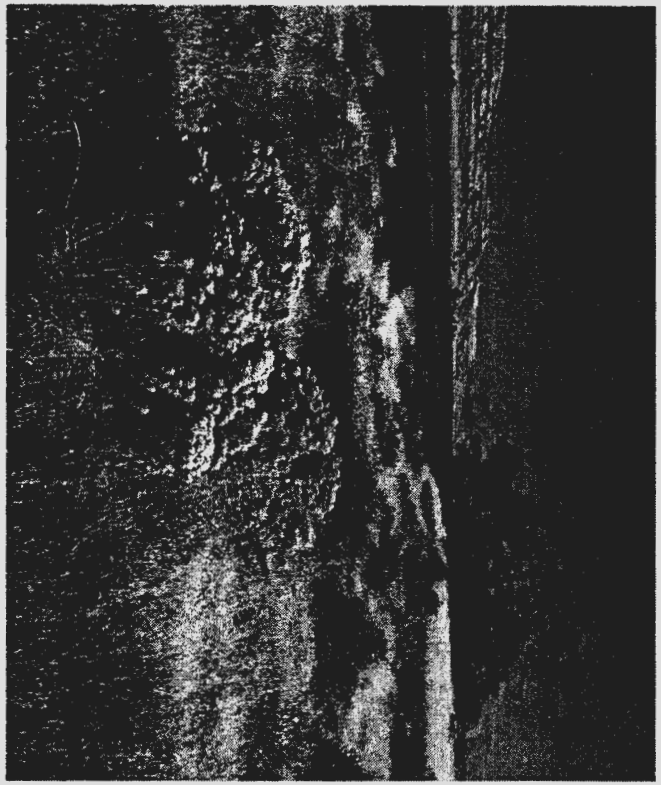


Introduction

96/3459, 1951

1.0 Introduction

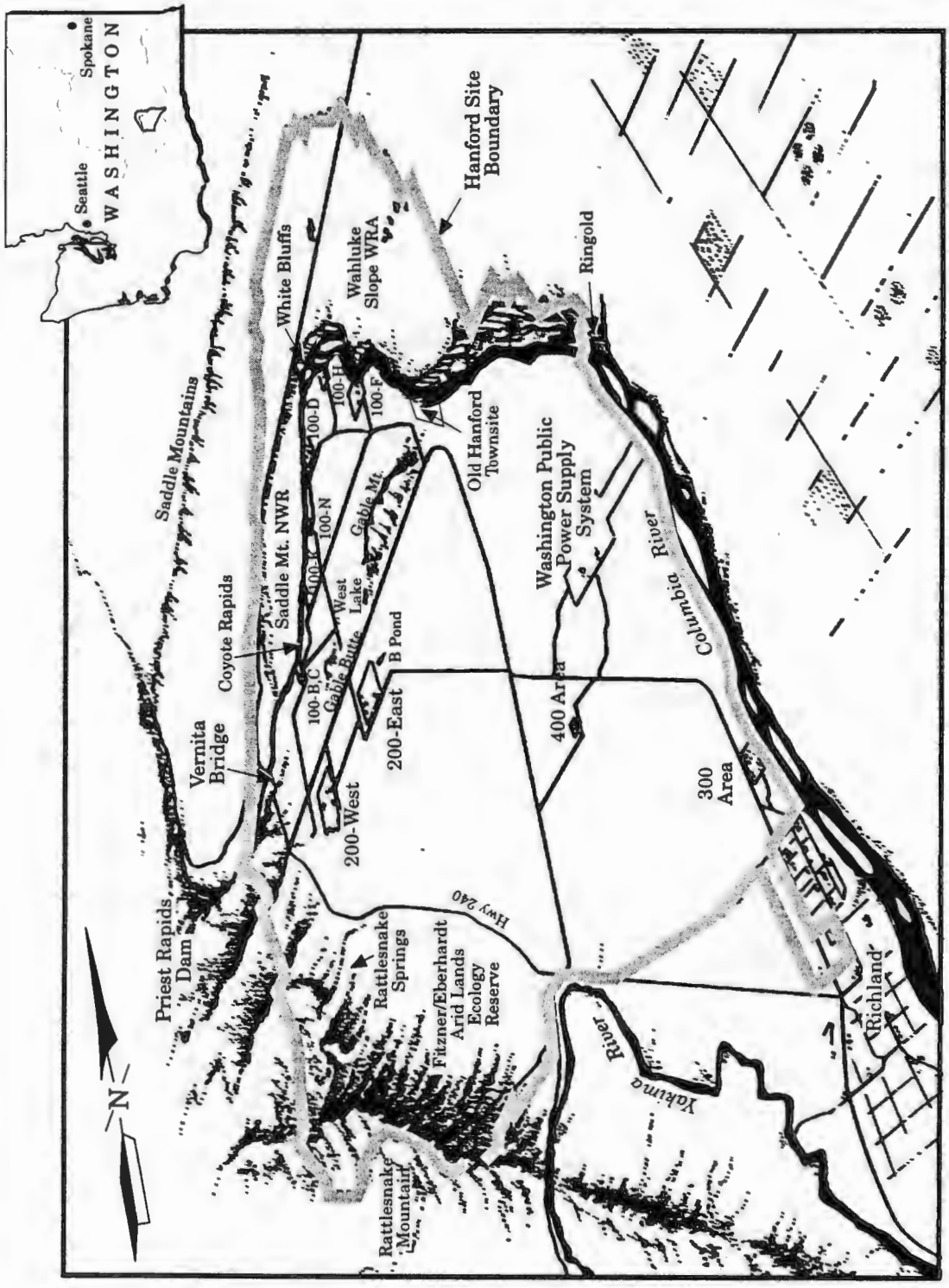
The U.S. Department of Energy (DOE) is proposing to establish future land-use objectives for the Hanford Site (Figure 1-1). These objectives would guide the process of remediating the radioactive and hazardous wastes that were generated during the Hanford Site's defense nuclear material production mission. A key element of the DOE's decisionmaking is a thorough understanding of the environmental impacts that might occur during the implementation of the proposed action. The *National Environmental Policy Act of 1969* (NEPA) provides federal agency decisionmakers with a process to use when considering the potential environmental consequences (both positive and negative) of a proposed action. The DOE has prepared this Environmental Impact Statement (EIS) to assess various future land-use alternatives and provide the necessary background data and analyses that will help decisionmakers and the public understand the potential environmental impacts of each alternative.

The proposed action is to establish future land-use objectives for the Hanford Site. Future land-use objectives are used to establish remedial-action objectives under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and identify the corresponding preliminary remediation goals (using existing standards, readily available risk information, and other site-specific, risk-related factors). The proposed action will allow remediation decisionmakers to focus on remedial actions and goals needed to achieve a desired future land-use objective (Table 1-1). This EIS provides an assessment of the potential impacts (primarily from remediation activities) associated with achieving a desired future land use. Site-specific decisions regarding remediation technologies and activities will not be made by this EIS, but by processes specified by the *Resource Conservation and Recovery Act of 1976* (RCRA) and CERCLA. This EIS uses general bounding assumptions to assess the potential environmental impacts of future remediation activities. These assumptions ensure that the range of environmental impacts considered necessary to facilitate land-use objectives adequately encompass probable future impacts.

Table 1-1. Relationship of Decisions Made Under National Environmental Policy Act and Comprehensive Environmental Response, Compensation, and Liability Act Statutes.

Determined Through the NEPA Process	Determined Through the CERCLA Process
Future Land-Use Objective Restricted use of the Reactors on the River geographic area.	Remedial Action Objective Prevent ingestion of water containing Sr-90 in excess of 8 pCi/L by users in the Reactors on the River geographic area. Preliminary Remediation Goals Achieve remediation of Sr-90 to 8 pCi/L in the Reactors on the River geographic area or prohibit installation of drinking water wells in the vicinity of Sr-90 plumes.

Figure 1-1. Location of the Hanford Site.



1.1 Background

On August 21, 1992, the DOE published the "Notice of Intent to Prepare the Hanford Remedial Action Environmental Impact Statement, Richland, Washington," 57 *Federal Register* (FR) 37959, and invited members of the public along with Tribal, state, and local governments to comment on the preliminary scope, content, and alternatives of this EIS. The public scoping period was scheduled to be held from August 21, 1992, to November 25, 1992; however, at the public's request, the scoping period was extended to January 25, 1993.

The DOE held several meetings to involve the public in developing the scope of the 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, Richland, Washington* (IP), which provided recorded the results of the scoping process and provided guidance for the preparation of this EIS. The IP was approved, published, and distributed to the public in July 1995 (DOE-RL 1995a).

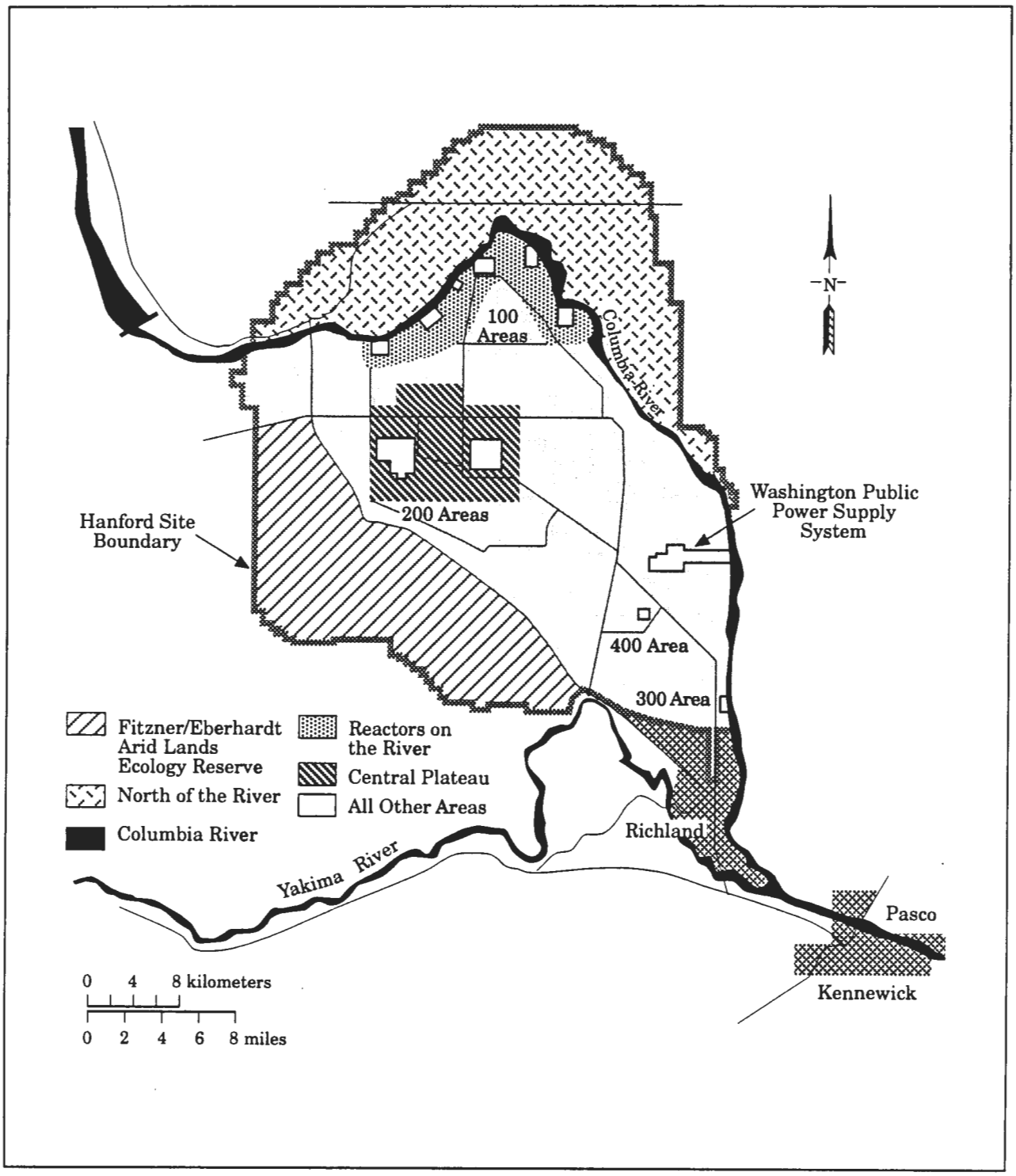
1.1.1 Hanford Future Site Uses Working Group

As part of the EIS scoping process, 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 developing 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 the appropriate cleanup scenarios needed 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.

To facilitate these three tasks, the Working Group members divided the Hanford Site into six distinct geographic areas (Figure 1-2). They developed future-use options, cleanup scenarios, and other recommendations for each of the six geographic areas. Their efforts were based on the assumption that cleanup activities at the Hanford Site would benefit greatly from having a better understanding of the range of potential future uses of Hanford Site lands. An understanding of potential future uses at Hanford could focus efforts of the DOE, and state and federal regulators, as well as Congress and the public, on the manner of cleanup needed and the most important objectives 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).

Figure 1-2. Six Geographic Areas Established by the Hanford Future Site Uses Working Group (adapted from HFSUWG 1992).



This EIS incorporates three levels of access (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 (Columbia River, Reactors on the River, Central Plateau, and All Other Areas) of the Hanford Site. The waste sites in the remaining two geographic areas, the Fitzner/Eberhardt Arid Lands Ecology (ALE) Reserve and North of the River (North Slope) (also known as the Wahluke Slope) have been remediated, and are considered unrestricted. For cohesive land-use planning purposes, the North Slope and the ALE Reserve are included in Appendix M, "Hanford Site Comprehensive Land Use Plan," and their future land uses will be addressed in the ROD.

1.2 Scope

The scope of this EIS includes RCRA and CERCLA-regulated waste sits in the Columbia River, Reactors on the River, Central Plateau, and All Other Areas geographic areas of the Hanford Site, and the RCRA- and CERCLA-regulated waste sites within these geographic areas. Decommissioning of the surplus facilities for which the DOE can readily make decisions is addressed in this EIS (DOE-RL 1996a). In addition, the closure of RCRA waste treatment, storage, and/or disposal (TSD) units located in or near past-practice waste sites is included. Chemical and radiological contaminants associated with these past-practice waste sites, TSD units, and surplus facilities are included within the scope of this EIS. For additional information about Hanford Site contaminants, see Section 1.3.1. A detailed listing and discussion of the facilities, waste sites, and operable units within the scope of this EIS is provided in Appendix A.

The waste sites in the following two geographic areas have been remediated, and are not included in the impacts analysis of this EIS. Appendix M, "Hanford Site Comprehensive Land Use Plan," includes the analyses of the available resources of these two areas. The North Slope and the ALE Reserve are included in this EIS because of their potential use as buffer zones for remediation activities and the DOE's policy for ecosystem management.

- **North of the River**. Remediation of the North Slope was completed in October 1994 in accordance with the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989). The 100-IU-3 operable unit in this area included 39 suspect waste sites. The major contaminants associated with this area were dichlorodiphenyltrichloroethane (DDT), and petroleum-contaminated soils.

- **The Fitzner/Eberhardt Arid Lands Ecology Reserve**. Remediation of the ALE Reserve, which included the 1100-IU-1 operable unit, was completed in accordance with the Tri-Party Agreement in October 1994. 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 DDT.

Tri-Party Agreement

The Tri-Party Agreement is an enforceable agreement among the DOE, Ecology, and the EPA for achieving environmental compliance at the Hanford Site. The agreement accomplishes the following:

- Defines CERCLA cleanup provisions for past contamination
- Defines RCRA waste treatment, storage, and disposal requirements and corrective actions for waste management
- Establishes the responsibilities for each agency
- Establishes enforceable milestones for achieving remediation and regulatory compliance.

The following facilities and waste sites are excluded from impact analysis under this EIS:

- Wastes and the associated environmental impacts from future land uses implemented after remediation is complete.

- The 149 single-shell tanks (SST), 28 double-shell tanks (DST), and their associated piping, structures, and contaminated soils. The management of SST and DST waste is the subject of an EIS for the Tank Waste Remediation System (DOE and Ecology 1996).

- The waste sites included in the Hanford Site's 1100 Area CERCLA National Priorities List operable units. CERCLA remedial actions for these sites have been categorically excluded from documentation requirements under the provisions of 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, which has a separate regulatory package that consists of a CERCLA Remedial Investigation/Feasibility Study (DOE-RL 1994a), 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 Plan* (DOE-RL 1994c). These facilities include B Plant, T Plant, U Plant, the Reduction Oxidation Plant, the Plutonium-Uranium Extraction Plant, the Plutonium Finishing Plant (PFP), the Waste Encapsulation and Storage Facility, the 105-N Reactor (N Reactor), and the Fast Flux Test Facility (FFTF). These facilities would receive appropriate levels of environmental reviews under NEPA or CERCLA before any action is taken.

- Current or planned actions covered in the *Final Environmental Impact Statement: Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes* (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 *Final Environmental Impact Statement: Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington* (DOE 1992) (e.g., B, C, D, DR, F, H, KE, and KW reactors).

- Treated liquid wastes from the 200 Area Effluent Treatment Facility disposed of in the state-approved land disposal site located north of the 200 West Area.

Other facilities and developed areas on the Hanford Site, including the Washington Nuclear Plant-Two (WNP-2), the Laser Interferometer Gravitational-Wave Observatory (LIGO), and the US Ecology, Inc. commercial low-level waste (LLW) disposal site are excluded from impact analyses. However, for cohesive land use planning purposes, the geographic areas where these facilities are located are within the scope of this EIS. Some of the impacts associated with these facilities and waste sites are analyzed cumulatively in Chapter 5.0 of this EIS; other associated impacts are or will be more extensively analyzed in other environmental documents (Section 1.8).

1.3 Site Description

The DOE's Hanford Site is situated in southeastern Washington State, and occupies an area of approximately 1,450 km^2 (560 mi^2). The Hanford Site is owned by the U.S. Government, and administered (managed) by the U.S. Department of Energy, Richland Operations Office (RL). The Hanford Site lies in the Pasco Basin of the Columbia Plateau, directly northwest of the confluence of the Columbia River with the Snake, Walla Walla, and Yakima rivers (see Figure 1-1). 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. 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 since the 1940s required the exclusion of the public and most nongovernment-related development on the Hanford Site. The Hanford Site has provided *de facto* protection of the natural environment and cultural resources unparalleled in the Pacific Northwest or along the Columbia River (NPS 1994). The defense nuclear materials production mission has, however, 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 and hazardous contaminants. These contaminants have been disposed of or discharged to the air, soil, and water at the Hanford Site.

1.3.1 Waste Types Present at the Hanford Site

Radioactive wastes at the Hanford Site include high-level waste (HLW), TRU waste, LLW, and mixed waste. The classification of a particular radioactive waste depends on the origin and concentration of the waste, as well as the particular radioisotopes in the waste.

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 and fission products in concentrations high enough to require permanent isolation.

> ***What is Contamination?***
>
> For this EIS, contamination is defined as the presence of unwanted radioactive and/or hazardous materials above background concentrations in air, soil, surface water, and groundwater, or on the surfaces of structures or objects. This definition is very broad and does not address the risks that might be associated with each contaminant.
>
> Determination of whether a contaminant poses a risk to human health or the environment will be determined through the CERCLA process on a site-specific basis.

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).

Principal radionuclide environmental contaminants found on the Hanford Site include, but are not limited to:

- tritium
- cobalt-60
- strontium-90
- cesium-137
- technetium-99
- iodine-129
- isotopes of uranium, plutonium, and europium.

Principal hazardous chemical environmental contaminants found on the Hanford Site include, but are not limited to:

- chromium
- chloroform
- mercury
- various inorganic acids
- polychlorinated biphenyl
- cyanide
- nitrate
- fluoride
- carbon tetrachloride
- ferrocyanide
- trichloroethylene
- uranium
- petroleum compounds.

Hanford Site Waste Types

Hazardous Waste - A solid waste that, because of its quantity, concentration, or physical, chemical, or infectious characteristics, may (1) cause an increase in mortality or significant illness, or (2) pose a substantial hazard to human health or the environment if not appropriately managed. RCRA regulates the treatment, storage, and disposal of hazardous wastes.

High-Level (Radioactive) Waste - Results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing, and solid waste derived from the liquid that contains a combination of transuranic and fission product nuclides in quantities that require permanent isolation.

Low-Level (Radioactive) Waste - Contains radioactivity and is not classified as high-level waste, transuranic waste, or spent nuclear fuel.

Mixed Waste - Contains hazardous waste regulated under RCRA and radioactive waste regulated under the *Atomic Energy Act of 1954*.

Transuranic Waste - Contains the following alpha-emitting transuranic radionuclides with half-lives greater than 20 years and concentrations greater than 100 nCi/g at the time of assay.

- neptunium
- plutonium
- americium
- californium
- curium
- berkelium

Other nontransuranic elements can be included by agreement.

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, management, and regulatory problems.

1.3.2 Waste Sites and Geographic Areas at the Hanford Site

Radioactive, hazardous, and mixed wastes are found in various individual waste sites throughout the Hanford Site. These individual sites include past-practice waste sites, surplus facilities, and TSD units. Past-practice waste sites and TSD units might 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 and uncontaminated buildings, exhaust stacks, and underground transfer lines. These individual sites are organized into operable units, under the Tri-Party Agreement, based on geographic proximity or similarity of waste disposal history.

The operable units are located primarily in the operating areas of the Hanford Site. Normally these areas are referred to as the 100, 200, 300, 400, 600, 1100, and 3000 Areas; however, for purposes of this EIS, the operating areas are discussed within the context of the geographic areas concept established by the Working Group (see Figure 1-2).

1.3.2.1 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 riparian (riverside) ecology characteristics 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 in the United States. Nearly 60% of the Columbia River's entire native wild stock of fall chinook salmon spawn in the Hanford Reach (NPS 1994). River water downstream from the Hanford Site is used by both Washington and Oregon residents for drinking water, agriculture, industry, transportation, and recreation. The riverbanks and islands in the Hanford Reach 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).

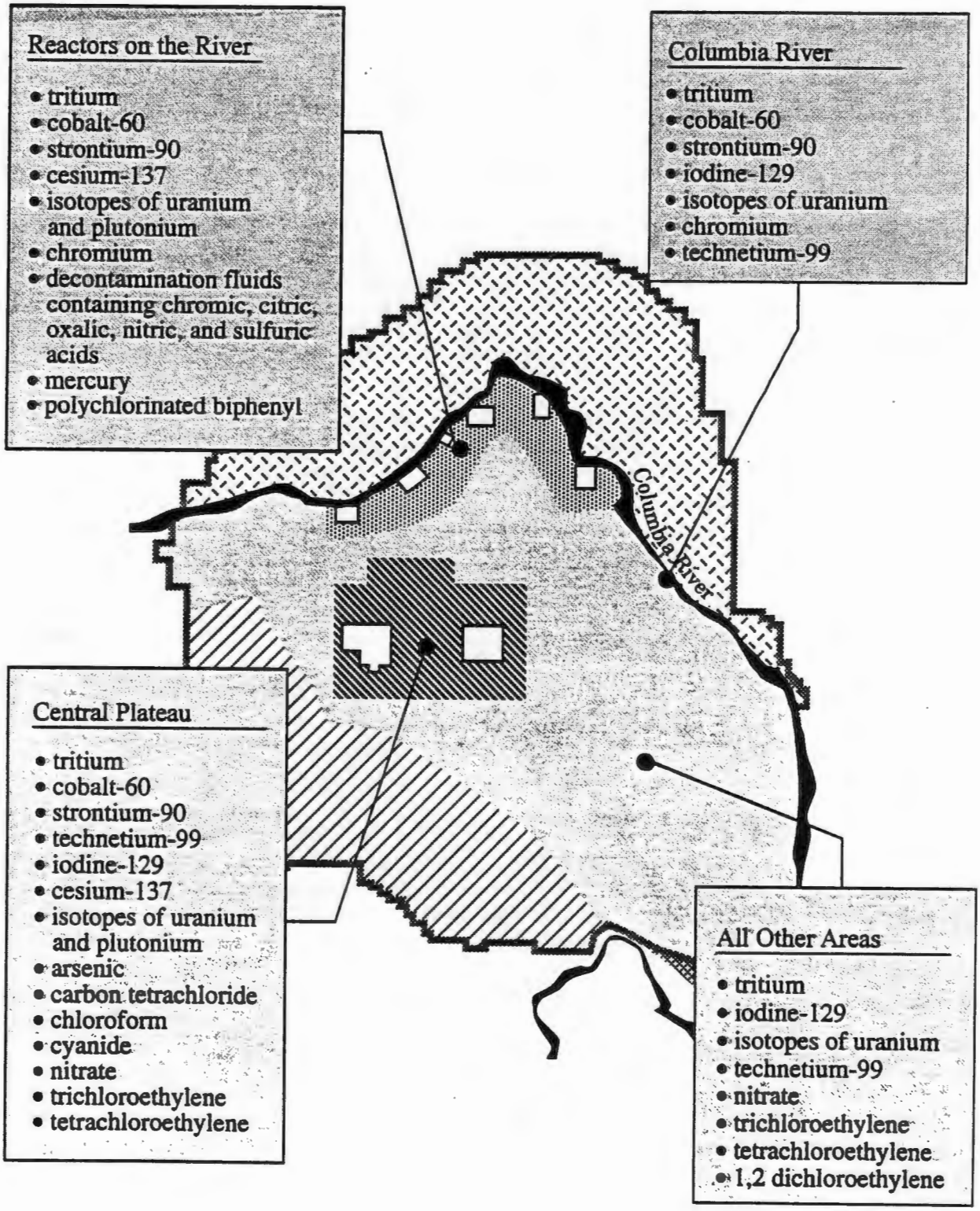
Future public access to the Columbia River raises concerns because groundwater contamination from the Hanford Site reaches the river (through springs and seeps) at several locations. Contamination sources also include reactor effluent lines that protrude into the river. These structures were used to 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 potential source of contamination (DOE-RL 1993a, PNL 1994). 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, the radiological contaminants in the river water (Figure 1-3) are well below State of Washington and EPA drinking water standards (PNL 1995).

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

Extensive contamination exists in some portions of the Reactor on the River surface soils, subsurface soils, and groundwater (see Figure 1-3). This contamination resulted from the operation of the plutonium production reactors 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.

1.3.2.3 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 operation of these facilities resulted in the storage, disposal, and unplanned release of radioactive and hazardous waste. Extensive contamination exists in the surface soils,

Figure 1-3. Principal Contaminants Present in the Geographic Areas of the Hanford Site.



subsurface soils, and groundwater of the Central Plateau (see Figure 1-3). Groundwater contamination concentrations exceed EPA drinking water standards for some contaminants. 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).

1.3.2.4 All Other Areas. The All Other Areas geographic area comprises approximately 624 km^2 (241 mi^2) in the 300, 400, 600, 1100, and 3000 Areas of the Hanford Site. A description of these areas follows.

1.3.2.4.1 300 Area. The 300 Area is located north of the City of Richland and covers 1.5 km^2 (0.6 mi^2). Former reactor fuel-fabrication facilities were sited in this area. The 300 Area is the principal location of nuclear research and development (R&D) facilities on the Hanford Site. Wastes in this area have resulted from the fuel fabrication process and various R&D projects.

1.3.2.4.2 400 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. Recently, however, a consortium of private companies expressed an interest in purchasing and operating the facility. Much of the 400 Area overlies groundwater contaminant plumes.

1.3.2.4.3 600 Area. The 600 Area is defined to include all of the lands within the Hanford Site not occupied by the 100, 200, 300, 400, 1100, and 3000 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 leased by the DOE to the State of Washington and subleased to US Ecology, Inc. for the disposal of commercial LLW; the LIGO which, when completed, will detect gravitational waves for research purposes; and a Reference Repository Site once used as the principal borehole and exploratory shaft for a candidate Basalt Waste Isolation Program, which was terminated in 1987.

1.3.2.4.4 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. Hazardous waste in this area resulted from the disposal of batteries, paints, solvents, and antifreeze. Waste sites in the 1100 Area have been remediated, and are not within the scope of this EIS (see Section 1.2).

1.3.2.4.5 3000 Area. The 3000 Area, located northeast of the 1100 Area, accommodates engineering and construction support facilities. The 3000 Area is relatively uncontaminated, and discussions are underway to turn this property over to other government entities that have a need for the facilities.

1.3.2.5 Fitzner/Eberhardt Arid Lands Ecology Reserve. The ALE Reserve encompasses 315 km^2 (120 mi^2) in the southwestern portion of the Hanford Site, and is managed as a habitat and wildlife reserve, and nature research center, under the DOE's National Environmental Research Park program.

A number of small, contaminated sites found on the ALE Reserve were remediated in 1994 and 1995, and have been revegetated. Because the waste sites on the ALE Reserve have been remediated, they are included within the scope of this EIS (see Section 1.2).

This geographic area includes the northeast-facing flank of Rattlesnake Mountain, the southern extremity of Yakima Ridge, and intervening gentle slopes and valleys. Prior to 1940, major land uses included winter sheep and cattle grazing, homesteading, natural gas drilling and production, and the construction of roads (PNL 1993). Included as part of the Hanford Nuclear Reservation in 1943, the ALE Reserve has served as a protective buffer for nuclear materials storage and waste management activities, and has been closed to public access since that time. These public access restrictions have been beneficial to native plant and animal populations.

The ALE Reserve now supports one of the largest remnants of relatively undisturbed shrub-steppe ecosystem in the State of Washington. Vegetation on the ALE Reserve contains largely undisturbed stands of several typical plant communities (i.e., sagebrush-bluebunch wheatgrass, sagebrush-Sandberg's bluegrass, sagebrush-bitterbrush-needle and thread grass, cheatgrass, and cottonwoods and willows) (DOE 1994a). Extensive wildfires in 1957, 1973, 1981, and 1984 removed the shrub component from much of the ALE Reserve. These areas now support stands of perennial bunchgrasses at the upper elevations and cheatgrass and bunchgrasses on lower elevations (PNL 1993).

As a naturally functioning shrub-steppe ecosystem, this geographic area provides a baseline for research studies of species of concern (e.g., elk, deer, and raptoral birds) and ecosystem studies to support habitat revegetation efforts. A variety of game animals, fur-bearing animals, and small mammals inhabit different elevations on the ALE Reserve. Breeding birds (e.g., the horned lark and western meadowlark), as well as many migratory species, utilize steppe vegetation on lower elevations. The riparian communities provide nesting sites for other bird species.

A large number of intermittent or ephemeral springs are scattered across Rattlesnake Mountain on the ALE Reserve. Two permanent springs (known as Snively Springs and Rattlesnake Springs) in this geographic area support extensive riparian ecosystems (PNL 1993). Two archaeological districts, which are listed on the *National Register of Historic Places* (NPS 1988) and associated with the Snively and Rattlesnake springs, are located on the ALE Reserve.

Rattlesnake Mountain has been used for ecological research dating back to 1952, but it was not until 1967 that the Richland Office of the U.S. Atomic Energy Commission (AEC) (a predecessor to the DOE) established the ALE Reserve by administrative order (PNL 1993). As a result of a federal interagency cooperative agreement, the ALE Reserve was designated the Rattlesnake Hills Research Natural Area in 1971. In 1977, the U.S. Energy Research and Development Administration (ERDA) (another predecessor to the DOE) designated the ALE Reserve as one of four National Environmental Research Park sites located across the United States. The ALE Reserve currently retains its status as an administratively protected environment and as a valuable ecological study site. The DOE is not planning to alter current land uses at the ALE Reserve.

1.3.2.6 North of the River. The geographic area north of the Columbia River, known as the North Slope, encompasses approximately 365 km^2 (140 mi^2). The North Slope is administered as two wildlife areas, known as the Saddle Mountain National Wildlife Refuge and the Wahluke State Wildlife Recreation Area. The Saddle Mountain National Wildlife Refuge is managed by the U.S. Fish and Wildlife Service (USFWS); the Wahluke State Wildlife Recreation Area is managed by the Washington Department of Fish and Wildlife.

The North Slope contained numerous nonradioactively contaminated sites, primarily from past NIKE missile sites and pre-Hanford Site homestead debris. These waste sites were remediated and revegetated in 1994 and 1995. Because the waste sites on the North Slope has been remediated, they are not included within the scope of this EIS (see Section 1.2).

Part of the North Slope serves as a protective buffer zone for the plutonium production reactors located immediately across the Columbia River; therefore, a portion of the North Slope has been closed to the public since 1943 (NPS 1994). The public access restriction has proven to be beneficial to native plant and animal populations (e.g., the area is a sanctuary for a wide variety of migratory birds). Prior to 1943, the North Slope was used for livestock grazing and crop farming. In the 1940s and 1950s, portions of the North Slope were used for military training. Today, cattle grazing on the middle and upper slopes of the Saddle Mountains is authorized during the spring and the summer.

Dominant natural features within this geographic area include the Wahluke Slope, the Saddle Mountains, the White Bluffs, large dune fields above the White Bluffs, and the Hanford Reach. Abundant lakes and wetlands have resulted from irrigation wasteways and the rise of the watertable (caused by local irrigation). Occasional fires on portions of the North Slope have resulted in sparse shrub cover or relatively young shrubs (TNC 1995).

Sixteen different plant community types have been identified on the North Slope. Cheatgrass and other nonnative species dominate, most likely because of disturbances caused by military training activities, historical livestock grazing, dry soil, and multiple fires. However, the North Slope still possesses extensive remnants of the original shrub-steppe ecosystem. For example, the most extensive and highest quality antelope bitterbrush and Indian ricegrass plant community in the State of Washington is found on the North Slope (TNC 1995). In 1994, The Nature Conservancy discovered a new plant species of the genus *Lesquerella*. This recent discovery illustrates the potential ecological value of this geographic area.

The DOE is not planning to alter the current land use of the North of the River geographic area, and is specifically prohibited from causing any adverse impacts on the values that might affect the consideration of this area for Wild and Scenic River status.

1.4 Brief History of the Hanford Site

Nuclear material 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 materials production programs to energy research, and then to the current missions of environmental restoration and waste management. Past site administrators have included the U.S. Army Corps of Engineers (Corps), the AEC, and the ERDA. The DOE is the current administrator, and has controlled operations at the Hanford Site since 1977.

In January 1943, the Corps 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 the 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 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. In response to a need by the AEC to increase plutonium production, a major expansion program was initiated at the Hanford Site in the late 1940s. 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 towards 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. Both types of these tanks continue to provide interim waste storage capacity today.

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

1.5 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 is addressed in NEPA analyses
- provide options for agencies undertaking NEPA analyses that consider biodiversity.

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

1.6 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 environmental justice part of their missions. To the greatest extent practicable and permitted by law, 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 February 11, 1994 memorandum, which accompanied the Executive Order, "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 might adversely affect their lives.

In addition, the memorandum and Executive Order indicate 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 *Draft U.S. Department of Energy Public Participation Guidance for Environmental Justice Activities* (DOE 1994b) and the *Predecisional Draft: U.S. Department of Energy Proposed Environmental Justice Strategy, Executive Order 12898* (DOE 1994c) are being prepared. Guidance and strategies provided in these publications are used, to the extent practicable, in this EIS.

1.7 Comprehensive Land Use Planning

Appendix M, "Hanford Site Comprehensive Land Use Plan" (Comprehensive Plan) is being developed to guide land- and facility-use decisions through an analysis of potential land-use opportunities and constraints. In a manner consistent with CEQ guidance (46 FR 18026), the Comprehensive Plan relies on the analysis of environmental impacts in this EIS. The ROD issued for this EIS will be the decision process for finalization and adoption of the Comprehensive Plan. In accordance with DOE Order 430.1, *Life-Cycle Asset Management* (DOE 1995a), the DOE will coordinate with Tribal and local governments to consider the long-term goals and objectives of Hanford Site stakeholders during development of the Comprehensive Plan.

Early community involvement in the development of this EIS should result in a more participatory and better-informed decisionmaking process; greater community support for cleanup remedies selected as a result of this process; and more expedited remediation. The DOE, the EPA, and Ecology will be able to rely on the future land uses identified in this EIS.

1.8 Other Ongoing Major Federal Actions and 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 is intended to delineate the boundaries among the EISs and show the interrelationships.

- *Hanford Reach of the Columbia River, Comprehensive River Conservation Study and Environmental Impact Statement, Final-June 1994* (NPS 1994). This final EIS was prepared by the National Park Service and the U.S. Department of Interior, in consultation with the DOE. The EIS identifies and evaluates the outstanding features of the Hanford Reach, including fish and wildlife, and examines alternatives for preservation of these features, including addition of the Hanford Reach to the National Wild and Scenic Rivers System. The Secretary of the Interior signed the ROD for the EIS on July 16, 1996. The preferred alternative 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. The geographic boundaries between the *Hanford Reach of the Columbia River, Comprehensive River Conservation Study and Environmental Impact Statement, Final-June 1994* (NPS 1994) and this EIS overlap in the strip of land within 0.4 km (0.25 mi) of the Columbia River in the 100 Areas. If Congress does not take the action recommended by the EIS (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 the 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 responsible for remediation of the areas under designation (NPS 1994), and would consult with the USFWS to ensure that remediation does not adversely impact significant values of the Hanford Reach.

- The *Final Environmental Impact Statement: Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington* (DOE 1992) included in its scope the decommissioning of eight surplus production reactors (B, C, D, DR, F, H, KE and KW), associated nuclear fuel storage basins, and the buildings that house the reactors. The ROD for this action was issued on September 10, 1993 (58 FR 178). The DOE decided to implement safe storage, followed by deferred one-piece removal of the reactor blocks. This 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 and contaminated equipment and components from the reactors also would be disposed of in the 200 West Area. 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.

- *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 this draft EIS. The U.S. Army and the DOE are cooperating in the preparation of the EIS. The EIS analyzes the impacts of siting a SMES-ETM north of the 200 Area of the Hanford Site or one of four other candidate sites in the United States. The project and final EIS have been placed on hold.

- *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs, Final Environmental Impact Statement* (DOE 1995b). This EIS analyzed 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. A ROD was issued on June 1, 1995 (60 FR 28680), which presents the DOE's decision to regionalize the management of SNF. Hanford's production reactor fuel would remain at the Hanford Site, until future decisions on ultimate disposition are made.

  An amendment to the ROD (61 FR 9441) was issued to the public on February 28, 1996, to reflect modifications to the original decision resulting from a Settlement Agreement reached by the DOE, the State of Idaho, and the Department of the Navy. The amended ROD indicates that only 12 of the originally planned 524 shipments of SNF would be shipped from the Hanford Site to Idaho. These 12 shipments will consist of the sodium-bonded fuel from the FFTF.

- *Storage and Disposition of Weapons-Usable Fissile Materials Draft Programmatic Environmental Impact Statement* (DOE 1996a). This EIS evaluates alternatives for long-term storage of weapons-usable plutonium and nonsurplus highly enriched uranium. In addition, the EIS evaluates strategies and technologies for disposition of surplus weapons-usable plutonium. Modification of an existing facility or construction of a new facility for storage of some weapons-usable plutonium, the entire inventory of weapons-usable plutonium, and collocation of plutonium and highly enriched uranium is evaluated for several existing DOE sites, including the Hanford Site. Furthermore, facilities required for several of the immobilization alternatives considered in the EIS are evaluated for each potential storage site. On March 8, 1996, the DOE announced that the draft EIS was available for public review and comment through May 7, 1996.

- *Draft Environmental Impact Statement for the Tank Waste Remediation System* (TWRS-EIS) (DOE and Ecology 1996). The TWRS-EIS evaluates the environmental impacts of retrieving and treating the wastes in the Hanford Site's 177 DSTs and SSTs, associated structures and contaminated soils, about 60 smaller active and inactive miscellaneous USTs, and 1,930 cesium and strontium capsules stored in the Waste Encapsulation and Storage Facility. The TWRS-EIS includes a discussion of the waste forms and treatment processes to be used, and is a follow-on and update to the tanks portions of the *Final Environmental Impact Statement: Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes* (DOE 1987). The draft EIS was prepared by the DOE and Ecology to satisfy requirements of both the NEPA and the *State Environmental Policy Act of 1971*; the final EIS should be released in the summer of 1996.

- *Plutonium Finishing Plant Stabilization Final Environmental Impact Statement* (PFP-EIS). The DOE issued the final PFP-EIS in May 1996 (DOE-RL 1996b). The final PFP-EIS addresses actions necessary to reduce radiation exposure to workers and risk to the surrounding population and the environment from plutonium-bearing materials present at the PFP facility within the 200 West Area. The ROD, issued on July 10, 1996 (61 FR 36352), presents the DOE's preferred alternative for stabilizing containerized material and removing surface contamination.

- *Final Environmental Impact Statement: Safe Interim Storage of Hanford Tank Wastes* (Ecology and DOE-RL 1995), previously referred to as the *Multifunction Waste Tank Facility Environmental Impact Statement*. This is an interim-action EIS prepared to resolve near-term tank safety issues for certain Hanford Site waste tanks while the larger TWRS-EIS is being finalized. This interim action EIS is consistent with the CEQ's NEPA regulations, 40 CFR 1506.1, "Limitation of Actions During the NEPA Process." The ROD, issued on November 22, 1995 (60 FR 61687), presents the DOE's decision to continue operation of the existing cross-site transfer system until a replacement system is operational. The DOE also decided to continue operation of a mixer pump installed in Tank 101-SY to mitigate the accumulation of gases. Pending resolution of an identified safety issue, the DOE is deferring a decision on the retrieval of solids from Tank 102-SY and limiting the transfer of wastes through Tank 102-SY to noncomplexed wastes.

- *Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled Cruiser, Ohio Class, and Los Angeles Class Naval Reactor Plants* (Navy 1996). This U.S. Navy EIS evaluates the environmental impacts of disposal of defueled reactor plants from decommissioned naval vessels. The preferred alternative is land burial in the low-level burial ground at the Hanford Site. The DOE is a cooperating agency in the preparation of the EIS.

- *Draft Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (DOE 1995c). This EIS evaluates the environmental impacts of environmental restoration and waste management across the DOE complex.

- *Columbia River System Operation Review Final Environmental Impact Statement* (DOE et al. 1994). This EIS is a joint project of the Bureau of Reclamation, the Corps, and the Bonneville Power Administration. The EIS assesses the multipurpose

management of the Columbia River System, including the Hanford Reach. Four actions are being considered with respect to multi-purpose management of the Columbia River system.

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.

- *Addendum (Final Environmental Impact Statement): Management of Spent Nuclear Fuel from the K Basins at the Hanford Site, Richland, Washington* (DOE 1996b). The EIS and the ROD are tiered from the *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs, Final Environmental Impact Statement* (DOE 1995b). The ROD for management of K Basin SNF was issued on March 4, 1996, and identifies the DOE's decision to remove the SNF from the K Basins, vacuum dry, condition, and seal the SNF in inert gas-filled canisters for dry vault storage (61 FR 10736). Basin sludge will be transferred to double-shell tanks for management or will continue to be managed as SNF. Non-SNF debris stored in the basins will be disposed of in a LLW burial ground on the Hanford Site.

- Proposed: "Interior Columbia Basin Ecosystem Management Project Draft Environmental Impact Statement" (59 FR 4680). This EIS is being developed through a joint effort of the U.S. Department of Agriculture (Forest Service) and the Bureau of Land Management (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.

1.9 The U.S. Department of Energy's Planning Process

Several DOE initiatives that make future land-use assumptions or identify broad goals for future land uses are in preparation. Table 1-2 presents a comparison of the land-use assumptions or goals of the *Baseline Environmental Management Report* (BEMR) (DOE 1996c), the *Hanford Strategic Plan* (Strategic Plan) (DOE-RL 1994d), and this EIS.

The BEMR is the first of a series of annual reports on the activities and potential costs required to address the waste, contamination, and surplus nuclear facilities across the country that are the responsibility of the DOE's Office of Environmental Management. The BEMR provides the life-cycle cost estimates, tentative schedules, and projected activities needed to remediate DOE sites. Many broad assumptions were required to estimate the long-range costs and schedules, including assumptions regarding future land uses, cleanup levels, and priority rankings. The BEMR should not be interpreted as final DOE policy or long-term plans; instead, it is a tool to help guide overall policy development for the DOE complex.

Table 1-2. Comparison of U.S. Department of Energy Planning Efforts for Future Land Uses at the Hanford Site.

Geographic Areas	Baseline Environmental Management Report[a] Future Use Assumptions	Strategic Thinking[b] Preliminary Goals	EIS Future Land-Use Alternatives	Comprehensive Plan[c] Land-Use Designations
Columbia River	Recreational	Pending Congressional action on the Wild and Scenic River designation, use would continue to be restricted; sensitive ecological, cultural, and Native American resources would be protected.	Unrestricted Use Restricted Use No Action	Wildlife Habitat and Management Controlled Access and Recreation Special Use Areas
Reactors on the River	Open Space Wildlife Management	Remove and/or stabilize spent fuel, surplus facilities, and waste sites to eliminate the potential for future contamination of groundwater and the Columbia River and to ensure protection of people, the environment, and natural/cultural resources. The DOE would retain control of this land throughout the remediation mission and would protect archaeological, cultural, and environmental resources.	Unrestricted Use Restricted Use No Action	Environmental Restoration Open Space Restricted Controlled Access and Recreation Special Use Areas
Central Plateau	Industrial Commercial	The 200 Area and the Central Plateau would be used for management of nuclear materials, collection and disposal of waste materials that remain onsite, and other related and compatible uses. Remediation levels and disposal standards that are consistent with these long-term uses would be established.	Exclusive Use No Action	Waste Management
All Other Areas - Central Core	Open Space Wildlife Management	This area would remain in federal ownership, which is consistent with safety analysis boundaries and continued waste management operations in the 200 Area. These areas would be available for other federal programs or leased for nonfederal uses, consistent with appropriate recognition of cultural and ecosystem values.	Restricted Use No Action	Open Space Restricted Special Use Zone
All Other Areas - South 600 Area	Industrial Commercial	The 300 Area waste sites, materials, and facilities would be remediated to allow industrial and economic transition opportunities. The Federal Government would retain ownership of land in and adjacent to the 300 Area, but would lease land for private and public uses to support regional industrial and economic development. Excess land within the 1100 and 3000 Areas would be targeted for transition to nonfederal ownership.		Potential Economic Development Zone Industrial

[a]DOE 1996c.
[b]DOE-RL 1995c.
[c]DOE-RL 1996a.

The Strategic Plan establishes top level operational direction for Hanford, and provides a measurable path to achieve Hanford missions. The Strategic Plan and the *Draft Hanford Mission Direction Document* (DOE-RL 1995b) define the guidance and requirements needed to develop the detailed project plans and performance measures necessary for fulfillment of Hanford's missions. The DOE is in the process of revising the Strategic Plan (DOE-RL 1994d); completion is expected in the summer of 1996.

This EIS presents information on potential future land uses for the Hanford Site, and provides an assessment of the impacts (primarily from remediation activities) associated with achieving the future land-use objectives. The function of this EIS is to obtain input from the public and stakeholders, document the process of developing future land-use objectives, and determine the costs and benefits associated with remediating the Site to achieve the land-use objectives. Ultimately, this EIS makes irreversible and irretrievable commitments of public resources to the DOE's congressionally mandated missions.

The comprehensive land-use planning process presented in Appendix M relies on the analysis of environmental impacts presented in this EIS. The Comprehensive Plan presented in Appendix M would designate (1) site-specific land uses required to support all the DOE missions identified in the Strategic Plan through the evaluation of land-use opportunities and constraints posed by natural, cultural, and socioeconomic factors, and (2) future land uses at the Hanford Site.

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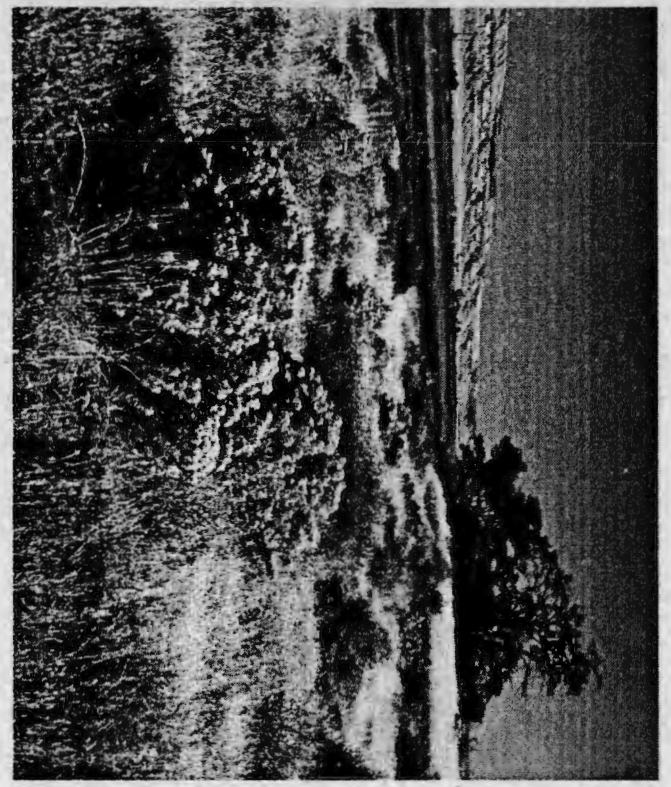

Purpose and Need

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2.0 Purpose and Need

The U.S. Department of Energy (DOE) needs to establish future land-use objectives to develop a coordinated, cost-effective, and technically sound remediation strategy for the Hanford Site. By establishing these objectives, the decisionmaking process would be streamlined, and the DOE could realize significant cost and time savings in future remediation activities.

The underlying purpose of this action is to facilitate the change in Hanford's primary mission from production of nuclear materials for national defense to long-term management of wastes. As part of this transition, the DOE must determine the optimum use of Hanford Site lands, facilities, and resources and how these lands and facilities should be remediated to allow for beneficial future uses. As a transition to the new mission, the *Richland Environmental Restoration Project Plan* (DOE-RL 1994) was developed to provide information about the mission needs and objectives, technical planning, project schedule, and resource planning necessary for remediation of past-practice waste sites and surplus facilities.

The role of this EIS is to document, in the public forum, the process of determining the best combination of potential land uses, remediation benefits, and remediation costs. Through this EIS, the DOE is responding to the need to:

- Evaluate the potential overall cumulative impacts from implementing the *Richland Environmental Restoration Project Plan* (DOE-RL 1994). Appendix A provides information on the scope of the *Richland Environmental Restoration Project Plan.*

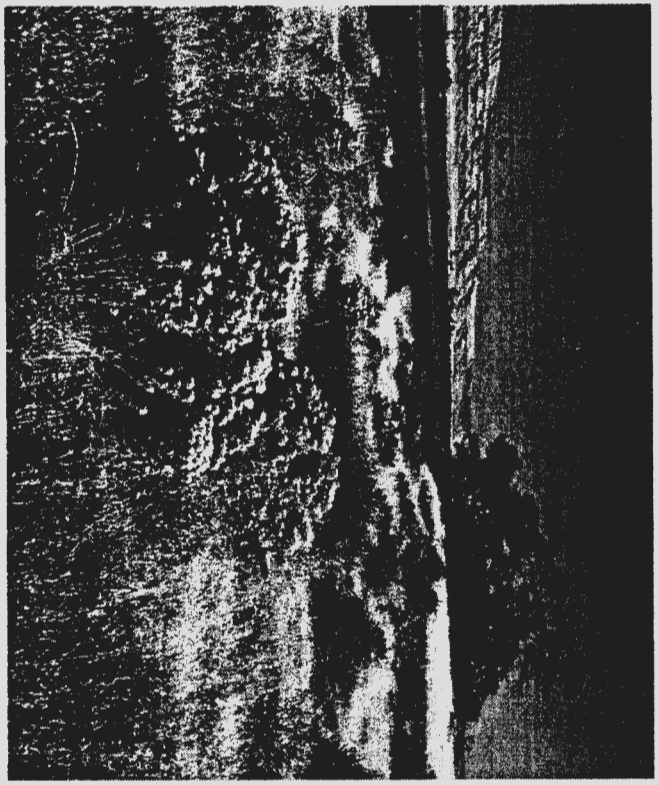
- Ensure that sitewide future land-use objectives are considered during the selection of remediation methods. U.S. Environmental Protection Agency guidance presented in Appendix L provides additional details on the consideration of land-use designations during remediation decisions.

- Develop a comprehensive land use plan (Appendix M) for the Hanford Site in accordance with DOE Order 430.1, *Life-Cycle Assessment Management* (DOE 1995).

- Identify the irreversible and irretrievable commitment of natural resources necessary to implement the *Richland Environmental Restoration Project Plan.*

The goal of this EIS is to provide decisionmakers with the information necessary to make an informed decision about the environmental impacts associated with Hanford Site remediation. The EIS provides the information needed to balance environmental impacts with (1) programmatic needs, and (2) the wishes of the public, in determining future land-use objectives for the Hanford Site. By integrating these land-use objectives in remediation decisions, the DOE will help Hanford regulators develop a coordinated, cost-effective remediation strategy (Appendix L). The comprehensive land-use planning process presented in this EIS designates the site-specific land uses required to support Hanford Site missions.

In June 1994, the Secretary of Energy issued the "Secretarial Policy Statement on the National Environmental Policy Act," (DOE 1994), which provides that the Department normally will rely on the CERCLA process for reviewing actions to be taken under CERCLA and primarily will address NEPA values and public involvement procedures through the CERCLA process. The policy also contemplates, however, that NEPA reviews may be undertaken in consultation with stakeholders and as a matter of policy for specific proposed actions. Since the proposed action to be taken under this EIS (i.e., to establish broad land use objectives) serves programmatic purposes in addition to supporting CERCLA actions, and in recognition of the support expressed by the Department's stakeholders for the preparation of this EIS, the Department has determined to prepare this EIS consistent with the 1994 NEPA policy statement.



Proposed Action and Alternatives

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3.0 Description of the 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.

The proposed action is to establish land-use objectives in order to simplify the process currently used for determining appropriate remediation levels, and minimize the likelihood of making inconsistent remediation decisions at the operable unit level for the following areas of the Hanford Site (Figure 3-1):

- Columbia River (Hanford Reach of the Columbia River [Hanford Reach])
- Reactors on the River (100 Areas)
- Central Plateau (200 Areas)
- All Other Areas (300, 400, 600, 1100, and 3000 Areas).

Implementation of the proposed action would ensure that remediation of the Hanford Site reduces human health and environmental risks to acceptable levels, while making the most efficient use of available resources.

Before the U.S. Department of Energy (DOE) can establish future land-use objectives for the Hanford Site, a range of potential future land uses for each geographic area must be evaluated. These potential future uses (land-use alternatives) are described in the following sections.

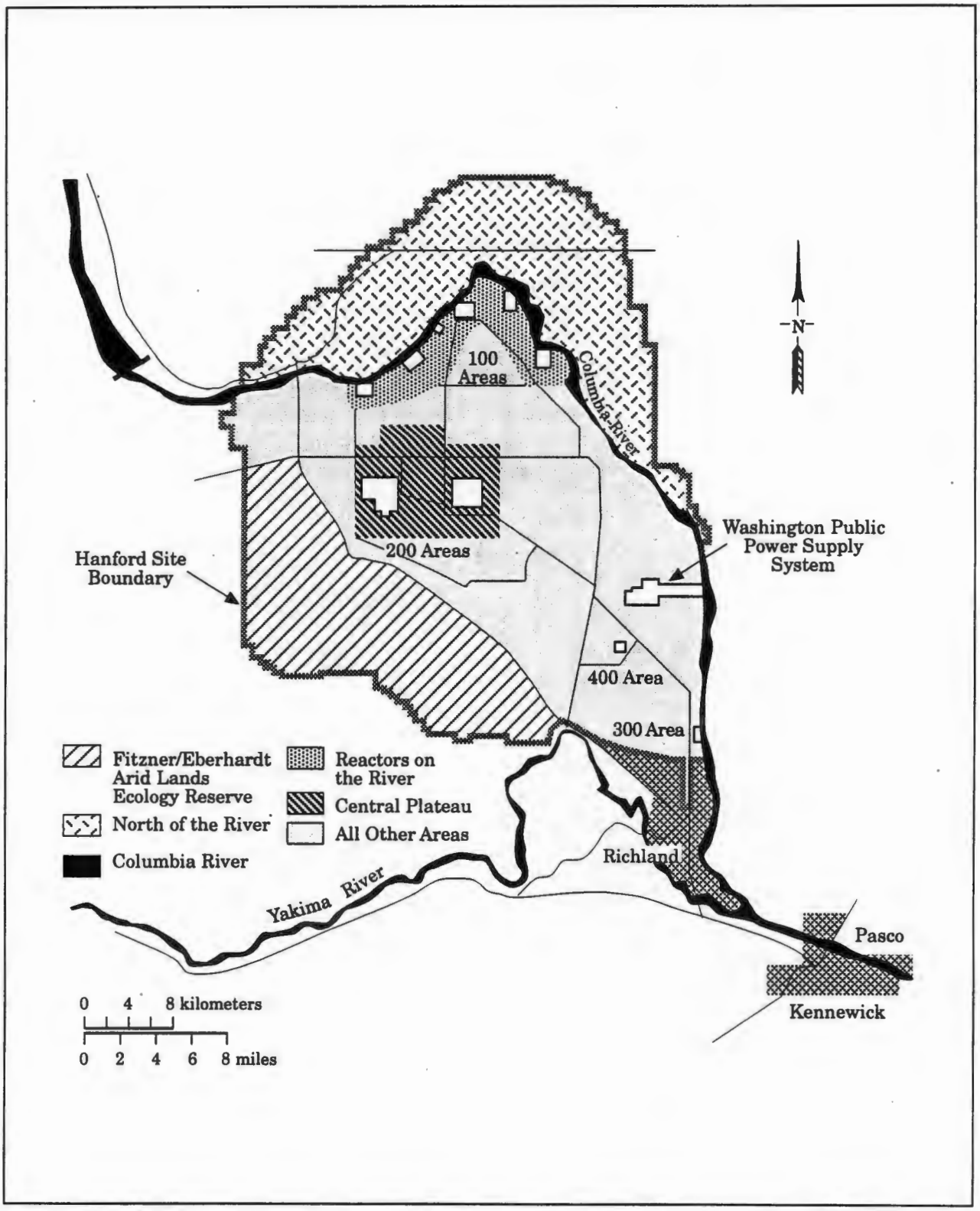
3.1 Development of Alternatives

The future land-use alternatives presented in this Environmental Impact Statement (EIS) were developed using input from the EIS scoping process, which included the report produced by the Hanford Future Site Uses Working Group (Working Group), transcripts from the four scoping meetings held in Spokane, Washington; Seattle, Washington; Richland, Washington; and Portland, Oregon, and other comments received by mail from members of the public, interested groups, and Tribal, federal, state, and local governments (DOE-RL 1994a).

Working Group Concepts Used to Establish Future Land-Use Alternatives for the Hanford Site.

The DOE has adopted the geographic area and levels of access concepts developed in the Working Group's report entitled *The Future For Hanford: Uses and Cleanup, A Final Report of the Hanford Future Site Uses Working Group* (HFSUWG 1992).

Figure 3-1. Geographic Areas of the Hanford Site.



Remediation activities would result in risk reductions to levels protective of human health and the environment. However, the means by which risk would be reduced differ among the levels of access. In developing the future land-use alternatives, risk was assumed to be lowered to acceptable levels for unrestricted use through the removal of waste. For restricted and exclusive use, the analyses assumed that risk would be lowered through continued access restrictions, removal of waste, and/or engineering and institutional controls.

Levels of Access (adapted from the Working Group's Report)

- **Unrestricted Land Use**--Residual contamination does not preclude any human uses; however, access or certain uses might 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 use or disturbance of surface soils, subsurface soils, surface water, or groundwater.
- **Exclusive Land Use**--Potential health risks due to residual contamination would limit use and require strict controls on access. Use of the area would be limited to (1) the management of radioactive and hazardous materials, and (2) similar and compatible uses. Control of the area would be maintained by the DOE. Exclusive-use areas would include buffer zones around active facilities.

The DOE is currently undecided about which combination of potential future land-use alternatives would make the best use of public resources. The information in this EIS is being presented to the public with the intent that the public will assist the DOE in formulating a long-term land use plan for the Hanford Site. After this EIS has been released to the public, and comments have been received, a preferred alternative will be developed and presented in the Final EIS, which should be available in late 1996.

3.1.1 Potential Future Land-Use Alternatives

To develop a range of potential future land-use alternatives, the DOE applied the levels of access developed by the Working Group to each of the geographic areas, with the exception of exclusive use in the Columbia River (Table 3-1). Exclusive use of the Columbia River is not considered a viable alternative because the DOE does not control nor can it impose exclusive use restrictions on the river.

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

Geographic Area	Levels of Access		
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.

The level of access applied to each of the geographic areas would determine what type of remediation is required. Much of the land within each geographic area 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, groundwater contamination or levels of contamination in some past-practice waste sites, surplus facilities, or treatment, storage, and/or disposal (TSD) units could result in unacceptable risk to human heath or 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

Although all of the future land-use alternatives identified in Table 3-1 are possible, some alternatives might be unreasonable or impractical to implement. Using guidance issued in the *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements* (DOE 1993c), three criteria were developed and used to screen the alternatives, and eliminate those alternatives determined to be unreasonable or impractical to implement. The criteria are listed as follows.

1. The alternative should be technically feasible.

2. The alternative should be economically feasible.

3. The alternative should be feasible from a common sense standpoint.

Using these screening criteria, the list of reasonable potential future land-use alternatives was reduced to 10. The shaded areas presented in Table 3-2 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 3.3.

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

Geographic Area	Potential Future Land-Use Alternatives			
Columbia River	U	R	NA	No Action
Reactors on the River	U	R	E	No Action
Central Plateau	U	R	E	No Action
All Other Areas	U	R	E	No Action

E = Exclusive.
NA = Not Applicable.
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 determined 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
  - No Action

- Reactors on the River
  - Unrestricted Future Land Use
  - Restricted Future Land Use
  - No Action

- Central Plateau
  - Exclusive Future Land Use
  - No Action

- All Other Areas
  - Restricted Future Land Use
  - No Action.

With the exception of No Action, these alternatives would allow land uses similar to those envisioned by the Working Group (HFSUWG 1992), while allowing the DOE to fulfill its missions at the Hanford Site.

Each future land-use alternative would have an associated exposure scenario, based on exposure conditions presented in the *Hanford Site Risk Assessment Methodology (HSRAM)* (DOE-RL 1995a). The exposure scenarios presented in the HSRAM define the conditions under which humans could be exposed to residual contamination. These conditions 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 *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) process when establishing remediation levels for waste sites within each geographic area. Tables 3-3 through 3-6 identify some of the exposure factors associated with each of the exposure scenarios used in this EIS. For a more complete discussion of exposure factors, refer to the HSRAM (DOE-RL 1995a).

Exposure scenarios are assumptions that establish all of the potential ways (pathways) contaminants could injure a receptor. The general intent when developing exposure scenarios is to overestimate exposures so that there is some degree of certainty that the true exposure will be lower than the estimated exposure. Similarly, the intent is not to precisely estimate exposure but to ensure that all relevant and important aspects of a person's lifestyle have been incorporated into high-end exposure scenarios so that the same degree of conservativeness is applied to both suburban and subsistence/traditional scenarios. Although these scenarios are labelled with land use names (e.g., agricultural and residential), they are actually based on activities instead of land uses. The details of these scenarios, such as groundwater accessibility or exposure duration, are determined through the CERCLA process.

Table 3-3. Agricultural Scenario Exposure Factors for Radioactive and Nonradioactive Carcinogens.

Pathway		HSRAM 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,d]	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,d]	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,e]	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

*All exposure parameters are subject to negotiation under the CERCLA process.
[a]Exposure factors for radioactive and nonradioactive carcinogens.
[b]Exposure factors for nonradioactive carcinogens.
[c]Exposure factors for radioactive carcinogens.
[d]Inhalation rate evaluated only for volatile contaminants.
[e]Ingestion of game is included in the beef ingestion exposure pathway for the human health risk assessment presented in Appendix B.
(A) = Adult.
(C) = Child.

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Table 3-4. Residential Scenario Exposure Factors for Radioactive and Nonradioactive Carcinogens.

Pathway		HSRAM 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[e]	Ingestion[a]	2 L/d	365	30
	Inhalation[a,d]	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,d]	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	Fish[a]	54 g/d	365	30
	Fruit[a]	42 g/d	365	30
	Vegetable[a]	80 g/d	365	30

*All exposure parameters are subject to negotiation under the CERCLA process.

[a]Exposure factors for radioactive and nonradioactive carcinogens.

[b]Exposure factors for nonradioactive carcinogens.

[c]Exposure factors for radioactive carcinogens.

[d]Inhalation rate evaluated only for volatile contaminants for nonradioactive contaminants; evaluated for radon-222 only for radioactive contaminants.

[e]Intake rate for noncarcinogens listed only as 200 mg/d; does not differentiate between adult and child.

(A) = Adult.

(C) = Child.

Table 3-5. Industrial Scenario Exposure Factors for Radioactive and Nonradioactive Carcinogens.

Pathway		HSRAM 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,d]	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,d]	20 m^3/d	250	20
	Dermal[b]	0.17 hr/d	250	20

*All exposure parameters are subject to negotiation under the CERCLA process.
[a]Exposure factors for radioactive and nonradioactive carcinogens.
[b]Exposure factors for nonradioactive carcinogens.
[c]Exposure factors for radioactive carcinogens.
[d]Inhalation rate evaluated only for volatile contaminants.

Table 3-6. Recreational Scenario Exposure Factors for Radioactive and Nonradioactive Carcinogens.

Pathway		HSRAM 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/cm^2/d	7	6 (C) 24 (A)
	External[c]	8 hr/d	7	30
Air	Inhalation[a]	20 m^3/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/cm^2/d	7	6 (C) 24 (A)
Biota	Game[a]	1 g/d	365	30
	Fish[a]	54 g/d	365	30

*All exposure parameters are subject to negotiation under the CERCLA process.
[a]Exposure factors for radioactive and nonradioactive carcinogens.
[b]Exposure factors for nonradioactive carcinogens.
[c]Exposure factors for radioactive carcinogens.
(A) = Adult.
(C) = Child.

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 this scenario involves exposures along the largest number of pathways (including human intake and exposure to agricultural products) for the longest period of time (Table 3-3). The residential, recreational, and industrial exposure scenarios are all potential scenarios under the restricted future land-use alternatives (R1 and R2). Each of these scenarios involve some level of restriction (i.e., restricted exposure pathway or duration period). The public will be provided the opportunity to assist the agencies in developing site-specific exposure scenarios through the CERCLA process.

Residential, industrial, and recreational exposure scenarios would be used in the All Other Areas geographic area to reflect potential industrial use of the 300 Area, the 400 Area, and the Washington Public Power Supply System (WPPSS) leasehold, and nonindustrial uses of 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. Restrictions would be required because irrigation of land overlying contamination plumes could drive additional contaminants into the groundwater. In addition, irrigation of land located upgradient of contaminated plumes could change groundwater flow paths and associated contaminant plumes.

Only the industrial exposure scenario would be used for the Central Plateau geographic area, because the Exclusive Future Land-Use Alternative assumes that only DOE waste management and similar activities would occur, and that the buffer zone around the 200 East and 200 West Areas, where needed, would not be available for other uses.

Table 3-7 identifies the relationships between the future land-use alternatives, and cleanup scenarios and land-use options identified by the Working Group for each geographic area. The DOE used the Working Group's potential land-use options and cleanup scenarios to identify which HSRAM exposure scenarios best fit the EIS future land-use alternatives.

Table 3-7. Relationship Between the Hanford Future Site Uses Working Group Land-Use Options, Cleanup Scenarios, and Environmental Impact Statement Future Land-Use Alternatives.

WORKING GROUP LAND-USE OPTIONS	WORKING GROUP CLEANUP SCENARIOS	ENVIRONMENTAL IMPACT STATEMENT FUTURE LAND-USE ALTERNATIVES
COLUMBIA RIVER		
1. Wildlife and Recreation 2. Recreational and Related Commercial, Scenic and Economic Uses 3. Native American Uses	Unrestricted (All Options)	Unrestricted (Agricultural)*
		Restricted (Recreational, Industrial, or Residential)*
REACTORS ON THE RIVER		
1. Native American Uses 2. Wildlife and Recreation 3. Limited Recreation, Recreation-Related Commercial Uses, and Wildlife 4. B Reactor as a Museum/Visitor Center	All Unrestricted	Unrestricted (Agricultural)*
	Clean Enough for Land Use Option 3 (Option 3) Unrestricted; B Reactor Restricted (Option 4)	Restricted (Residential Industrial, or Recreational)*
CENTRAL PLATEAU		
1. Onsite Waste and Existing Obligations for Disposal 2. Option 1 plus Offsite DOE Waste for Treatment Only 3. Option 2 plus Offsite Commercial Waste for Treatment Only 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 long-term MRS 6. Option 5 plus Compatible Commercial or Industrial Activity	Exclusive Use with Buffer (All Options)	Exclusive (Industrial)* (within the squared-off area between and including the 200 East and 200 West Areas and the industrial region located east of the 200 East Area)
ALL OTHER AREAS		
1. Focus on Economic Development 2. Focus on Wildlife 3. Native American Uses 4. Agricultural Use	Cleanup for Economic Development Wildlife (Options 1, 2, and 3) Cleanup for Agricultural and Native American uses outside the 300 Area (Options 3 and 4)	Restricted (Recreational Residential, or Industrial)*

*Exposure scenarios from the *Hanford Site Risk Assessment Methodology* associated with the EIS future land-use alternatives.

DOE = U.S. Department of Energy.
HLW = high-level waste.
LLW = low-level waste.
MRS = monitored retrievable storage.
SNF = spent nuclear fuel.
TRU = transuranic.

3.2 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 the fact that specific remediation activities, technologies, strategies, and costs would be assessed and refined through CERCLA and/or *Resource Conservation and Recovery Act of 1976* (RCRA) processes on a case-by-case basis. This general discussion allows the evaluation of potential environmental consequences associated with remediation and would allow for the development and use of innovative technologies.

The proposed action includes decommissioning of surplus facilities for which the DOE is ready to make decommissioning decisions (DOE 1996). 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)* (DOE 1995b). This policy established the approach agreed upon by the DOE and the EPA to conduct decommissioning projects under CERCLA authority. Any decision made regarding the potential fate of the river discharge pipelines and surplus facilities in this EIS will be the basis for a decision on an overall strategy for remediation and decommissioning; specific plans will be developed through the CERCLA process. Before this policy was issued, the DOE conducted decommissioning activities as separate and discrete projects that were not subject to CERCLA or RCRA requirements. The majority of current decommissioning projects, including those addressed in this EIS, will be managed through the CERCLA process.

Decommissioning Under CERCLA

As defined in the *Policy on Decommissioning of Department of Energy Facilities Under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)* (DOE 1995b): "... 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."

3.2.1 No-Action Alternative

Consideration of a No-Action Alternative is required by the DOE and the Council on Environmental Quality (CEQ) regulations implementing NEPA, 40 *Code of Federal Regulations* (CFR) 1500-1508, to provide a baseline for comparison of impacts from the other alternatives. In this EIS, the term "no action," does not mean that the DOE would take no further action of any kind at the Hanford Site; instead, "no action" is defined for purposes of this document to mean that the DOE would conduct a long-term monitoring and maintenance program instead of continuing with the current program of TSD unit closures, past-practice waste site remedial actions, and surplus facility decommissioning actions. The No-Action Alternative is common to all of the geographic areas, but specific monitoring and maintenance activities would vary depending on the types of waste sites and facilities found in each area.

Although the activities conducted under the No-Action Alternative would provide a measure of containment and control of contaminants, they do not constitute permanent remedial actions or complete decommissioning actions. The DOE recognizes that actual implementation of the No-Action Alternative, for the Hanford Site as a whole, might be contrary to the provisions of the *Hanford Federal Facility Agreement and Consent Order* (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 in the Tri-Party Agreement. Should the No-Action Alternative be selected and if, in the future, the DOE determines that portions of the Hanford Site 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 that allow for that desired land use would be conducted.

The No-Action Alternative is not expected to pose unacceptable risk to human health or the environment as long as the monitoring and maintenance program is in place. However, evaluation of long-term risks under the No-Action Alternative requires consideration of the eventual loss of DOE management and control. 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 active institutional control would cease. After that time, for purposes of the analysis, it is assumed 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, and is an assumption made without reference to legal requirements[1].

Exposure Controls Under the No-Action Alternative

Under the No-Action Alternative, administrative controls that regulate allowable worker and public exposure to radioactive and hazardous materials would remain in place. These controls include:

- 10 CFR 835, "Occupational Radiation Protection," provides exposure guidelines, training requirements, monitoring requirements, access restrictions, and design and control requirements. These controls are designed to minimize radiation exposure at DOE facilities.
- As Low As Reasonably Achievable (ALARA) principles implemented at DOE facilities. ALARA provides an approach to be used in managing and controlling exposures to hazardous or radiological materials. ALARA is not a dose limit, but a process that has the objective of attaining doses as far below the applicable limits as is reasonably achievable.
- DOE Orders 5480.4, *Environmental Protection, Safety and Health Protection Standards* (DOE 1993a), and 5400.5, *Radiation Protection of the Public and the Environment* (DOE 1993b), identify mandatory environmental, safety, and health standards applicable to construction, operation, and decommissioning activities for DOE facilities. These standards identify allowable exposure levels and procedures to ensure that exposures are minimized in accordance with the ALARA process.

Activities included in the definition of the No-Action Alternative fall into two major 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 these two categories are discussed in more detail in the following sections.

[1]Loss of institutional control after 100 years is referenced in U.S. Nuclear Regulatory Commission regulations (10 CFR 61.59), which are not applicable to the DOE, but are helpful in this context.

3.2.1.1 Monitoring. 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 1995a). 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), external radiation, and chemical levels on and near the Hanford Site.

3.2.1.2 Maintenance. The DOE would continue a program of maintenance activities similar to those activities presently conducted under established Hanford Site maintenance programs. These activities would consist of surveillance and maintenance of surplus facilities, stabilization of waste sites, and safeguards and security, as described below.

3.2.1.2.1 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. This would ensure containment and control of radiological, environmental, and safety hazards, and protection of 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.

3.2.1.2.2 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 minimize the spread of surface contamination and the associated potential for 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 activities would include consolidation of contaminated soil. 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 waste site boundaries and stabilized by covering with clean soil. The areas would be revegetated or otherwise covered to reduce or prevent soil erosion. Stabilization activities also could involve stabilizing contaminated sediments along the Columbia River shoreline by covering sediments with riprap to prevent human access. 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 the use of herbicides during spring and fall to prevent the establishment of aggressive, deep-rooted weed species in order to prevent uptake of contaminants through the plant root systems and spread 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).

3.2.1.2.3 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: 1994 Fiscal Year Work Plan* (WHC 1994) would be conducted to maintain security of materials and facilities, and prevent unauthorized access. These activities would consist of patrol force operations, security systems testing, security education, security systems maintenance and engineering, security upgrade projects, and the locksmith program.

3.2.2 Columbia River Alternatives

The Columbia River geographic area encompasses 82 km (51 mi) of the Columbia River, which flows through or borders the Hanford Site, and includes the river islands and island sediments, riverbottom and riverbank sediments, and the area 0.4 km (0.25 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 Environmental Impact Statement, Final - June 1994* (NPS 1994). This stretch of the river, referred to as the Hanford Reach, offers a unique example of riparian ecologies that characterized the Columbia Basin before construction of hydroelectric dams on the river. The Columbia River is not a designated CERCLA operable unit; however, contamination has occurred at several locations along the Hanford Reach as a result of contaminated groundwater entering the Columbia River from other areas on the Hanford Site. The major radiological and chemical contaminants in the groundwater include tritium, strontium-90, chromium, technetium-99, and uranium. Additional contamination and physical hazards are associated with the river discharge pipelines from the production reactors, which are buried beneath the riverbank and riverbottom sediment (Figure 3-2). These pipelines extend from the outfall structures into the river, and are contaminated primarily with cobalt-60, europium-152, europium-154, and europium-155 (UNI 1986). Specific locations and concentrations of radiological and chemical contaminants are not presently well known and will be determined by characterization activities conducted under the CERCLA process. Remediation of the Columbia River (to address Hanford Site contamination) will be undertaken through the CERCLA process.

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

3.2.2.1 No-Action Alternative. The No-Action Alternative for the Columbia River geographic area would consist of continuing environmental monitoring, surveillance and maintenance, and the safeguards and securities program (see Section 3.2.1). The DOE would maintain institutional control over the Columbia River geographic area, and would allow continued use of the area for wildlife research and controlled recreation. Public access to the riverbank and islands would continue to be restricted. Restrictions on activities that disturb sediments on the riverbank, riverbottom, and islands would be maintained. For analysis purposes, it is assumed that the DOE relinquishes institutional control of the Hanford Site after 100 years.

3.2.2.2 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. 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 (Ecology et al. 1989). Under this alternative, contamination detected in future characterization studies would be removed to levels that would not preclude any human use.

9613459.1953

Figure 3-2. Reactor Outfall Pipeline Schematic.

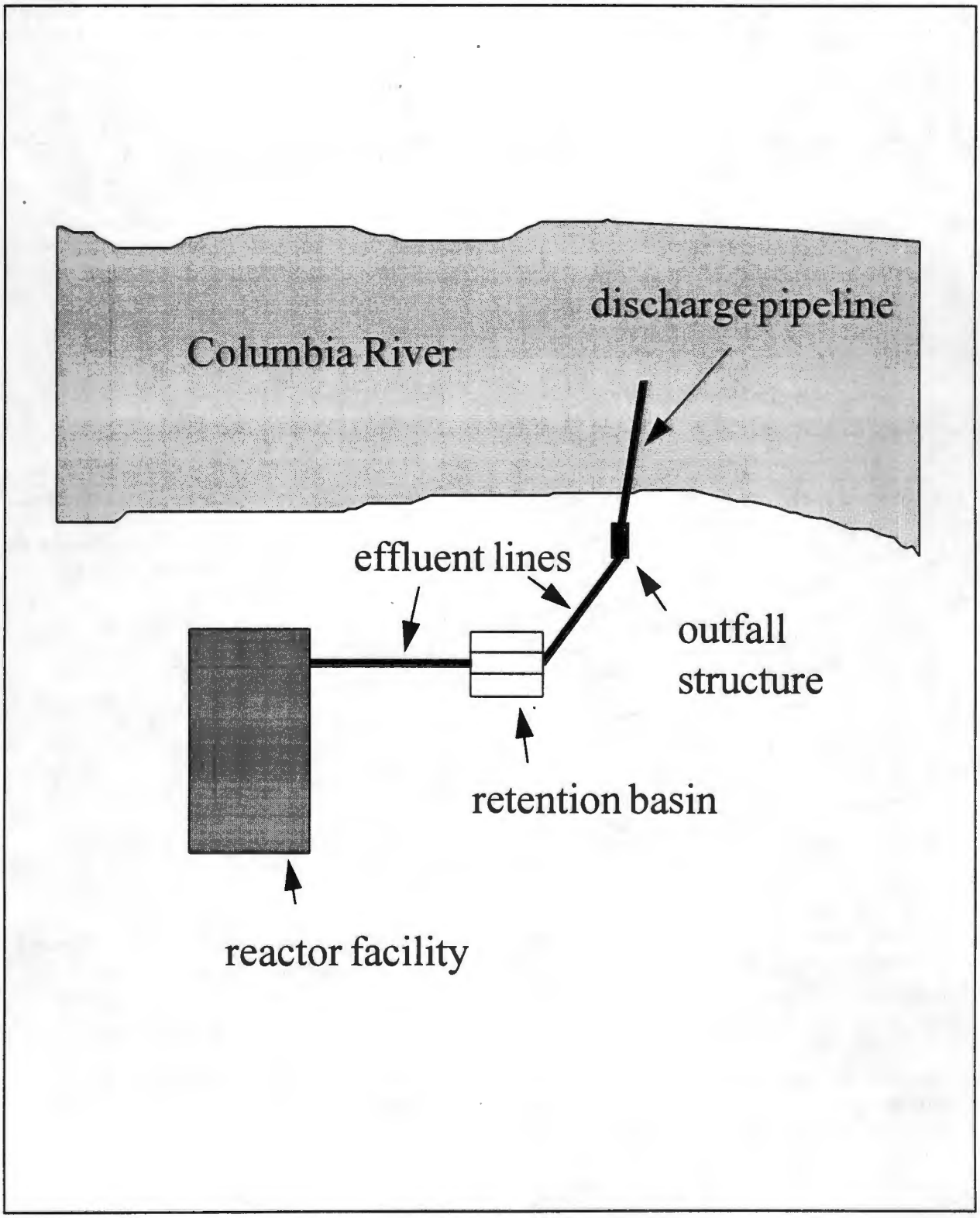


Table 3-8. Future Land-Use Alternatives for the Columbia River Geographic Area.

Alternatives	Actions to be Implemented	Exposure Scenario[a]	Land-Use Restrictions
No-Action	• Continue environmental monitoring • Continue safeguards and security program • Continue institutional controls • Stabilize contaminated sediments as necessary with riprap	Not Applicable	• Maintain restrictions on sediment disturbance • Maintain current controlled use of the river by recreational users
Unrestricted Future Land Use	• Excavate contaminated riverbank, riverbottom, and island sediments • Remove river discharge pipelines through use of cofferdams and sediment dewatering • Transport contaminated materials to an onsite disposal facility • Establish and maintain upgradient control of groundwater plumes to avoid recontaminating sediments • Perform site reclamation • Recontour riverbottom and shoreline, where necessary • Continue environmental monitoring • Continue institutional controls	Agricultural	• Remove access and activity restrictions after remediation • Eliminate restrictions on public access because of contaminants; access might continue to be restricted because of physical hazards or environmental sensitivity
Restricted Future Land Use	• Stabilize river discharge pipelines in place; seal ends with grout • Remove any detached pipeline segments, if found; leave associated tie-down structures in place • Perform limited excavation of contaminated sediments, as necessary, consistent with the recreational, residential, or industrial exposure scenario • Transport contaminated materials to onsite disposal facility • Recontour riverbottom and shoreline, where needed • Continue environmental monitoring • Continue institutional controls	Recreational Residential Industrial	• Maintain restrictions on sediment disturbance • Maintain current controlled use of river by recreational users

[a]Exposure scenarios such as these would be negotiated in the CERCLA process, and would be used to establish cleanup levels.

However, access or certain uses could continue to be controlled for other reasons (i.e., the presence of physical hazards or to protect cultural resources and sensitive wildlife habitat). This alternative would enable future land uses that are consistent with those envisioned by the Working Group (see Table 3-7). 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 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. Upgradient control of groundwater plumes would be required to prevent recontamination of sediment. 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). Similar remedial actions could be implemented for other river shoreline areas outside the Reactors on the River geographic area, but detailed site-specific 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 might require use of a cofferdam and a sediment dewatering system in the river. Tie-down structures used to anchor 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 waste containers at a staging area 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 geographic area for disposal. Uncontaminated structures would be recycled and used within the DOE complex, or compacted for disposal as solid waste in an onsite facility.

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. Decommissioning decisions would be modified, as necessary, through the CERCLA process or, where applicable, the Tri-Party Agreement change process.

3.2.2.3 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 that require some continuing restrictions on human use of the Columbia River geographic area. Under the Restricted Future Land-Use Alternative, current 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 riverbottom sediments. Use and access restrictions would be enforced by institutional controls (e.g., land use plans, use permits, fencing, signs, and deed restrictions). This alternative would enable future land uses that essentially are consistent with those envisioned by the Working Group (see Table 3-7). The CERCLA exposure scenarios associated with these land uses include recreational, residential, or industrial (see Section 3.1.3).

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

If any sections of pipelines become detached, the pipeline segments would be cut into manageable pieces, the ends sealed, and sections wrapped or placed in containers for disposal as LLW or LLMW (DOE-RL 1994b). The pipeline sections then would be hauled by truck or rail to the Central Plateau geographic area 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 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 and transported by truck or rail to the Central Plateau geographic area for storage or disposal.

3.2.3 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 sites, TSD units, and surplus facilities in the 100 Area, as listed in Appendix A. The effluent lines running from the reactor facilities to the outfall structures are included in this geographic area (see Figure 3-2). The boundaries of the Reactors on the River geographic area correspond to the area that 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 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, and isotopes of uranium. Chemical contaminants include chromium, nitrate, and trichloroethylene. Specific locations and concentrations of radiological and chemical contaminants will be determined by characterization activities conducted under CERCLA.

The Hanford Site'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. For purposes of analysis, 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 Record of Decision (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* (FR) (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 105-N Reactor is dismantled and removed for disposal on the Central Plateau geographic area in a method similar to the other surplus reactors.

Table 3-9 depicts the Reactors on the River future land-use alternatives selected for detailed analysis, with associated actions to be implemented; exposure scenarios; and potential land-use restrictions.

Table 3-9. Future Land-Use Alternatives for the Reactors on the River Geographic Area.

Alternatives	Actions to be Implemented	Exposure Scenario[a]	Land-Use Restrictions
No-Action	• Stabilize waste sites • Continue environmental monitoring • Continue institutional controls • Continue safeguards and security program	Not Applicable	• Maintain restrictions on public access • Maintain restrictions on use of groundwater • Maintain restrictions on soil disturbance
Unrestricted Future Land Use	• Excavate contaminated soils and materials; treat as necessary • Close TSD units • Decommission surplus facilities and reactor effluent lines • Remove any TRU waste discovered to storage in the 200 Areas • Transport contaminated materials to onsite disposal facility • Perform groundwater remediation to allow unrestricted future use and to protect the river • Perform site reclamation • Continue environmental monitoring	Agricultural	• Remove access restrictions after remediation • Eliminate restrictions on public access because of contaminants; access might continue to be restricted because of physical hazards or environmental sensitivity
Restricted Future Land Use (R1)	• Perform limited excavation, and treatment, as necessary, of contaminated soils and materials, consistent with the recreational, residential, or industrial exposure scenario • Transport the residual contaminated materials to onsite disposal facility • Remove any TRU waste to storage in the 200 Areas • Perform groundwater remediation to protect uncontaminated groundwater and the river • Perform site reclamation • Continue environmental monitoring • Continue institutional controls	Recreational Residential Industrial	• Maintain restrictions on use of groundwater • Maintain restrictions on subsurface disturbance
Restricted Future Land Use (R2)	• Construct caps over waste sites and TSD units • Perform groundwater sampling to monitor cap performance • Perform groundwater remediation to protect uncontaminated groundwater and the river • Perform site reclamation • Continue environmental monitoring • Continue institutional controls	Recreational Residential Industrial	• Maintain restrictions on use of groundwater • Maintain restrictions on subsurface disturbance

[a]Exposure scenarios such as these would be negotiated in the CERCLA process, and would be used to establish cleanup levels.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
TRU = transuranic.
TSD = treatment, storage, and/or disposal.

3.2.3.1 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 3.2.1. The DOE would maintain institutional control of the Reactors on the River geographic area and continue the management of existing waste sites. Public access would remain restricted. These uses and restrictions would remain in place until DOE determined that the lands were no longer needed to fulfill the current mission or DOE relinquished institutional control of the Hanford Site (assumed to be 100 years for analysis purposes).

3.2.3.2 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 sites and groundwater, in conjunction with closure of TSD units 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 do not preclude any human use. However, access or certain uses might continue to be controlled for other reasons (i.e., the presence of physical hazards or to protect cultural resources and/or sensitive wildlife habitat). This alternative would enable future land uses that are consistent with those envisioned by the Working Group (see Table 3-7). As described in Section 3.1.3, the CERCLA exposure scenario associated with this alternative is agricultural.

This alternative would include extensive excavation of surface/subsurface past-practice waste sites and TSD units to reduce contaminant exposure through the dermal, ingestion, and inhalation pathways under the agricultural exposure scenario. If transuranic (TRU)-contaminated waste is identified, the waste would be processed and placed into interim storage in the 200 Areas until permanent disposal is available. Buried LLW and LLMW would be retrieved, treated (if needed), packaged, 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 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 waste containers at a staging area 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 existing contaminant plumes located in, or 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 exposure scenario.
- Protect the Columbia River and its associated ecosystem.

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

- Extensive excavation of past-practice waste sites and TSD units, as described above, to reduce sources of contamination.
- Pumping and treating groundwater plumes to levels protective of future groundwater users and 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 that controls are no longer necessary.

This groundwater operable unit remediation strategy would be determined through the CERCLA process.

*3.2.3.3 **Restricted Future Land-Use Alternative**.* A restricted future land-use alternative for this geographic area could be achieved through a combination of remedial activities, including excavation and disposal of contaminated soil, remediation of past-practice waste sites, closure of TSD units, site reclamation, decommissioning of surplus facilities, and/or use of engineering and institutional controls. In addition to these potential remediation activities, a groundwater remediation strategy would be developed and employed for the Reactors on the River geographic area.

Some residual contamination would be left in place in areas where exposures do not pose unacceptable risk. Because of the presence of residual contamination, implementation of a Restricted Future Land-Use Alternative would require continuing restrictions on certain human uses within the Reactors on the River geographic area. These restrictions would be placed on withdrawal and use of groundwater and soil disturbing activities at or near sites with residual contamination. This alternative would be consistent with the CERCLA Interim Action ROD (EPA 1995a) for 100 Area wastes sites. This ROD allows for unrestricted surface use under a residential exposure scenario and restricted use (through the use of deed restrictions) of the subsurface (generally below 4.6 m, 15 ft) and groundwater. As indicated above, there are many potential remediation activities that would be appropriate to achieve the objectives of a Restricted Future Land-Use Alternative for the Reactors on the River geographic area. One of the following options, or a combination of options, could be used to remediate the geographic area to allow restricted future land uses. The first option (R1) would

emphasize removal and disposal of waste and contaminated materials, groundwater remediation, and continuing access restrictions. The second option (R2) would emphasize the placement of engineered caps over waste sites, in addition to groundwater remediation. The following sections describe in more detail the potential remediation associated with options R1 and R2.

3.2.3.3.1 Restricted Future Land-Use Alternative (R1). As with the Unrestricted Future Land-Use Alternative (see Section 3.2.3.2), this Restricted Future Land-Use Alternative (R1) would be achieved through excavation of contaminated soil and remediation of past-practice waste sites and groundwater, in conjunction with closure of TSD units 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 continued restrictions on use because of residual contamination. Restrictions on activities that disturb soil would apply in and around revegetated excavation sites. In addition, withdrawal and use of groundwater would be controlled for an indefinite period. Monitoring and institutional controls (e.g., signs, land use plans, fencing, and deed restrictions) would be used, as necessary, to restrict use and access. This alternative would enable future land uses that essentially are consistent with those envisioned by the Working Group (see Table 3-7). The CERCLA exposure scenarios associated with this alternative include recreational, residential, or industrial.

Restricted Future Land-Use

The Restricted Future Land-Use Alternative is subdivided into two alternatives: R1 and R2, for the Reactors on the River and All Other Areas geographic areas. Each alternative achieves protection of human health and the environment to a degree consistent with restricted future uses, but the remediation approaches of the alternatives are different. The Restricted Future Land-Use Alternative (R1) focuses on limited excavation, removal, and disposal of surface and subsurface waste site contaminants, while the Restricted Future Land-Use Alternative (R2) focuses on construction of protective surface caps over surface and subsurface waste sites to prevent exposures and surface water intrusion.

The levels of continued restrictions probably would not be applied to the entire Reactors on the River geographic area; the restrictions primarily would apply 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, however, access or certain uses could continue to be controlled for other reasons (e.g., the presence of physical hazards or to protect cultural resources and sensitive wildlife habitat).

The Restricted Future Land-Use Alternative (R1) for the Reactors on the River geographic area would include limited excavation of surface and/or subsurface past-practice waste sites and TSD units, in conjunction with decommissioning of surplus contaminated and uncontaminated facilities. Further excavation would be required where residual contamination remains in quantities sufficient to be a threat to groundwater. However, some contamination would be left in place where exposures do not pose unacceptable risk. Contaminant exposure would be reduced to levels acceptable under the recreational, residential, or industrial exposure scenarios. If TRU-contaminated waste was identified, the waste would be processed and placed into interim storage until permanent disposal is available. Buried LLW and LLMW 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 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 existing contaminant plumes located in, or potentially entering into, the Reactors on the River geographic area. This groundwater remediation strategy would include two primary goals.

- Protect currently uncontaminated groundwater.
- Protect the Columbia River and its 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 toward the Columbia River. These measures would include:

- Limited excavation of past-practice waste sites and TSD units, 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 groundwater sampling results indicate that controls are no longer necessary.

This groundwater operable unit remediation strategy would be determined through the CERCLA process.

3.2.3.3.2 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, and groundwater remediation. Past-practice waste sites and TSD units 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 that require continued restrictions on use because of residual contamination. Restrictions on activities that disturb soil would apply in and around capped waste sites. In addition, withdrawal and use of groundwater would be controlled for an indefinite period. Monitoring and institutional controls (e.g., signs, land use plans, 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 that essentially are consistent with those envisioned by the Working Group (see Table 3-7). The CERCLA exposure scenarios associated with these land uses include recreational, residential, or industrial.

The Restricted Future Land-Use Alternative (R2) for the Reactors on the River geographic area would involve leaving in place contaminated soils, and buried LLW and LLMW contained within past-practice waste sites and TSD units. Human and ecosystem exposure to contamination would be limited through the use of protective caps. Several alternative cap designs are being considered. For purposes of this analysis, 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 long-term integrity of caps. Groundwater monitoring would be used to monitor cap performance.

The groundwater remediation strategy for the Restricted Future Land-Use Alternative (R2) would be the same as described in the Restricted Future Land-Use Alternative (R1) (pump and treat), but would not include excavation activities. Instead, caps would be used to prevent migration of source contaminants to the groundwater.

3.2.4 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, and waste management and disposal activities, and is the most extensively contaminated area of the Hanford Site. Appendix A provides a listing of the past-practice waste sites and TSD units that are located within the Central Plateau geographic area and included within the scope of this EIS. Contaminants within the Central Plateau geographic area include, but are not limited to, tritium, cobalt-60, strontium-90, technetium-99, iodine-129, cesium-137, uranium, plutonium, carbon tetrachloride, trichloroethylene, nitrate, chloroform, and fluoride (DOE-RL 1994b, DOE-RL 1994c, PNL 1995b).

Table 3-10 depicts the Central Plateau future land-use alternatives selected for detailed analysis, with associated actions to be implemented; exposure scenarios; and potential land-use restrictions.

Table 3-10. Future Land-Use Alternatives for the Central Plateau Geographic Area.

Alternatives	Actions to be Implemented	Exposure Scenario[a]	Land-Use Restrictions
No-Action	• Stabilize waste sites • Continue environmental monitoring • Continue institutional controls • Continue safeguards and security program	Not Applicable	• Maintain restrictions on public access • Maintain restrictions on the use of groundwater • Maintain restrictions on soil disturbance
Exclusive Future Land Use	• Perform limited excavation of contaminated soils and materials • Transport contaminated soils and materials to a common area for consolidation • Construct caps over waste sites and TSD units • Perform groundwater sampling to monitor cap performance • Perform groundwater remediation to protect uncontaminated groundwater and the Columbia River • Perform site reclamation • Continue environmental monitoring • Continue institutional controls	Industrial	• Maintain restrictions on public access • Maintain restrictions on the use of groundwater • Maintain restrictions on soil disturbance

[a]Exposure scenarios such as these would be negotiated in the CERCLA process, and would be used to establish cleanup levels.
TSD = treatment, storage, and/or disposal.

3.2.4.1 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 (see Section 3.2.1). The DOE would maintain institutional control of the Central Plateau geographic area, and would continue to use the area for waste management and similar activities. Public access, withdrawal and use of groundwater, and soil disturbing activities would remain restricted. These uses and restrictions would remain in place until the DOE determined that the lands were no longer needed to fulfill its current mission or the DOE relinquished institutional control of the Hanford Site (assumed to be 100 years for analysis purposes).

3.2.4.2 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, groundwater remediation, and capping of past-practice waste sites and TSD units. This alternative would enable future land uses that are consistent with those envisioned by the Working Group (see Table 3-7). The CERCLA exposure scenario associated with this alternative is industrial. In an effort to respond to comments made during the EIS scoping process, the DOE would ensure that this Exclusive Future Land-Use Alternative allowed certain Native American uses in portions of the area. These uses, however, probably would be constrained in order to continue to protect human health and safety. Tribal members entering waste management zones would be subject to the same administrative controls as workers, which could include badging and training requirements. The DOE is anticipated to maintain institutional control of the Central Plateau geographic area, and would continue to use the area for waste management activities and other similar compatible uses. 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 risk associated with managing the contamination present in the Central Plateau geographic area. Although the buffer zone would be classified as an exclusive use area, waste management activities, other than those associated with environmental restoration, would not be allowed within this zone. The boundaries of this buffer zone would be determined through conventional risk management practices, and periodically would be reassessed to reflect current risk (HFSUWG 1992). Remediation of the Central Plateau geographic area was assumed to reduce risk 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 purposes.

Central Plateau Buffer Zone

The Working Group proposed a protective buffer zone around the borders of the 200 Area waste management zone to minimize human exposure to radioactive and chemical substances. Within the buffer zone, environmental restoration activities, which include waste site capping, consolidation, and other permitted activities (e.g., waste treatment facilities), could occur.

Remediation of the Central Plateau geographic area would reduce risk 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 and could be used for other purposes; however, DOE controls for emergency preparedness might still apply. See Section 4.11.3 for information about emergency preparedness requirements.

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 sites and TSD units, 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 this analysis, a modified RCRA cap was used in the analysis of environmental

consequences for the Central Plateau geographic area in Chapter 5.0[2]. 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. Groundwater monitoring would be used to monitor cap performance.

Where determined cost effective, contaminants from past-practice waste sites and TSD units would be consolidated in order to minimize the size of waste sites. For example, it might be more cost effective to excavate and consolidate contaminated soils from several waste sites than to construct several separate caps. Remediated sites would be recontoured to blend in with the surrounding topography and revegetated or otherwise covered.

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

- Protect currently uncontaminated groundwater.
- Protect the Columbia River and its 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. These measures would include:

- Pumping and treating localized groundwater plumes.
- Pumping and treating high-concentration core areas of existing plumes.
- Monitoring natural attenuation of contaminated groundwater plumes.
- Maintaining institutional controls to regulate groundwater use until sampling results indicate that controls are no longer necessary.

This groundwater remediation strategy would be determined through the CERCLA process based on the future land-use alternatives selected for the Reactors on the River and the Columbia River geographic areas. If the Restricted Future Land-Use Alternative is selected for these two geographic areas, the groundwater plumes originating from the Central Plateau would be remediated to levels protective of the Columbia River. Should the Unrestricted Future Land-Use Alternative be selected for these geographic areas, the groundwater plumes entering the Reactors on the River or the Columbia River geographic areas would be remediated to levels corresponding to acceptable risks under the agricultural exposure scenario.

3.2.5 All Other Areas Alternatives

The All Other Areas geographic area is comprised 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), 1100, and 3000 Areas. Portions of this geographic area have been used for research and development, fuel fabrication, an experimental breeder reactor, physical plants, and

[2]A RCRA cap would not be used for TRU waste sites; a cap similar to the design presented in Appendix E would be used.

commercial power facilities. This area contains large tracts of undeveloped land that are located between developed sections. Appendix A provides a list of past-practice waste sites, TSD units, and surplus facilities located within the All Other Areas geographic area that are included in the scope of this EIS.

Table 3-11 depicts the All Other Areas future land-use alternatives selected for detailed analysis, with associated actions to be implemented; exposure scenarios; and potential land-use restrictions.

Table 3-11. Future Land-Use Alternatives for the All Other Areas Geographic Area.

Alternatives	Actions to be Implemented	Exposure Scenario[a]	Land-Use Restrictions
No-Action	• Stabilize waste sites • Continue environmental monitoring • Continue institutional controls • Continue safeguards and security program	Not Applicable	• Maintain restrictions on public access • Maintain restrictions on use of groundwater • Maintain restrictions on soil disturbance
Restricted Future Land-Use (R1)	• Perform limited excavation of contaminated soils and material, consistent with the recreational, residential, or industrial exposure scenario • Transport contaminated materials to onsite disposal facility • Perform groundwater remediation to protect uncontaminated groundwater and the river • Perform site reclamation • Continue environmental monitoring • Continue institutional controls	Recreational Residential Industrial	• Maintain restrictions on use of groundwater • Maintain restrictions on subsurface disturbance
Restricted Future Land-Use (R2)	• Construct cap over waste sites and TSD units • Perform groundwater sampling to monitor cap performance • Perform groundwater remediation to protect uncontaminated groundwater and the river • Perform site reclamation • Continue environmental monitoring • Continue institutional controls	Recreational Residential Industrial	• Maintain restrictions on use of groundwater • Maintain restrictions on subsurface disturbance

[a]Exposure scenarios such as these would be negotiated in the CERCLA process, and would be used to establish cleanup levels.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
TSD = treatment, storage, and/or disposal.

3.2.5.1 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 (see Section 3.2.1). The DOE would maintain institutional control of the All Other Areas geographic area, and would continue to manage the area for industrial, waste management, wildlife research, and Native American uses. Public access would remain restricted. These uses and restrictions would remain in place until the DOE determined that the lands were no longer needed to fulfill its current mission or the DOE relinquished institutional control of the Hanford Site (assumed to be 100 years for analysis purposes).

*3.2.5.2 **Restricted Future Land-Use Alternative***. A restricted future land-use alternative for this geographic area could be achieved through a variety of remediation activities, including excavation and disposal of contaminated soil, remediation of past-practice waste sites, closure of TSD units, site reclamation, decommissioning of surplus facilities, and/or use of engineering and institutional controls. In addition to these potential remediation activities, a groundwater remediation strategy would be developed and employed for the All Other Areas geographic area.

Some residual contamination would be left in place in areas where exposures do not pose unacceptable risk. Because of the presence of residual contamination, implementation of a Restricted Future Land-Use Alternative would require continuing restrictions on certain human uses within the All Other Areas geographic area. These restrictions would be placed on withdrawal and use of groundwater and soil disturbing activities at or near sites with residual contamination. As indicated above, there are many potential remediation activities that would be appropriate to achieve the objectives of a Restricted Future Land-Use Alternative for the All Other Areas geographic area. One of the following options, or a combination of options, could be used to remediate the geographic area sufficient to allow restricted future land uses. The first option (R1) would emphasize removal and disposal of waste and contaminated materials, groundwater remediation, and continuing access restrictions. The second option (R2) would emphasize the placement of engineered caps over waste sites, in addition to groundwater remediation. The following sections describe in more detail the potential remediation associated with options R1 and R2.

*3.2.5.2.1 **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. The DOE would maintain institutional control of the All Other Areas geographic area, and would continue to use the area for activities similar to those allowed under current Hanford Site management. Restrictions on activities that disturb soil would apply in and around revegetated excavation sites. In addition, withdrawal and use of groundwater would remain controlled for an indefinite period.

Engineering and institutional controls (e.g., signs, land use plans, fencing, and deed restrictions) would be used, as necessary, to restrict use and access. This alternative would enable future land uses that essentially are consistent with those envisioned by the Working Group (see Table 3-7). The CERCLA exposure scenarios associated with this alternative include recreational, residential, or industrial.

This alternative includes limited excavation of surface and/or subsurface past-practice waste sites and TSD units to reduce contaminant exposure through the ingestion, dermal, or inhalation pathways under the recreational, residential, and industrial exposure scenarios. Further excavation would be required where residual contamination remains in sufficient quantities to be a threat to groundwater. However, where exposures do not pose unacceptable risk, it is expected that some contamination would be left in place. As determined in the ROD for the "Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes Environmental Impact Statement" (53 FR 12449), retrieved pre-1970 TRU-contaminated waste from the 618-11 burial ground (located north of the 300 Area) would be removed to the 200 Areas to be processed for disposal as solid TRU waste.

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 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. For site restoration, excavation sites would be recontoured to blend in with the surrounding topography and revegetated or covered with a suitable cover.

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.

- Protect currently uncontaminated groundwater.
- Protect the Columbia River and its 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. These measures would include:

- Limited excavation of past-practice waste sites and TSD units, 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 that controls are no longer necessary.

This groundwater remediation strategy would be determined through the CERCLA process based on the future land-use alternatives selected for the Reactors on the River and the Columbia River geographic areas. If the Restricted Future Land-Use Alternative is selected for these geographic areas, the groundwater plumes originating from the All Other Areas geographic area would be remediated to levels protective of the Columbia River. If the Unrestricted Future Land-Use Alternative is selected for these geographic areas, the groundwater plumes entering the Reactors on the River or Columbia River geographic areas would be remediated to levels corresponding to acceptable risks under the agricultural exposure scenario.

3.2.5.2.2 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, and groundwater remediation. 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 that essentially are consistent with those envisioned by the Working Group (see Table 3-7). The CERCLA exposure scenarios associated with this alternative include recreational, residential, or industrial.

A Restricted Future Land-Use Alternative (R2) for the All Other Areas geographic area involves leaving in place contaminated soils and buried LLW and LLMW contained within past-practice waste sites and TSD units. Human and ecosystem exposure to contamination would be limited through the use of protective caps. Several alternative cap designs are being considered. For purposes of this analysis, 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 injection grouting would be used to minimize subsidence at burial grounds and cribs, and would enhance the long-term integrity of caps. Groundwater monitoring would be used to monitor cap performance.

Under this Restricted Future Land-Use Alternative (R2), the groundwater remediation strategy would be the same as described in the Restricted Future Land-Use Alternative (R1), but would not include excavation activities. Instead, caps would be used to prevent migration of source contaminants to the groundwater.

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

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

3.3.1 Reactors on the River

3.3.1.1 Exclusive Future Land-Use Alternative. The Exclusive Future Land-Use Alternative would emphasize leaving some contaminants in place and using the geographic area for waste management purposes. This alternative would involve continuing waste management activities and similar, compatible uses, and restricting use of the area to properly trained DOE and contractor personnel.

The Reactors on the River geographic area is not projected to be needed for future DOE missions involving the management of radioactive and hazardous materials. Therefore, from a common sense standpoint it would not be reasonable to designate the geographic area for exclusive waste management future land use.

The B Reactor in the 100-B/C Area has been placed on the *National Register of Historic Places* (NPS 1988), 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 historically significant B Reactor.

An exclusive use area within or adjacent to 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 Environmental Impact Statement, Final - June 1994* (NPS 1994). This EIS recommends that Congress designate the Hanford Reach as a Recreational River under the Wild and Scenic River System. This Wild and Scenic designation would conflict with most of the activities associated with an Exclusive Future Land-Use Alternative, including the siting of long-term waste management facilities adjacent to the river. A DOE decision that conflicts with a Congressional mandate would not be feasible from a common sense standpoint.

An Exclusive Future Land-Use Alternative for the Reactors on the River geographic area could be contrary to Tri-Party Agreement (Ecology et al. 1989) direction, 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 Reactors on the River geographic area could conflict with provisions of the renegotiated Tri-Party Agreement, which puts greater emphasis on remediation of the 100 Areas and protection of the Columbia River through acceleration of groundwater treatment programs. The evaluation of future land use objectives that are contrary to the spirit of the Tri-Party Agreement and clearly stated public wishes would not be feasible from a common sense standpoint.

An Exclusive Future Land-Use Alternative for this geographic area conflicts with the ROD for the "Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington, Environmental Impact Statement" (58 FR 48509). Removing the reactor blocks in accordance with the ROD would not produce benefits commensurate with costs if the surrounding surface and subsurface contamination sites were remediated only to exclusive use levels. Implementing the Exclusive Future Land-Use Alternative and the decisions identified in the ROD for decommissioning the surplus production reactors would not be feasible from a common sense standpoint, would not be a reasonable approach to long-term management of wastes and facilities, and would not be an effective use of public funds.

3.3.2 Central Plateau

3.3.2.1 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 Central Plateau geographic area 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, remediation of the Hanford Site as outlined in the *Richland Environmental Restoration Project Plan* (DOE-RL 1994d) 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 suitable for use in disposing of waste generated during remediation (EPA 1995b). During scoping, most members of the public and the Working Group expressed a preference to have waste management activities, including disposal and waste consolidation, on the Central Plateau geographic area. Key facilities under construction or completed for the Central Plateau geographic area include the Environmental Restoration Disposal Facility (ERDF), which will be used for permanent disposal of Hanford Site remediation waste (EPA 1995b), and two treated effluent disposal facilities (TEDF), one of which would be used for soil-column disposal of tritiated water (DOE-RL 1992, DOE-RL 1993b, and DOE-RL 1993c). The Unrestricted Future Land-Use Alternative in this area also would conflict with the function of planned waste management facilities, such as the Tank Waste Remediation System Vitrification Facility. Therefore, from a common sense standpoint, remediating the Central Plateau to allow for an unrestricted future land-use would not be reasonable.

In the absence of the ERDF, the TEDFs, and other key waste management facilities on the Central Plateau geographic area, waste generated during Hanford Site remediation would require packaging and transportation for offsite disposal. Suitable offsite disposal capacity currently does not exist, and there is no basis for assuming that this capacity would become available within the time-frame of the Tri-Party Agreement (Ecology et al. 1989). Should offsite disposal capacity become available, it might be prohibitively expensive for the waste volumes expected to be generated at the Hanford Site. Based on public scoping comments, offsite shipment for disposal of Hanford Site remediation waste probably would encounter strong Tribal, public, and regulator opposition (DOE-RL 1994a). Therefore, remediating the Central Plateau to allow unrestricted future land use would probably not be technically or economically feasible.

An Unrestricted Future Land-Use Alternative for the Central Plateau geographic area also 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 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). This alternative also conflicts with the CERCLA ROD to construct the ERDF (EPA 1995b) and the CERCLA Interim Action ROD (EPA 1995a) that prescribes disposal of 100 Area wastes at ERDF. The DOE would have to modify the decisions and the actions taken under these RODS in order to be consistent with an unrestricted future land use objective. Costs associated with implementing these modifications would be economically prohibitive.

Finally, portions of the Central Plateau have historically been used for disposal of wastes from Hanford Site operations and other actions. Remediating these wastes to levels that would allow for an Unrestricted Future Land-Use Alternative might not be feasible from a technical or economic standpoint. Contaminants would need to be removed from the Central Plateau and disposed at another site. This disposal capacity does not presently exist. Furthermore, the cost of remediation of the Central Plateau to allow for unrestricted future uses would likely be prohibitive.

3.3.2.2 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.

During scoping, most members of the public and the Working Group expressed a preference to have waste management activities consolidated on the Central Plateau geographic area. The Working Group's report included the following findings and recommendations: wastes from throughout the Hanford Site should be concentrated in the 200 Areas; waste management, storage, and disposal activities should be concentrated in the 200 Areas whenever feasible to minimize the amount of land devoted to or contaminated by waste management activities; some type of government presence or oversight of the 200 Areas should be assumed for the foreseeable future due to the anticipated level of residual contamination; and access to the exclusive use areas, including the buffer zones, would be restricted to personnel who were properly trained and monitored for working under these conditions and exposures. These findings and recommendations are not consistent with a Restricted Future Land-Use Alternative for the Central Plateau geographic area.

The success of the Hanford Site's Environmental Restoration Program hinges on the ability to dedicate the Central Plateau geographic area for waste management and disposal operations (DOE-RL 1993b and DOE-RL 1994c). No other area of the Hanford Site is considered suitable for use in disposing of waste generated during Hanford Site remediation (WHC 1992). Consequently, detailed evaluation of the Restricted Land-Use Alternative for the Central Plateau is not considered reasonable from a common sense standpoint.

The Restricted Future Land-Use Alternative for the Central Plateau geographic area would not be consistent with decisions made in other NEPA and CERCLA RODs addressing waste management activities that are ongoing or planned for the Central Plateau. These waste management activities include, but are not limited to, disposal of decommissioned Navy reactor plants, disposal of wastes generated by remedial activities at the Hanford Site, storage of spent nuclear fuel from the 105-KE/KW fuel storage basin, and potential alternatives that could be implemented for remediation of wastes presently stored in single- and double-shell tanks on the Central Plateau. Potential health risks associated with these activities limit use of the area and require strict controls on access.

Protective Safety Buffer Zones

Exclusive Use Zones have been developed from Safety Analysis Reports for facilities within the Central Plateau geographic area. These Exclusive Use Zones limit public access to the area for purposes of protection of public health and safety. The size and shape of an Exclusive Use Zone is based on the inventory of materials and contaminants, potential release mechanisms, and atmospheric transport parameters. This zone extends from the facility fenceline to a distance at which the threats to the public from routine and accidental releases diminish to the point where public access can be routinely allowed. Access and activities within the Exclusive Use Zones are restricted to personnel who have undergone the required DOE training and activities that are compatible and consistent with the facility safety requirements identified in the facility-specific Safety Analysis Report. Refer to Section 4.11.3 for additional information about Exclusive Use Zones.

Exclusive Use Zones associated with ongoing and planned waste management activities for the Central Plateau have been developed to minimize these health risks. The zones preclude public access from a large portion of the Central Plateau geographic area. Evaluation of a future land-use alternative in conflict with prior decisions regarding ongoing and planned waste management activities and protection of public health would not be feasible from a common sense standpoint.

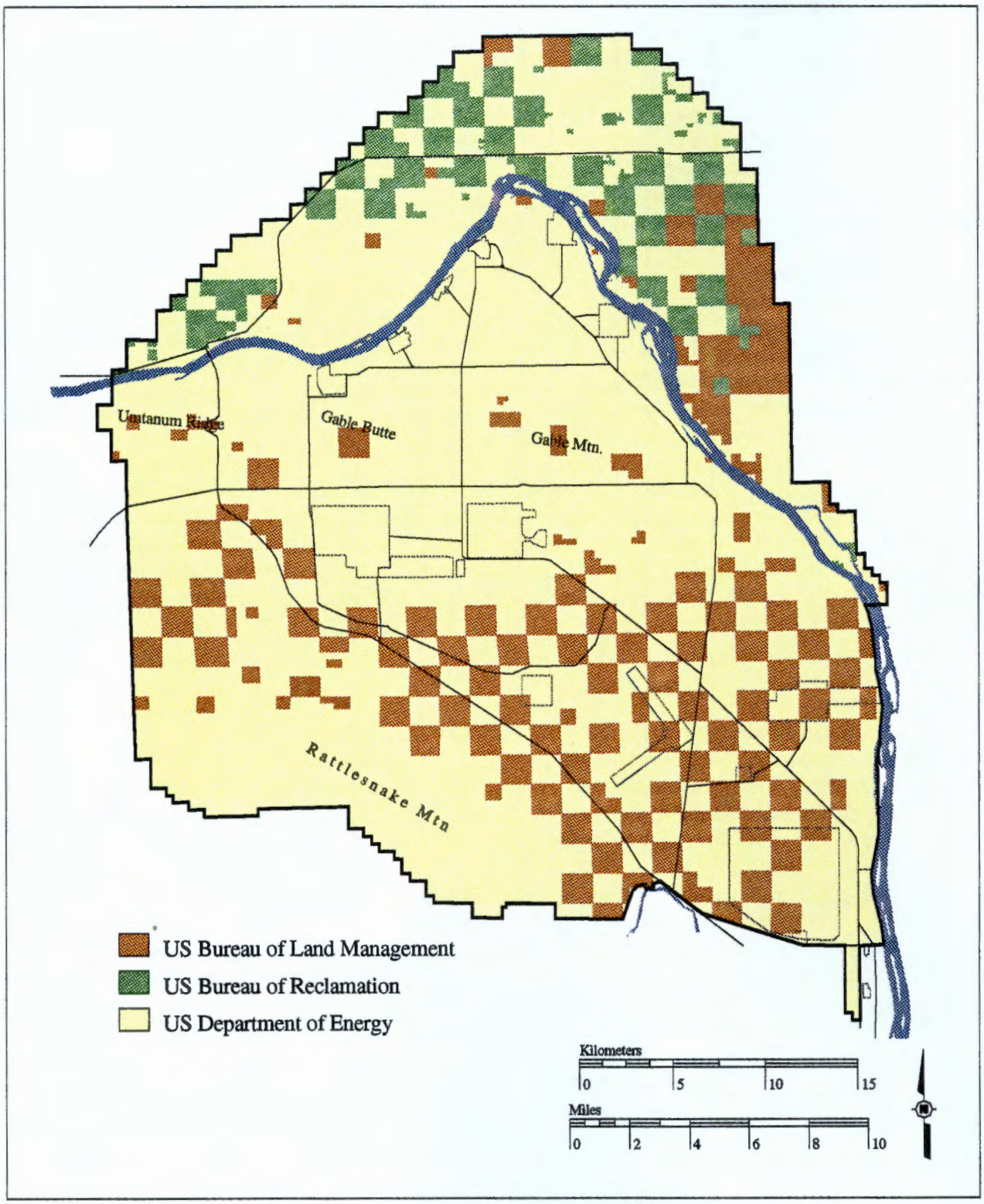
3.3.3 All Other Areas

3.3.3.1 Unrestricted Future Land-Use Alternative. This alternative would involve remediating contaminated surface and subsurface sites, surface water, and groundwater in the 300, 400, 600, and 3000 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 not considered feasible for other parts, as identified below.

- The groundwater underlying much of the All Other Areas geographic area is contaminated with several hazardous and radioactive constituents. These contaminant plumes cover a very large area; plumes at or above EPA drinking water standards cover about 8,400 ha (32 mi^2) within this geographic area. Remediation of these plumes to levels that would not preclude any human use would require substantial funds and time to accomplish. Furthermore, there is uncertainty regarding whether the task is even technically feasible.

- The Laser Interferometer Gravitational-Wave Observatory, which is currently under construction in the southern part of this geographic area (Figure 3-3), will pose constraints on future land uses. As the observatory becomes operational, vibrations in the vicinity of the facility must be kept to a minimum because significant vibrations will interfere with detection efforts. Unrestricted uses in the future could interfere with operations at this facility.

Figure 3-3. Hanford Site Land Ownership.



- A 259-ha (1-mi^2) section of land was sold to the State of Washington for the purpose of extremely hazardous waste disposal (Ecology 1993). The site is located south of the 200 East Area, near State Route 240 (see Figure 3-3). Should the State of Washington construct a hazardous waste disposal facility, it is likely that controls on public access would be required. The State has not indicated whether this tract is likely to be developed for waste disposal functions.

- A portion of the All Other Areas geographic area consists of public lands withdrawn or acquired by the Department of Interior under management authority of the Bureau of Land Management and the Bureau of Reclamation. The withdrawn public lands are roughly arranged in square mile checkerboard patterns on portions of this geographic area (see Figure 3-3). These lands are currently administered by DOE under a superseding public land withdrawal and would revert to the Department of the Interior when DOE no longer needs them. The eventual reversion might serve to limit non-mission-related long-term uses in the All Other Areas geographic area and therefore, an unrestricted future land use objective might be inconsistent with current land ownership patterns.

- There are several Exclusive Use Zones developed from Safety Analysis Reports for facilities in the 200 Areas, Fast Flux Test Facility (FFTF), and the WPPSS Reactor that require access restrictions to the All Other Areas geographic area.

- Under current DOE plans, the northern and western portions of the 300 Area would be used for waste operations and support facilities, such as the 300 Area TEDF, which recently became operational. These facilities constitute restricted or exclusive use, and require controls on public access. Because public use of these areas would be excluded indefinitely, protective-end states could be reached 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.

- A decommissioning program for the 300 Area surplus facilities is in the early stages of addressing the numerous contaminated facilities that eventually would undergo decommissioning (Winship and Hughes 1992). Many of these facilities are not included in the scope of this EIS. Although decisions on the fate of existing contaminated facilities would be forthcoming as remediation progresses, contaminated surplus facilities were assumed to 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.

- Unrestricted future land-use is also unreasonable because it is inconsistent with the proposed decisions identified in the *Proposed Plan for the 300-FF-1 and 300-FF-5 Operable Units* (DOE-RL 1995b) (recently issued for public comment) for the surface and groundwater operable units in the 300 Area. The preferred alternative for the 300-FF-5 operable unit would allow groundwater contaminants to naturally diminish over time. It is expected that uranium concentrations would decline to groundwater cleanup standards in 3 to 10 years, although isolated plumes of trichloroethylene and dichloroethylene would remain. These contaminants are not expected to reach the river in concentrations exceeding cleanup standards (DOE-RL 1995b).

- The continued existence of reactors, with or without operating missions, is anticipated in the 400 Area at the FFTF, and in the 600 Area on the 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 completed as of this time. The continued presence of these facilities would constitute restricted or exclusive uses, which would require 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 reasonable, because such remediation probably would not achieve additional protection of human health over remediation to restricted or exclusive levels.

3.3.3.2 Exclusive Future Land-Use Alternative. This alternative would reserve all of the 300, 400, 600, 1100, and 3000 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.

No long-term DOE waste management and/or disposal missions are projected for the 400 and 600 Areas of the Hanford Site (DOE-RL 1993a). Therefore, analyzing retention of these areas exclusively for such missions was not considered reasonable from a common sense standpoint. Advanced scientific research and engineering facilities (e.g., Laser Interferometer Gravitational-Wave Observatory) are planned or under construction in the 600 Area (DOE-RL 1993a); exclusive use throughout the 600 Area might interfere with these plans. Use of land located near the Columbia River in the 600 Area for waste management purposes would be incompatible with the preferred alternative in the *Hanford Reach of the Columbia River, Comprehensive River Conservation Study and Environmental Impact Statement, Final - June 1994* (NPS 1994).

In the 300 Area, because only a portion of the land is projected to be used for the waste management mission (DOE-RL 1991), analyzing an Exclusive Future Land-Use Alternative was not considered reasonable from a common sense standpoint. 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).

3.4 Comprehensive Land Use Planning Process

The analysis of environmental impacts in this EIS forms the basis for Appendix M, "Hanford Site Comprehensive Land Use Plan" (Comprehensive Plan). The Comprehensive Plan would guide land- and facility-use decisions through an analysis of potential land-use opportunities and constraints. In a manner consistent with CEQ guidance (46 FR 18026), the Comprehensive Plan relies on the environmental impacts analysis presented in this EIS. In accordance with DOE Order 430.1, *Life-Cycle Asset Management* (DOE 1995a), the DOE will work with Tribal and local governments to consider the long-term goals and objectives of Hanford Site stakeholders during the comprehensive land-use planning process.

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3.5 Summary of Potential Environmental Impacts and Mitigation Measures

Chapter 5.0 of this EIS presents detailed analyses of potential 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 resources affected by 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. Many of these natural and cultural features could be impacted directly by remedial activities associated with achieving desired future land-use objectives. Also, after remediation, if restrictions on public access were lifted, this indirectly connected action could result in additional adverse impacts to some resources.

Remediation of the Hanford Site is needed to protect members of the public and workers and the environment from exposure to radionuclides and hazardous chemicals. Worker and public exposure has been minimal under current Hanford Site management and control. However, exposures might become significant if control of, or current use of, the Hanford Site changes. Protection of human health and ecological resources would be achieved by continued control of the Hanford Site and restriction on uses, or by removal and/or isolation of contaminated areas.

Costs associated with remediation could be large, depending on the alternative selected for each geographic area. Factors such as safety precautions; environmental documentation; site characterization and sampling; widespread groundwater contamination; and the number and volume of contaminated surface waste sites all contribute to the costs of remediation. In general, remediation costs are lowest for continued monitoring and maintenance of the Hanford Site 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 of the Central Plateau geographic area, and restricted use of the All Other Areas geographic area.

The DOE intends to prepare a Mitigation Action Plan after the ROD for this EIS is issued. The Mitigation Action Plan will address mitigation commitments made in the ROD. Chapter 5.0 of this EIS addresses potential mitigation measures for each future land-use alternative. A comparative summary of the potential environmental impacts and mitigation measures associated with the future land-use alternatives is presented in Tables 3-12 through 3-15.

Table 3-12. Summary of Environmental Impacts and Mitigation Measures for the Columbia River Geographic Area. (5 sheets)

Resource Areas	No-Action Alternative	Remediation to the Unrestricted Future Land-Use Alternative	Remediation to the 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, 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 reduction 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 for the Unrestricted Future Land-Use Alternative
Water Resources	Impacts Increased contaminant releases could occur because of continued natural scouring of buried river discharge pipelines; natural shoreline erosion also could mobilize contaminated sediments Minimal 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, riverbottom, 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 include installing runoff caps, limiting areas disturbed below the high-water mark, stabilizing disturbed areas, and providing an 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 river discharge 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

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Table 3-12. Summary of Environmental Impacts and Mitigation Measures for the Columbia River Geographic Area. (5 sheets)

Resource Areas	No-Action Alternative	Remediation to the Unrestricted Future Land-Use Alternative	Remediation to the Restricted Future Land-Use Alternative
Ecological Resources	Impacts For the most part, minimal impacts are expected from continued exposure to radiological and chemical contaminants, and during waste site stabilization Potential impact to salmon redds from continued discharge of hexavalent chromium to the river 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 bald eagle perch or roost sites, direct mortality, and 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 include avoiding uncontaminated wetland areas, minimizing disturbance of uncontaminated wetland soils, employing protocols designed to prevent the spread or establishment of undesirable species in wetlands, and employing a no net-loss protocol when disturbing wetlands For aquatic habitat disturbance, mitigation measures include limiting activities below the high-water mark during times of anadromous fish spawning or migration, avoiding uncontaminated spawning areas, limiting total area disturbed, stabilizing 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 include limiting activities in the vicinity of the roost/nest sites during the appropriate seasons	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 3-12. Summary of Environmental Impacts and Mitigation Measures for the Columbia River Geographic Area. (5 sheets)

Resource Areas	No-Action Alternative	Remediation to the Unrestricted Future Land-Use Alternative	Remediation to the 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 disposal or treatment facilities Airborne pollutants would be generated in exhaust from equipment used for excavation, loading, and hauling Mitigation Measures Mitigation measures include dust suppression measures, wetting storage piles and haul roads, limiting size of disturbed areas, and temporarily enclosing areas being excavated	Impacts Generation of dust from hauling pipeline stabilization materials from borrow sites Airborne pollutants would be generated in the exhaust from equipment used to stabilize river pipelines Mitigation Measures Mitigation measures would be the same as described in 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 Exposures occasionally might exceed applicable occupational standards for remediation workers No violations of State of Washington noise standards Mitigation Measures Mitigation measures include issuing hearing protection devices for remediation workers, monitoring noise levels throughout the remediation process, and limiting activities near roost/nest sites during appropriate seasons	Impacts Temporary increase in noise levels from pipeline stabilization Exposures occasionally might exceed applicable occupational standards for remediation workers No violations of State of Washington noise standards Mitigation Measures Same as described in the Unrestricted Future Land-Use Alternative
Cultural Resources	Impacts Controlled access would help protect resources Mitigation Measures None identified	Impacts Potential impacts on prehistoric and historic sites Potential impacts on areas of cultural or spiritual importance to Native Americans Mitigation Measures Mitigation measures include consultations with the State Historic Preservation Office and concerned Native American tribal groups and governments before ground-disturbing activities; an archaeological monitor would be onsite when ground-disturbing activities are taking place; avoidance of identified cultural resource areas; and surface mapping to identify resources	Impacts Impacts could be similar to those described in the Unrestricted Future Land-Use Alternative, but are anticipated to be less extensive Mitigation Measures Same as described in the Unrestricted Future Land-Use Alternative

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Table 3-12. Summary of Environmental Impacts and Mitigation Measures for the Columbia River Geographic Area. (5 sheets)

Resource Areas	No-Action Alternative	Remediation to the Unrestricted Future Land-Use Alternative	Remediation to the Restricted 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 Minimizing overall area disturbed; controlling fugitive dust; 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[1]	Impacts Although no current hazards are known to exist, long-term impacts could be considered significant because of the lack of characterization data. Following loss of institutional control, areas with elevated risk to human health could occur from the migration of contaminants from other geographic areas. Residual contamination could cause 164 cancers in recreation shoreline users over a 10,000-year period. Mitigation Measures Continue existing institutional controls and environmental monitoring activities	Impacts Potential for 0.52 LCF for directly involved workers under routine conditions over the project life Potential for 1.0-mrem dose to an individual and 3.0 person-rem dose to the public from a shoreline excavation accident. This radiation exposure would result in an increased probability of an individual contracting a fatal cancer of 5.0E-07. The collective population dose corresponds to an increase of 1.5E-03 LCF in the exposed population. Long-term risk is expected to decrease upon completion of remediation; however, if institutional control is not maintained in the future, risk to recreational shoreline users over a 10,000-year period would be the same as the No-Action Alternative. Mitigation Measures Use of appropriate engineering and administrative controls to reduce exposures to remediation workers and the general public	Impacts Potential for 0.01 LCF for directly involved workers under routine conditions over the project life 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. The increased probability of an individual contracting a fatal cancer and the increase in LCF in the exposed population would be the same for the Unrestricted Future Land-Use Alternative. Long-term risk expected to decrease upon completion of remediation; however, if institutional control is not maintained in the future, risk to recreational shoreline users over a 10,000-year period would be the same as the No-Action Alternative. Mitigation Measures Same as described in 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 194 occupational loss cases and 2,640 estimated lost workdays (DOE statistics) Mitigation Measures Continued emphasis on safety awareness and worker training	Impacts Potential for 4 occupational loss cases and 55 estimated lost workdays (DOE statistics) Mitigation Measures Same as described in the Unrestricted Future Land-Use Alternative

Table 3-12. Summary of Environmental Impacts and Mitigation Measures for the Columbia River Geographic Area. (5 sheets)

Resource Areas	No-Action Alternative	Remediation to the Unrestricted Future Land-Use Alternative	Remediation to the Restricted Future Land-Use Alternative
Volumes and Costs	Impacts Minimal disturbed areas Estimated total cost is $2.4 billion[2] Mitigation Measures Use of less expensive methods of institutional controls	Impacts Excavated volume of contaminated soil is 1.1 E+07 BCM (1.4 E+07 BCY) Area of disturbance is 177 ha (437 ac) Estimated total cost is $3.2 billion with truck haul or $3.4 billion with rail haul Mitigation Measures Soil washing to reduce the amount of waste to be transported	Impacts Volume of pipeline stabilization materials required is 3.4 E+05 LCM (4.4 E+05 LCY) Area of disturbance is 4.1 ha (10 ac) Estimated total cost is $54 million with truck haul or $59 million with rail haul of pipeline stabilization materials Mitigation Measures None identified

[1]Analyzed for routine conditions and accident scenarios.
[2]Costs for 100 years of institutional control for the Hanford Site (not broken down by geographic area).
BCM = bank cubic meter.
BCY = bank cubic yard.
DOE = U.S. Department of Energy.
LCF = latent cancer fatality.
LCM = loose cubic meter.
LCY = loose cubic yard.

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Table 3-13. Summary of Environmental Impacts and Mitigation Measures for the Reactors on the River Geographic Area. (6 sheets)

Resource Areas	No-Action Alternative	Remediation to the Unrestricted Future Land-Use Alternative	Remediation to the Restricted Future Land-Use Alternative (R1)	Remediation to the 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 regional 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 regional glacial flood events (i.e., bergmounds and giant ripple marks) could be destroyed Continued restrictions on access to geologic resources Depletion of geologic resources for cap construction 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 measures to reduce soil, water, and wind erosion	Impacts Disturbance of 361 ha (903 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 measures to reduce soil, water, and wind erosion	Impacts Disturbance of 315 ha (788 ac) of soil; soil compaction resulting from use of earth-moving equipment; increased potential for erosion Mitigation Measures Same as described in the Unrestricted Future Land-Use Alternative	Impacts Disturbance of 317 ha (791 ac) of soil; soil compaction resulting from use of earth-moving equipment; increased potential for erosion Mitigation Measures Same as described in 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 during remediation because of residual contamination; changes in groundwater flow characteristics by operation of pump-and-treat system Beneficial long-term impacts on the Columbia River because of elimination of contaminated groundwater reaching the river Disturbance of 14 ha (35 ac) of Columbia River floodplain Mitigation Measures None identified	Impacts Continued restrictions on withdrawal and use of groundwater because of 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 Continued restrictions on withdrawal and use of groundwater because of 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 3-13. Summary of Environmental Impacts and Mitigation Measures for the Reactors on the River Geographic Area. (6 sheets)

Resource Areas	No-Action Alternative	Remediation to the Unrestricted Future Land-Use Alternative	Remediation to the Restricted Future Land-Use Alternative (R1)	Remediation to the Restricted Future Land-Use Alternative (R2)
Ecological Resources	Impacts 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 Mitigation Measures None identified for impacts to wetlands and shrub-steppe 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	Impacts Disturbance of 5 ha (12 ac) of wetlands and 29 ha (71 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 Mitigation Measures Mitigation measures for wetlands include avoiding uncontaminated areas, minimizing disturbance of uncontaminated wetland soils, preventing the spread or establishment of undesirable species in wetlands, and employing a no net-loss protocol when disturbing wetlands For shrub-steppe habitat, mitigation measures include restricting earth-moving equipment to trample zones; where available, using existing transportation routes; and revegetating with native species; providing compensation, as necessary 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	Impacts Disturbance of 4 ha (11 ac) of wetlands and 27 ha (68 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 Mitigation Measures Same as described in the Unrestricted Future Land-Use Alternative	Impacts Disturbance of 3 ha (7 ac) of wetlands and 28 ha (70 ac) of shrub-steppe habitat Potential impacts on biodiversity resulting from pipeline stabilization and waste site capping activities Reduction in potential for exposure of plants and wildlife to radionuclides and hazardous chemicals Mitigation Measures Same as described in the Unrestricted Future Land-Use Alternative

Table 3-13. Summary of Environmental Impacts and Mitigation Measures for the Reactors on the River Geographic Area. (6 sheets)

Resource Areas	No-Action Alternative	Remediation to the Unrestricted Future Land-Use Alternative	Remediation to the Restricted Future Land-Use Alternative (R1)	Remediation to the 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 and 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 in the Unrestricted Future Land-Use Alternative	Impacts Generation of dust from waste capping activities Generation of pollution by fuel combustion in equipment used for pipeline stabilization and waste site capping Mitigation Measures Same as described in 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 might exceed applicable occupational standards for remediation workers No violations of the State of Washington noise standards Mitigation Measures Mitigation measures include issuing hearing protection devices for remediation workers, monitoring noise levels, and limiting activities near roost/nest sites during appropriate seasons	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 might exceed applicable occupational standards for remediation workers No violations of the State of Washington noise standards Mitigation Measures Same as described in 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 might exceed applicable occupational standards for remediation workers No violations of the State of Washington noise standards Mitigation Measures Same as described in the Unrestricted Future Land-Use Alternative

Table 3-13. Summary of Environmental Impacts and Mitigation Measures for the Reactors on the River Geographic Area. (6 sheets)

Resource Areas	No-Action Alternative	Remediation to the Unrestricted Future Land-Use Alternative	Remediation to the Restricted Future Land-Use Alternative (R1)	Remediation to the Restricted Future Land-Use Alternative (R2)
Cultural Resources	Impacts Potential impacts on several prehistoric and historic sites. Continued restrictions on Tribal activities Mitigation Measures Mitigation measures include consultations with the State Historic Preservation Office, and Native American tribal groups and governments before any ground disturbing activities; avoidance of resource areas; conduct a full resource survey; surface mapping, and material and data recovery activities; develop resource awareness programs for remediation personnel Mitigation measures for potentially historic buildings and facilities include building construction surveys; documenting all historic structures; and restricting access to historic buildings/facilities	Impacts Potential impacts on several prehistoric and historic sites Potential impacts on areas of cultural or spiritual significance to Native Americans Mitigation Measures Same as described in the No-Action Alternative	Impacts Potential impacts on several prehistoric and historic sites Potential impacts on areas of cultural or spiritual significance to Native Americans Continued restrictions on Tribal activities Mitigation Measures Same as described in the No-Action Alternative	Impacts Potential impacts on several prehistoric and historic sites Potential impacts on areas of cultural or spiritual significance to Native Americans Continued restrictions on Tribal activities Mitigation Measures Same as described in the No-Action Alternative
Visual and Aesthetic Resources	Impacts Only minimal impacts to visual and aesthetic resources in vicinity of decontamination and/or stabilization of waste sites Mitigation Measures None identified	Impacts Temporary impacts on river users from excavation activities, generation of dust plumes, and reduced visual clarity Mitigation Measures Minimize the overall area of disturbance to the extent practicable; employ dust suppression activities; recontour remediated areas as close to original conditions as possible; and revegetate with native species as soon as possible following remediation	Impacts Temporary impacts on river users from excavation activities, generation of dust plumes, and reduced visual clarity Mitigation Measures Same as described in the Unrestricted Future Land-Use Alternative	Impacts Permanent alteration of landscape from capped waste sites Temporary impacts on river users from construction activities, generation of dust plumes, and reduced visual clarity Mitigation Measures Same as described in the Unrestricted Future Land-Use Alternative, as well as using surface waste markers that would blend in with the natural surroundings, and using natural materials for cap construction

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Table 3-13. Summary of Environmental Impacts and Mitigation Measures for the Reactors on the River Geographic Area. (6 sheets)

Resource Areas	No-Action Alternative	Remediation to the Unrestricted Future Land-Use Alternative	Remediation to the Restricted Future Land-Use Alternative (R1)	Remediation to the Restricted Future Land-Use Alternative (R2)
Human Health Risk[1]	Impacts 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 scenarios without restrictions and controls Range fire could result in radiation doses up to 3 mrem for workers and 2.6 mrem for offsite individuals. These radiation exposures would result in increased probabilities of an individual contracting a fatal cancer of 1.2E-06 and 1.3E-06, respectively. In the absence of institutional control, areas with elevated risk would occur from contamination left in place and migration of the contaminants from other geographic area. Over a 10,000-year period, a range of 104 to 5,587 cancers could occur, mainly because of contaminant migration from the Central Plateau. Mitigation Measures Continue existing institutional controls and environmental monitoring activities	Impacts Potential for 0.46 LCF for directly involved workers under routine conditions over the project life 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. These radiation doses would result in increased probability of an individual contracting a fatal cancer of 2.5E-04 and 2.6E-04, respectively. Long-term risk is expected to be minimal upon completion of remediation; however, if institutional control is not maintained in the future, areas with elevated risk could occur from migration of contaminants from other geographic areas. Over a 10,000-year period, an estimated 88 to 5,100 cancers could occur from the migration of contaminants from the Central Plateau. Mitigation Measures Use of appropriate engineering and administrative controls to reduce exposures to remediation workers and the general public	Impacts Potential for 0.33 LCF for directly involved workers under routine conditions over the project life Impacts from accidents are the same as for the unrestricted alternative. Likelihood of accidents occurring during remediation are less than or equal to that for the unrestricted alternative. Maximum potential increased probability of an individual contracting a fatal cancer would be the same as the unrestricted future land use. Long-term risk is expected to decrease upon completion of remediation; however, if institutional control is not maintained in the future, areas with elevated risk could occur from contamination being left in place and the migration of contaminants from other geographic areas. Over a 10,000-year period, an estimated 88 to 5,105 cancers could occur from contaminant migration from the Central Plateau. Mitigation Measures Same as described in the Unrestricted Future Land-Use Alternative	Impacts Potential for 0.62 LCF for directly involved workers under routine conditions over the project life Impacts from accidents are the same as for 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; however, if institutional control is not maintained in the future, long-term risk to human health from the contamination left in place and migration of contaminants from other geographic areas would be comparable to the No-Action Alternative. Mitigation Measures Same as described in 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 587 occupational loss cases and 7,783 lost workdays (DOE statistics) Mitigation Measures Continued emphasis on worker safety and training	Impacts Potential for 427 occupational loss cases and 5,564 lost workdays (DOE statistics) Mitigation Measures Same as described in the Unrestricted Future Land-Use Alternative	Impacts Potential for 832 occupational loss cases and 11,597 lost workdays (DOE statistics) Mitigation Measures Same as described in the Unrestricted Future Land-Use Alternative

Table 3-13. Summary of Environmental Impacts and Mitigation Measures for the Reactors on the River Geographic Area. (6 sheets)

Resource Areas	No-Action Alternative	Remediation to the Unrestricted Future Land-Use Alternative	Remediation to the Restricted Future Land-Use Alternative (R1)	Remediation to the Restricted Future Land-Use Alternative (R2)
Volumes and Cost	Impacts Area of disturbance is 87 ha (215 ac) Estimated total cost for No-Action Alternative is $2.4 billion[2] Mitigation Measures Alternate means of institutional control that result in cost reduction	Impacts Excavated volume of uncontaminated soil is 7.0 E+06 BCM (9.2 E+06 BCY) Excavation volume of contaminated soil is 6.7 E+06 BCM (8.7 E+06 BCY) Groundwater remediation cost is $606 million Area of disturbance is 420 ha (1,038 ac) Estimated total cost is $3.6 billion with truck haul or $3.7 billion with rail haul Mitigation Measures Continued emphasis on development and implementation of technologies that reduce volumes, levels of disturbance, and costs associated with remediation	Impacts Excavated volume of uncontaminated soil is 5.7 E+06 BCM (7.5 E+06 BCY) Excavated volume of contaminated soil is 4.6 E+06 BCM (6.0 E+06 BCY) Groundwater remediation cost is $251 million Area of disturbance is 390 ha (964 ac) Estimated total cost is $2.4 billion with truck haul or $2.5 billion with rail haul Mitigation Measures Same as described in the Unrestricted Future Land-Use Alternative	Impacts Volume of capping materials required is 1.9 E+07 LCM (2.5 E+07 LCY) Groundwater remediation cost is $251 million Area of disturbance is 373 ha (921 ac) Estimated total cost is $2.5 billion with truck haul or $2.8 billion with rail haul of capping material Mitigation Measures Same as described in 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

[1]Analyzed for routine conditions and accident scenarios.
[2]Costs for 100 years of institutional control for the Hanford Site (not broken down by geographic area).
BCM = bank cubic meter.
BCY = bank cubic yard.
DOE = U.S. Department of Energy.
LCF = latent cancer fatality.
LCM = loose cubic meter.
LCY = loose cubic yard.

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Table 3-14. Summary of Environmental Impacts and Mitigation Measures for the Central Plateau Geographic Area. (4 sheets)

Resource Areas	No-Action Alternative	Remediation to the 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 Features relevant to the study of regional glacial flood events could be destroyed Continued restrictions on access to geologic resources 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 Mitigation measures include spraying areas to reduce the amount of fugitive airborne dust, constructing fences to control wind erosion, and revegetating disturbed areas with native species	Impacts Disturbance of 1,614 ha (3,987 ac) of soil; soil compaction resulting from use of earth-moving equipment; increased potential for erosion Mitigation Measures Same as described in the No-Action Alternative, as well as restricting earth-moving equipment to trample zones and using existing transportation routes where possible
Water Resources	Impacts Groundwater would remain contaminated Continued groundwater migration downgradient of the Central Plateau geographic area would result in a gradual decrease in contaminant concentration within the Central Plateau and more contaminants in adjoining geographic areas Mitigation Measures Maintain restrictions on groundwater use	Impacts Withdrawal and use of groundwater would be restricted because of residual contamination Movement of contaminants from the Central Plateau geographic area to downgradient areas would be minimized through operation of pump-and-treat system 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

Table 3-14. Summary of Environmental Impacts and Mitigation Measures for the Central Plateau Geographic Area. (4 sheets)

Resource Areas	No-Action Alternative	Remediation to the Exclusive Future Land-Use Alternative
Ecological Resources	Impacts Disturbance of 50 ha (125 ac) 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 include limiting areas disturbed to the immediate waste site, revegetating disturbed areas with native plant species, and continuing ecological monitoring	Impacts Disturbance of 437 ha (1,079 ac) of shrub-steppe habitat in the Central Plateau geographic area Potential impacts on biodiversity because of 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 in disruption of connectivity among different habitats. Reduction in potential for exposure to radionuclides and hazardous chemicals Mitigation Measures Mitigation measures include limiting areas disturbed to the immediate waste site; using existing transportation routes, where possible; employing erosion control measure; revegetating disturbed areas with native plant species; and avoiding disturbance of known nesting/roosting sites for species of concern; providing compensation, as necessary
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 Mitigation measures include 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 might exceed applicable occupational standards for remediation workers No violations of the State of Washington noise standards are anticipated Mitigation Measures Mitigation measures include issuing hearing protection devices for remediation workers, monitoring noise levels throughout the remediation process, and limiting activities near roost/nest sites during appropriate seasons

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Table 3-14. Summary of Environmental Impacts and Mitigation Measures for the Central Plateau Geographic Area. (4 sheets)

Resource Areas	No-Action Alternative	Remediation to the Exclusive Future Land-Use Alternative
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 importance to Native Americans because of continued restriction on Tribal activities Mitigation Measures Mitigation measures include consultations with the State Historic Preservation Office, and Native American tribal groups and governments; avoidance of resource areas; conduct a full resource survey; surface mapping, and material and data recovery activities; develop resource awareness programs and present to remediation personnel Mitigation measures for historic buildings 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 importance to Native Americans Mitigation Measures Same as described in the No-Action 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 caps would not be 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; recontour remediated areas as close to original conditions as possible, use surface waste markers that would blend in with the natural surroundings, use natural materials for cap construction, and reseed with native species
Human Health Risk[1]	Impacts Potential high risk in the absence of institutional controls. Over a 10,000-year period, an estimated 160 to 5,587 cancers could occur. Much of the area exceeds target risk range for allowing agricultural, residential, industrial, and recreational exposures scenarios without restrictions and controls Range fire could result in radiation doses up to 1.4 mrem for workers and 3 E-03 mrem for offsite individuals. These radiation exposures would result in increased probabilities of an individual contracting a fatal cancer of 5.6E-07 and 1.5E-09, respectively. Mitigation Measures Continue existing institutional controls and environmental monitoring activities	Impacts Potential for 0.32 LCF for directly involved workers under routine conditions over the project life. If institutional control is not maintained in the future, long-term risk over a period of 10,000 years would be the same as the No-Action Alternative. 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. These radiation exposures would result in increased probabilities of an individual contracting a fatal cancer of 1.1E-04 and 3E-07, respectively. Mitigation Measures Use of appropriate engineering and administrative controls to reduce exposures to remediation workers and the general public

Table 3-14. Summary of Environmental Impacts and Mitigation Measures for the Central Plateau Geographic Area. (4 sheets)

Resource Areas	No-Action Alternative	Remediation to the Exclusive Future Land-Use Alternative
Occupational Impacts	Impacts Labor hour estimates were not available; no occupational losses were estimated Mitigation Measures None identified	Impacts Potential for 439 occupational loss cases and 6,427 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[2] Mitigation Measures Alternate means of institutional control that result in cost reduction	Impacts Volume of capping materials required is 17.5 E+06 LCM (22.9 E+07 LCY) (Modified RCRA Cap) Area of disturbance is 1,240 ha (3,063 ac) Groundwater remediation cost is $172 million Estimated total cost is $1.3 billion Mitigation Measures Continued emphasis on development and implementation of technologies that 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

[1]Analyzed for routine conditions and accident scenarios.
[2]Costs for 100 years of institutional control for the Hanford Site (not broken down by geographic area).
BCM = bank cubic meter.
BCY = bank cubic yard.
DOE = U.S. Department of Energy.
LCF = latent cancer fatality.
LCM = loose cubic meter.
LCY = loose cubic yard.

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Table 3-15. Summary of Environmental Impacts and Mitigation Measures for the All Other Areas Geographic Area. (5 sheets)

Resource Areas	No-Action Alternative	Remediation to the Restricted Future Land-Use Alternative (R1)	Remediation to the Restricted Future Land-Use Alternative (R2)
Geology	Impacts Minimal 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 Features relevant to the study of regional glacial flood events could be destroyed Mitigation Measures None identified	Impacts Continued restrictions on access to geologic resources Features relevant to the study of regional glacial flood events could be destroyed Depletion of geologic resources for cap construction Mitigation Measures None identified
Soils	Impacts Disturbance of approximately 45 ha (114 ac) of soil caused by stabilization of waste sites; increased potential for erosion Mitigation Measures Employ measures to reduce soil, wind, and water erosion	Impacts Disturbance of 206 ha (515 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; use existing transportation routes; and employ measures to reduce soil, wind, and water erosion	Impacts Disturbance of 280 ha (700 ac) of soil; soil compaction resulting from use of earth-moving equipment; increased potential for wind erosion Mitigation Measures Same as described in the Restricted Future Land-Use Alternative (R1)
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 because of residual contamination; changes in groundwater levels and flow direction by operation of pump-and-treat system; mounding of water table in vicinity of the 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 in the Restricted Future Land-Use Alternative (R1) 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 in the Restricted Future Land-Use Alternative (R1)

Table 3-15. Summary of Environmental Impacts and Mitigation Measures for the All Other Areas Geographic Area. (5 sheets)

Resource Areas	No-Action Alternative	Remediation to the Restricted Future Land-Use Alternative (R1)	Remediation to the 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 Limit areas disturbed to the immediate waste site, revegetate disturbed areas with native plant species, and continue ecological monitoring	Impacts Disturbance of 91 ha (229 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 because of additional loss of shrub-steppe habitat Mitigation Measures Limit areas disturbed to not exceed trample zone around each waste site; revegetating disturbed areas with native plant species; limiting unnecessary off-road travel and using existing transportation routes; using engineering controls to reduce potential for erosion, and avoiding disturbance of known nesting/roosting sites for species of concern; providing compensation, as necessary	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 because of additional loss of shrub-steppe habitat Mitigation Measures Same as described in the Restricted Future Land-Use Alternative (R1)
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 Mitigation measures include using engineering controls to reduce dust generation; using temporary enclosures over excavation sites; and monitoring 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 in the Restricted Future Land-Use Alternative (R1)

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Table 3-15. Summary of Environmental Impacts and Mitigation Measures for the All Other Areas Geographic Area. (5 sheets)

Resource Areas	No-Action Alternative	Remediation to the Restricted Future Land-Use Alternative (R1)	Remediation to the 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 the State of Washington noise standards Mitigation Measures Mitigation measures include issuing hearing protection devices for remediation workers, monitoring noise levels throughout the remediation process, and limiting activities near roost/nest sites during appropriate seasons	Impacts Temporary increase in noise levels from waste site capping activities No violations of the State of Washington noise standards Mitigation Measures Same as described in the Restricted Future Land-Use Alternative (R1)
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 because of continued restriction on Tribal activities Mitigation Measures Mitigation measures include consultations with the State Historic Preservation Office, and Native American tribal groups and governments; avoidance of resource areas; conduct a full resource survey; surface mapping, and material and data recovery activities; develop resource awareness programs and present to remediation personnel Mitigation measures for potentially historic buildings and facilities include building construction surveys; documentation of all historic structures; and restriction of access to historic buildings and/or facilities	Impacts Potential impacts on known prehistoric and historic sites because of excavation activities Potential impacts on areas of cultural or spiritual significance to Native Americans from encroachment on traditional Tribal use areas Mitigation Measures Same as described in 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 use areas Mitigation Measures Same as described in the No-Action Alternative

Table 3-15. Summary of Environmental Impacts and Mitigation Measures for the All Other Areas Geographic Area. (5 sheets)

Resource Areas	No-Action Alternative	Remediation to the Restricted Future Land-Use Alternative (R1)	Remediation to the Restricted Future Land-Use Alternative (R2)
Visual and Aesthetic Resources	Impacts Minimal 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 Groundwater 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; recontour remediated areas as close to original conditions as possible, and revegetate 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 in the Restricted Future Land-Use Alternative (R1), as well as using surface waste markers that blend in with the natural surroundings, and using natural materials for cap construction
Human Health Risk[1]	Impacts Potential high risk in some portions of area in the absence of institutional controls. In the absence of institutional control, areas with elevated risk would occur from contamination left in place and migration of contaminants from other geographic areas. Over a 10,00-year period, an estimated 98 to 5,149 cancers could occur from contaminant migration from the Central Plateau. Portions of area within or below target risk range for agricultural, residential, or industrial exposure scenarios without restrictions or controls. Most of area meets target risk range for recreational exposure Range fire could result in radiation dose up to 1.7 mrem for workers and 0.95 mrem for offsite individuals. These radiation exposures would result in increased probabilities of an individual contracting a fatal cancer of 6.8E-07 and 4.8E-07, respectively. Mitigation Measures Continue existing institutional controls	Impacts Potential for 0.11 LCF for directly involved workers under routine conditions over the project life 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. These radiation exposures would result in increased probabilities of an individual contracting a fatal cancer of 1.4E-04 and 9.5E-05, respectively. Long-term risk expected to decrease upon completion of remediation; however, if institutional control is not maintained in the future, areas with elevated risk could occur from contamination left in place and migration of contaminants from other geographic areas. Long-term risk over a period of 10,000 years would be the same as the No-Action Alternative. Mitigation Measures Use of appropriate engineering and administrative controls to reduce exposures to remediation workers and the general public	Impacts Potential for 0.28 LCF for directly involved workers under routine conditions over the project life 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 in the Restricted Future Land-Use Alternative (R1). However, there is a lower likelihood of accidents occurring during remediation under the Restricted Future Land-Use Alternative (R2). Maximum potential increased probability of an individual contracting a fatal cancer would be the same as for the Restricted Future Land-Use Alternative (R1). Long-term risk expected to decrease upon completion of remediation; however, if institutional control is not maintained in the future, long-term risk over a 10,000-year period would be the same as the No-Action Alternative. Mitigation Measures Same as described in the Restricted Future Land-Use Alternative (R1)

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Table 3-15. Summary of Environmental Impacts and Mitigation Measures for the All Other Areas Geographic Area. (5 sheets)

Resource Areas	No-Action Alternative	Remediation to the Restricted Future Land-Use Alternative (R1)	Remediation to the Restricted Future Land-Use Alternative (R2)
Occupational Impacts	Impacts Labor hour estimates were not available; no occupational losses were estimated Mitigation Measures None identified	Impacts Potential for 41 occupational injury cases and 558 estimated lost workdays (DOE statistics) Mitigation Measures Continued emphasis on safety awareness and worker training	Impacts Potential for 104 occupational injury cases and 1,416 estimated lost workdays (DOE statistics) Mitigation Measures Same as described in the Restricted Future Land-Use Alternative (R1)
Volumes and Costs	Impacts Area of disturbance is 43 ha (106 ac) Estimated total cost is $2.4 billion[2] Mitigation Measures Efforts to reduce cost of institutional control	Impacts Excavated volume of uncontaminated soil is 1.6 E+06 BCM (2.1 E+06 BCY) Excavation volume of contaminated soil is 1.6 E+06 BCM (2.1 E+06 BCY) Area of disturbance is 309 ha (765 ac) Groundwater remediation cost is $513 million Estimated total cost is $1.2 billion with truck haul or $1.3 billion with rail haul Mitigation Measures Monitor excavated soils to prevent excavation of noncontaminated soil; and continue emphasis on development and implementation of technologies that reduce volumes, levels of disturbance, and costs associated with remediation	Impacts Volume of capping materials required is 8.7 E+06 LCM (1.1 E+06 LCY) Area of disturbance is 384 ha (948 ac) Groundwater remediation cost is $513 million Estimated total cost is $1.4 billion with truck haul or $1.6 billion with rail haul Mitigation Measures Same as described in the Restricted Future Land-Use Alternative (R1), 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

[1]Analyzed for routine conditions and accident scenarios.
[2]Costs for 100 years of institutional control for the Hanford Site (not broken down by geographic area).
BCM = bank cubic meter.
BCY = bank cubic yard.
DOE = U.S. Department of Energy.
LCF = latent cancer fatality.
LCM = loose cubic meter.
LCY = loose cubic yard.

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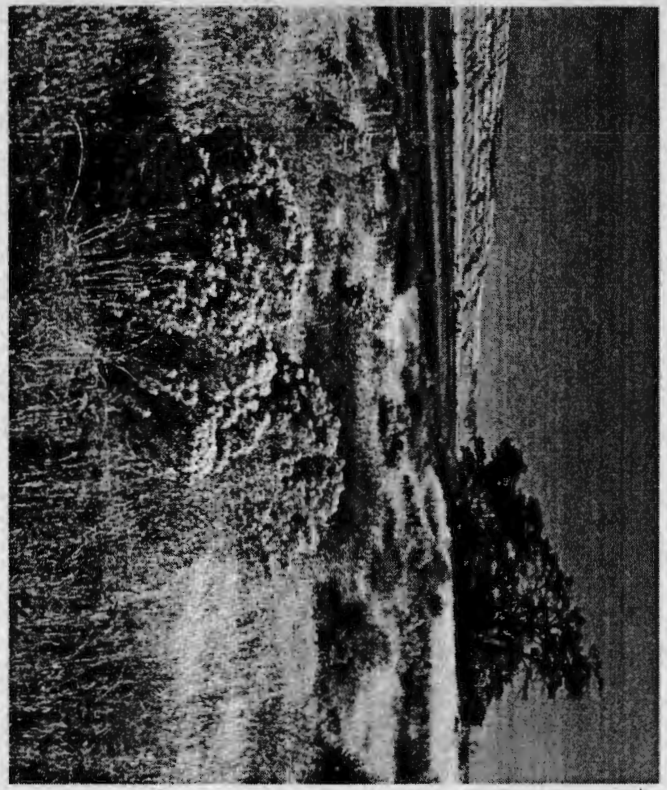

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Affected Environment

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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 approximately 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. 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 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. The *Richland Environmental Restoration Project Plan* (DOE-RL 1994a) focuses on remediation of contaminated soils and water resources.

This chapter describes the environmental setting and the existing conditions of the Columbia River, Reactors on the River, Central Plateau, and All Other Areas geographic areas of the Hanford Site. 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 (Cushing 1995, PNL 1995a, PNL 1995b).

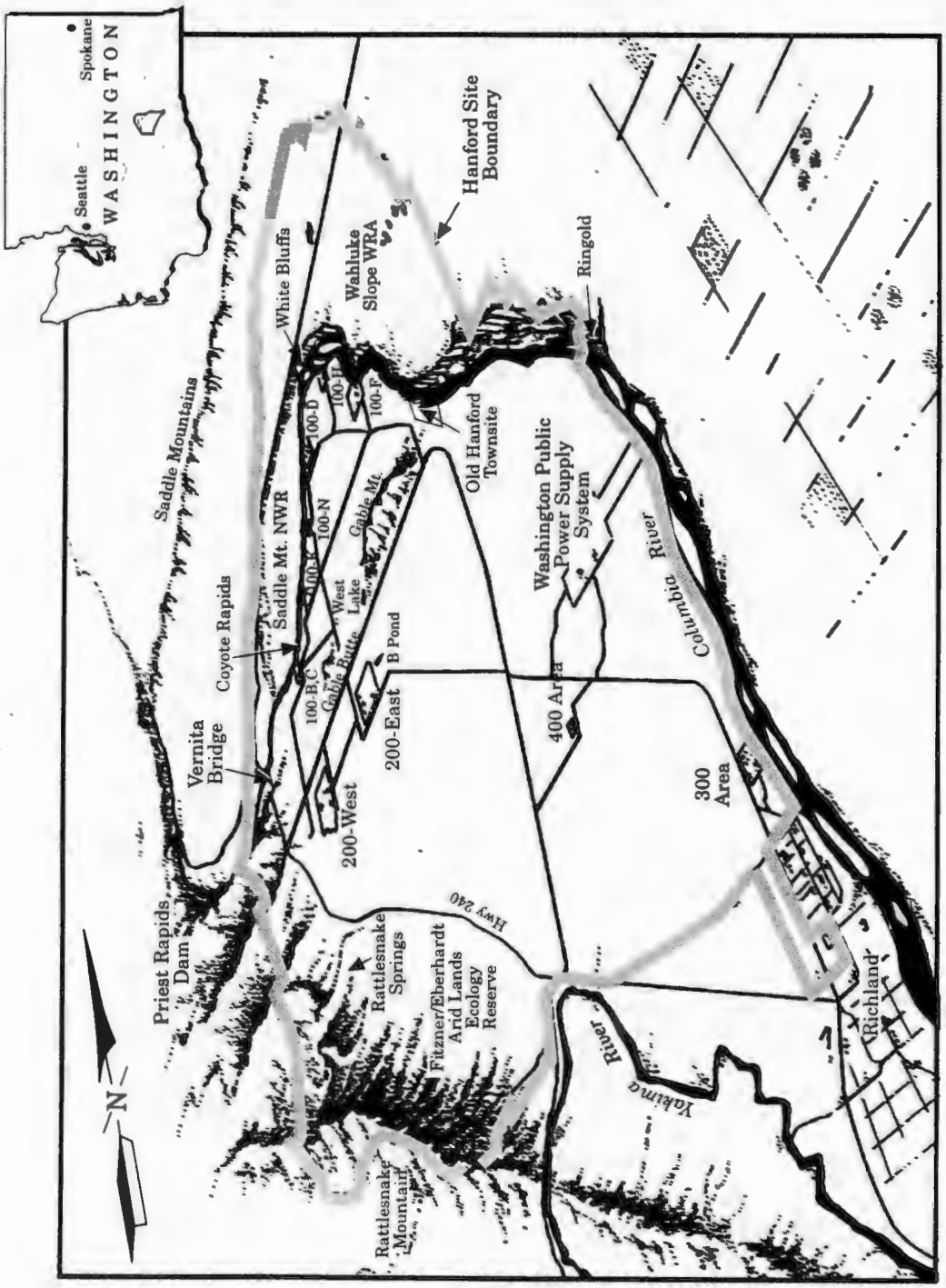
4.1 Geology

Geologic considerations for the Hanford Site include physiography, stratigraphy, structural geology, seismic and volcanic hazards, and soil characteristics. Much of the following discussion has been taken from the *Hanford Site National Environmental Policy Act (NEPA) Characterization* report (Cushing 1995).

4.1.1 Physiography

The physiography of the Hanford Site is dominated by the low-relief plains of the Central Plains and the anticlinal ridges of the Yakima Folds physiographic regions (Figure 4-1). The surface topography has been modified within the past several million years by several processes: (1) Pleistocene cataclysmic flooding, (2) Holocene eolian activity, and (3) landsliding. Cataclysmic flooding occurred when ice dams in western Montana and northern Idaho were breached, and allowed large volumes of water to spill across eastern and central Washington to form the channeled scablands and depositing sediments in the Pasco Basin. The last major flood occurred about 13,000 years ago,

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



during the late Pleistocene Epoch. Braiding flood channels, giant current ripples, and giant flood bars are among the landforms created by the floods. Central Plateau geographic area waste management facilities are located on one prominent flood bar, the Cold Creek bar (Figure 4-2).

Since the end of the Pleistocene, winds have locally reworked the flood sediments, and have deposited 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.

Landslides occur along the north limbs of some Yakima Folds and along steep river embankments such as White Bluffs. Landslides on the Yakima Folds occur along contacts between basalt flows or sedimentary units between the basalt, whereas active landslides at White Bluffs occur in sediments above the basalt flows. The active landslides at White Bluffs are the result of irrigation activity east of the Columbia River.

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 described in the following subsections, and summarized in Figure 4-3.

4.1.2.1 Columbia River Basalt Group. The Columbia River Basalt Group consists of an assemblage of continental flood basalts of the Miocene age. These basalts cover an area of more than 163,170 km^2 (63,000 mi^2) in Washington, Oregon, and Idaho, and have an estimated volume of about 174,000 km^3 (67,200 mi^2) (Cushing 1995). Isotopic age determinations suggest flows of the Columbia River Basalt Group were erupted during a period from approximately 17 to 6 million years ago, with more than 98% by volume being erupted in a 2.5 million-year period (17 to 14.5 million years ago).

Columbia River basalt flows were erupted from north-northwest-trending fissures (linear vent systems) in north-central and northeastern Oregon, eastern Washington, and western Idaho. The Columbia River Basalt Group is formally divided into five formations, from oldest to youngest: Imnaha Basalt, Picture Gorge Basalt, Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt. Of these, only the Grande Ronde, Wanapum, and Saddle Mountains Basalts are present in the Pasco Basin. The Saddle Mountains Basalt forms the uppermost basalt unit in the Pasco Basin except along some of the bounding ridges where the Wanapum and Grande Ronde Basalt flows are exposed.

4.1.2.2 Ellensburg Formation. The Ellensburg Formation includes sedimentary rocks interbedded with the Columbia River Basalt Group in the central and western part of the Columbia Plateau (Cushing 1995). The age of the Ellensburg Formation is principally Miocene, although locally it may be equivalent to early Pliocene. The thickest accumulations of the Ellensburg Formation lie along the western margin of the Columbia Plateau where Cascade Range volcanic materials interfinger with the Columbia River Basalt Group. The lateral extent and thickness of interbedded sediments generally increase upward in the section.

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

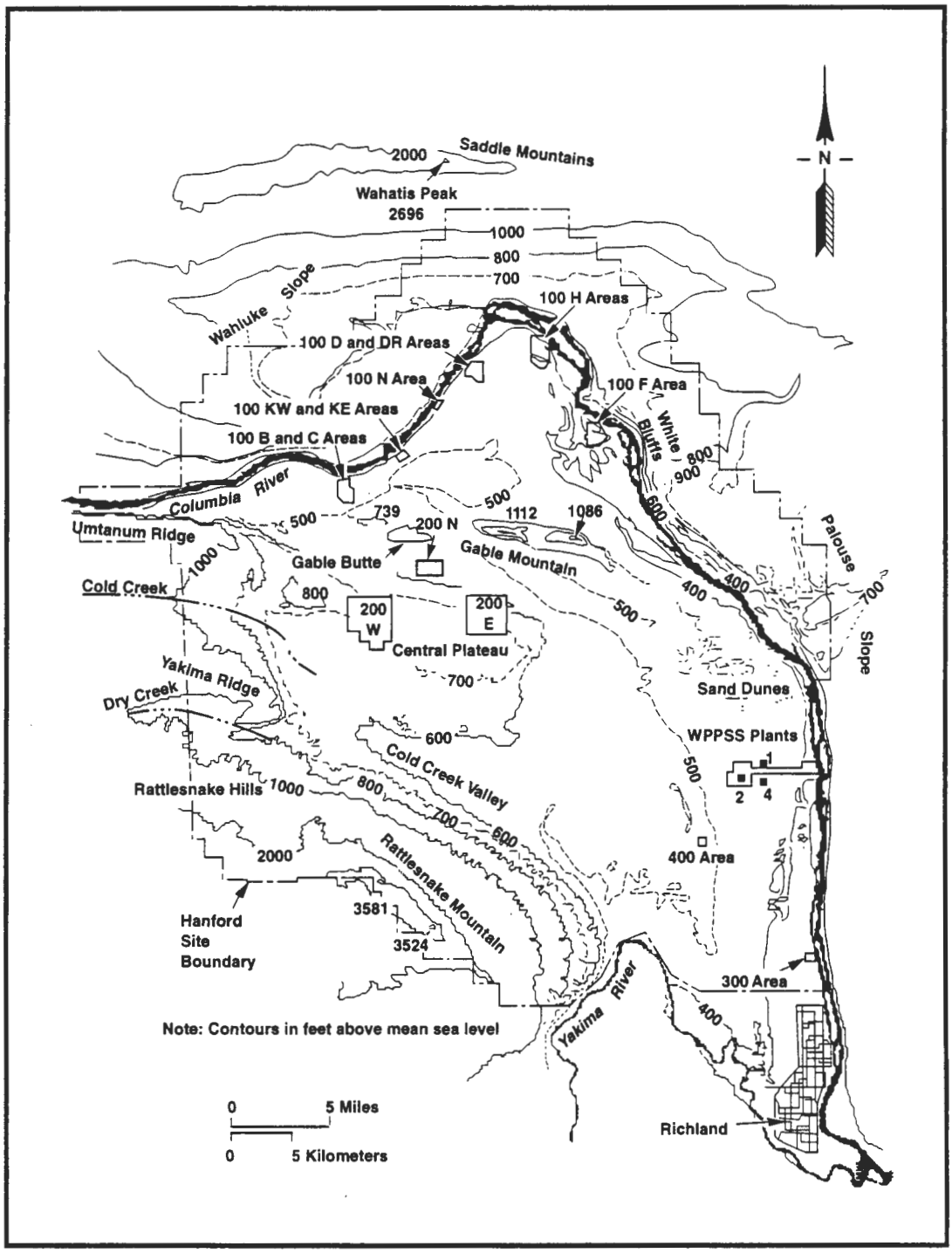


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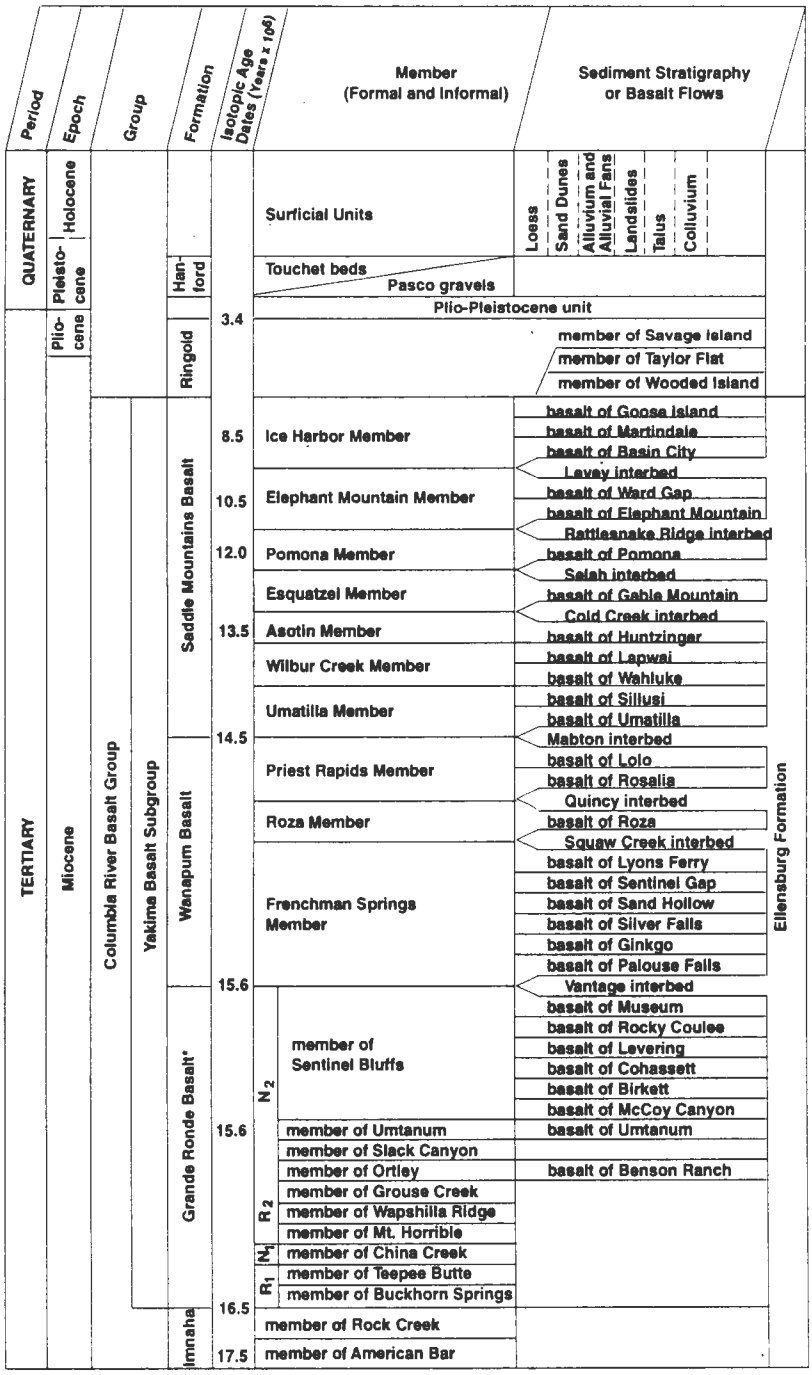
Figure 4-3. A Generalized Stratigraphic Column of the Major Geologic Units of the Hanford Site.



*The Grande Ronde Basalt consists of at least 120 major basalt flows comprising 17 members. N_2, R_2, N_1, and R are magnetostratigraphic units.

4.1.2.3 Suprabasalt Sediments. The suprabasalt (above the basalt) sediments within and adjacent to the Hanford Site are dominated by the Ringold and Hanford formations, with other minor deposits (Cushing 1995).

4.1.2.3.1 Ringold Formation. Late Miocene to Pliocene deposits, younger than the Columbia River Basalt Group, are represented by the Ringold Formation within the Pasco Basin. The Ringold Formation was deposited in east-west trending valleys by the ancestral Columbia River and its tributaries in response to development of the Yakima Fold Belt. While exposures of the Ringold Formation are limited to White Bluffs within the central Pasco Basin and Smyrna and Taunton Benches north of the Pasco Basin, extensive data on the Ringold Formation are available from boreholes.

Flood-related deposits of the Ringold Formation can be broken into different associations based on proximity to the ancestral Columbia and/or Snake River channels. Gravel and associated sand and silt represent a migrating channel deposit of the major river systems and generally are confined to the central portion of the Pasco Basin. Overbank sand, silt, and clay reflect occasional deposition and flooding beyond the influence of the main river channels, and generally are found along the margins of the Pasco Basin. Over time, the main river channels moved back and forth across the basin, causing a shift in location of the various facies. Periodically, the river channels were blocked, and caused lakes to develop where mud with minor amounts of sand were deposited.

4.1.2.3.2 Plio-Pleistocene Unit. A locally derived unit consisting of an alluvium and/or pedogenic calcrete occurs at the unconformity between the Ringold Formation and the Hanford formation. The sidestream alluvial facies is derived from Cold Creek and its tributaries and is characterized by relatively thick zones of unweathered basalt clasts along with wind-blown materials and soil. The calcrete is relatively thick and impermeable in areas of the western Pasco Basin, often forming an aquitard to downward migration of water in the vadose zone where artificial recharge is occurring.

4.1.2.3.3 Early Palouse Soil. Overlying the Plio-Pleistocene unit in the Cold Creek syncline area is a fine-grained sand to silt. It is believed to be mainly of eolian (derived from wind deposits) origin, derived from either an older reworked Plio-Pleistocene unit or upper Ringold. The early Palouse soil differs from the overlying slackwater flood deposits by a greater calcium-carbonate content, massive structure in core samples, and a high natural gamma response in geophysical logs.

4.1.2.3.4 Quaternary Deposits. Repositioning of sediments resumed during the Quaternary Period, following the period of late-Pliocene to early-Pleistocene erosion. In the Columbia Plateau, the Quaternary record is dominated by cataclysmic flood deposits with lesser amounts of sediments deposited by water and wind lying below, between, and above flood deposits.

Sand and gravel river sediments, referred to informally as the pre-Missoula gravels, were deposited after incision of the Ringold and before deposition of the cataclysmic flood deposits. The pre-Missoula gravels are similar to the Ringold Formation main-channel gravel facies, consisting of dominantly nonbasaltic clasts. These sediments occur in a swath that runs from the Old Hanford Townsite on the eastern side of the Hanford Site across the Site toward Horn Rapids on the Yakima River.

Cataclysmic floods inundated the Pasco Basin a number of times during the Pleistocene, beginning as early as 1 million years ago; the last major flood sequence is dated at about 13,000 years ago by the presence of erupted material from Mount St. Helens interbedded with the flood deposits.

The number and timing of cataclysmic floods continues to be debated. As many as 10 flood events have been documented during the last ice age. The largest and most frequent floods came from glacial Lake Missoula in northwestern Montana; however, smaller floods may have escaped downvalley from glacial Lakes Clark and Columbia along the northern margin of the Columbia Plateau, or down the Snake River from glacial Lake Bonneville. The flood deposits, informally called the Hanford formation, blanket low-lying areas over most of the central Pasco Basin (Cushing 1995).

Cataclysmic floodwaters entering the Pasco Basin quickly became impounded behind Wallula Gap (located about 32 km [20 mi] downstream from the Hanford Site), which was too restrictive for the volume of water involved. Floodwaters formed temporary lakes with a shoreline up to 381 m (1,250 ft) in elevation, which lasted only a few weeks or less (Cushing 1995). Two types of flood deposits predominate: a sand-and-gravel, main-channel facies; and a mud-and-sand, slackwater facies. Within the Pasco Basin, these are referred to as the Pasco Gravels and slackwater deposits of the Hanford formation. Sediments with intermediate grain sizes (e.g., sand-dominated facies) also are present in areas throughout the Pasco Basin, particularly on the south, protected half of Cold Creek bar.

Landslide deposits in the Pasco Basin are of variable age and genesis. Most occur within the basalt outcrops along the ridges, such as on the north side of Rattlesnake Mountain, or steep river embankments such as White Bluffs, where the Upper Unit Ringold crops out in the Pasco Basin.

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 (Figure 4-4). The Palouse subprovince primarily is a regional paleoslope that dips gently towards the Columbia Plateau and exhibits only relatively mild structural deformation. The Palouse Slope is underlain by a wedge of Columbia River basalt that thins gradually towards 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. These anticlinal ridges are separated by broad synclines or basins that, in many cases, contain thick accumulations of Tertiary- 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 4-5) (Cushing 1995). The amount of vertical stratigraphic offset associated with these faults varies, but commonly exceeds hundreds of meters.

Figure 4-4. Location of Structural Features.

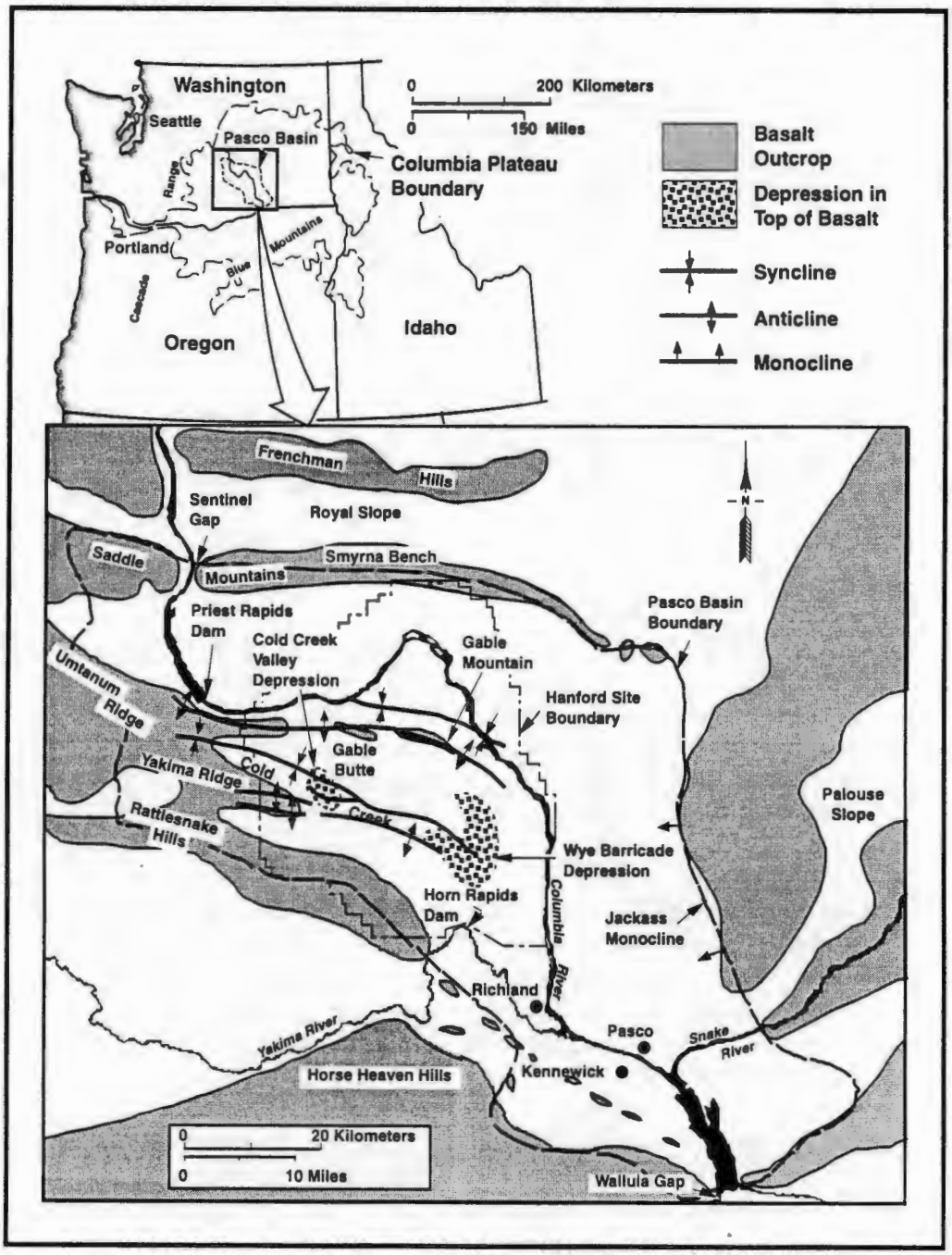


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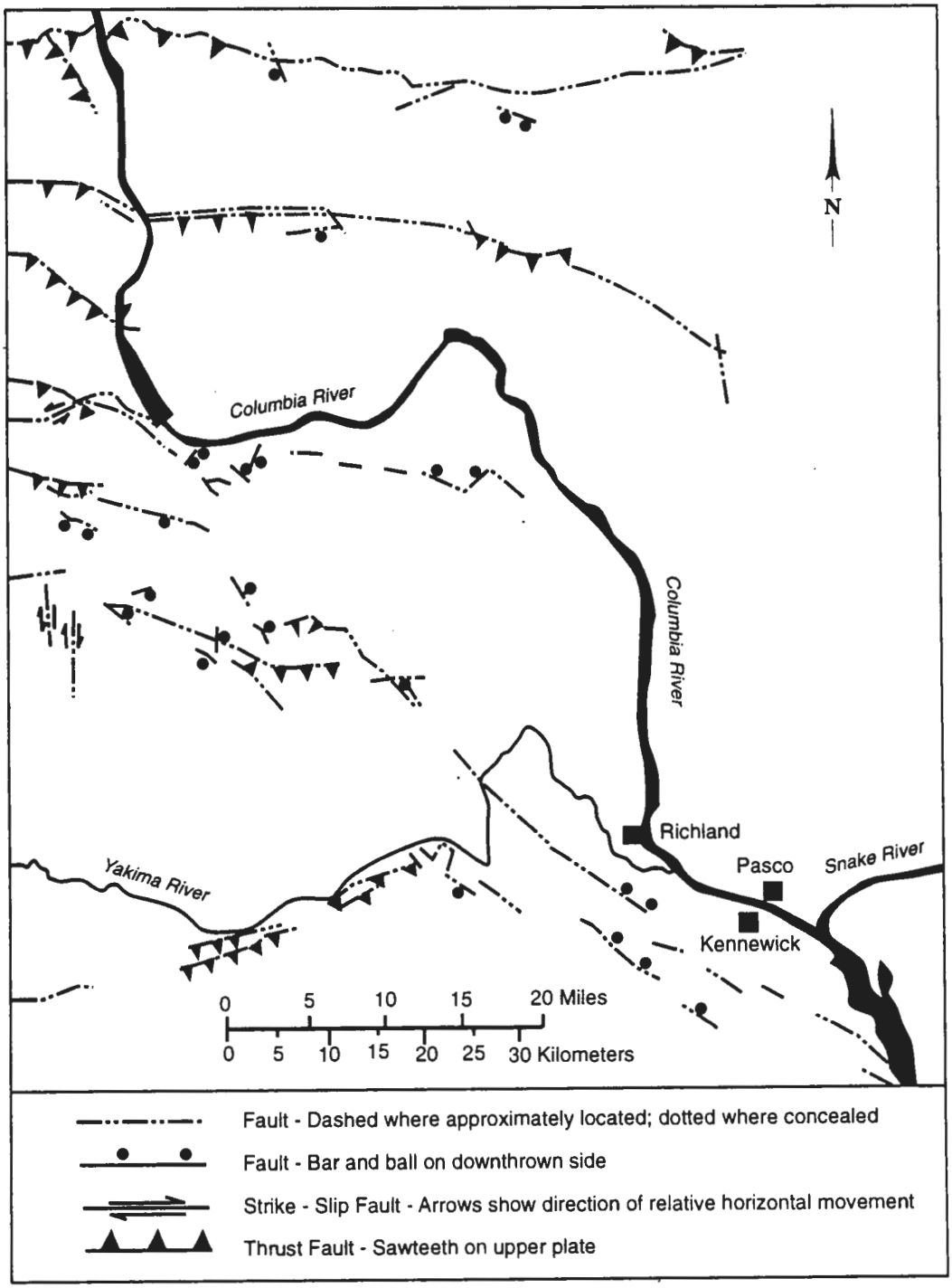
Figure 4-5. Map of the Hanford Site Region Showing Known Faults.



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 provided for the Columbia River geographic area, because the geologic characteristics of the river essentially are similar to the Reactors on the River geographic area and the 300 Area.

4.1.4.1 Reactors on the River. All of the operating 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) above mean sea level near the 100-H Area to -64 m (-210 ft) below mean sea level near the 100-B/C Area (Cushing 1995). 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 the 100-H Area and thicker (100 m [330 ft]) near the 100-F Area. Near the 100-B/C, 100-K, and 100-F Areas, the Ringold Formation consists of interbedded, 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 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, WHC 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. In this area, 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 the 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. Towards 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 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 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 greater than 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 producing 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 of X, and the 1983 Borah Peak earthquake in eastern Idaho, which had a MMI of IX and a 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, western Montana, and 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 indicates 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 an MMI of V. Earthquakes often occur in spatial and temporal clusters in the Columbia Plateau, and are termed earthquake swarms. The region north and east of the Hanford Site is concentrated with 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, not on a single fault plane.

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

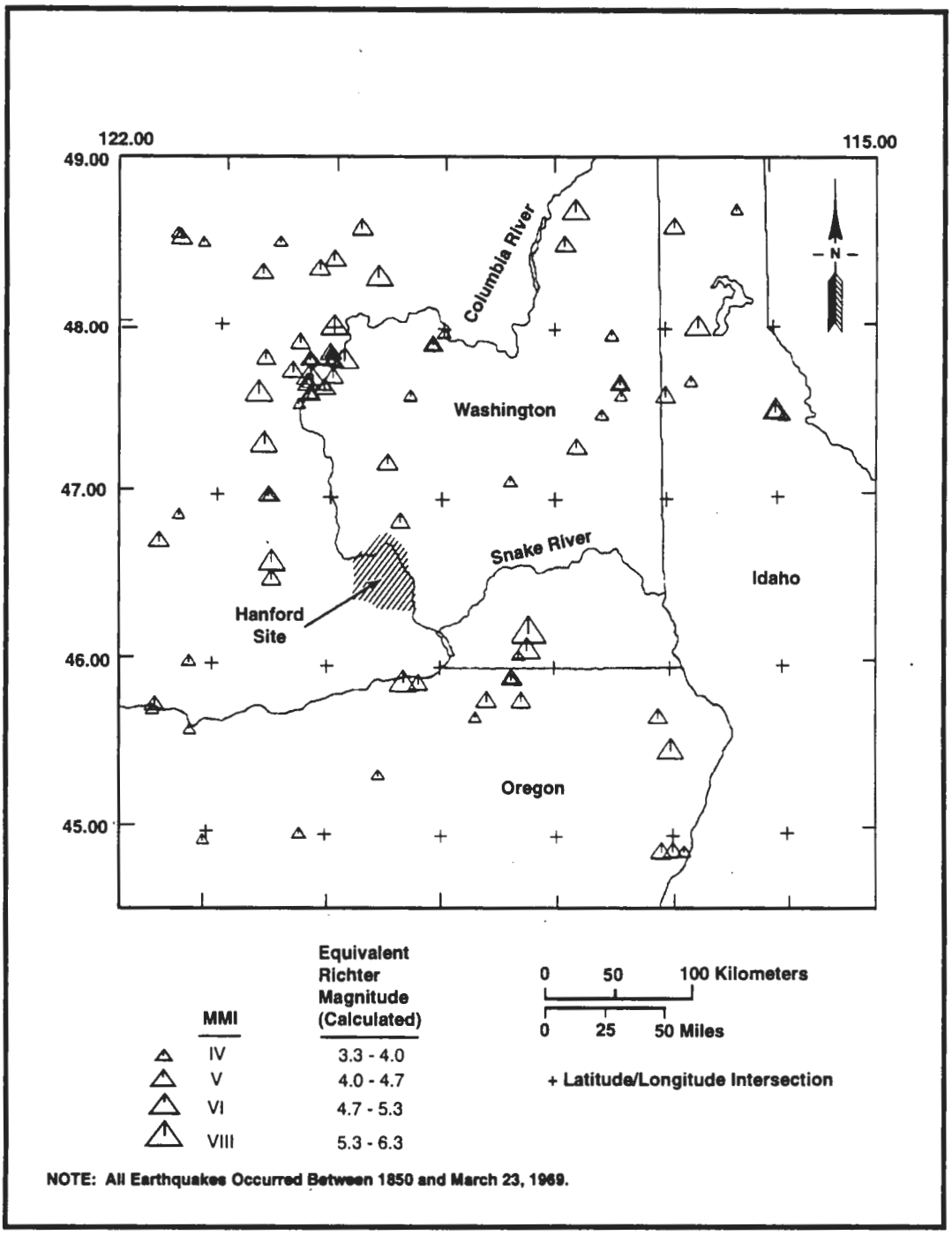
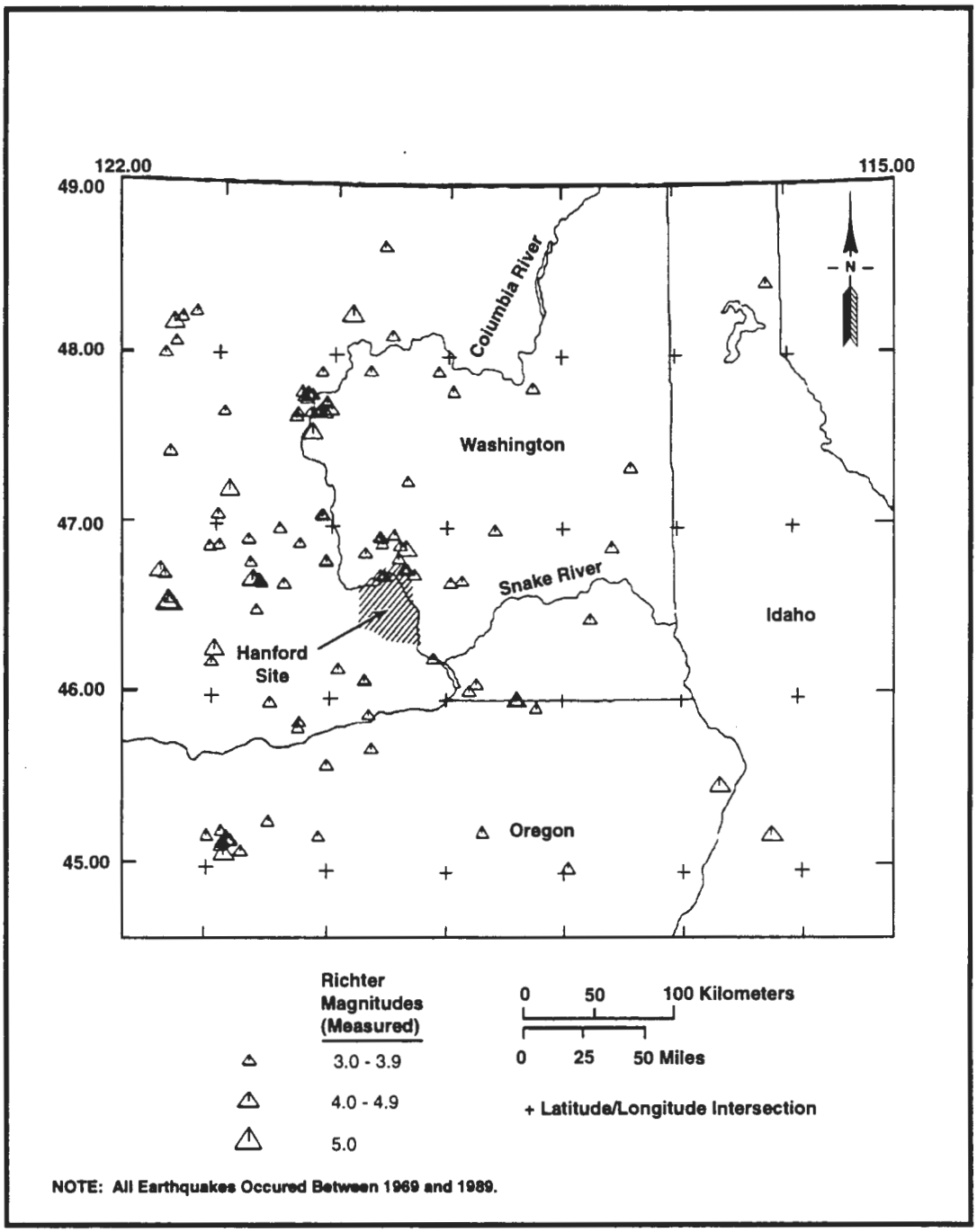


Figure 4-7. Recent Seismicity of the Columbia Plateau and Surrounding Areas as Measured by Seismographs (Cushing 1995).



Earthquakes in the 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 occur in the Columbia River Basalts and the deeper earthquakes occur in crustal layers below the basalts.

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. The most active volcano, Mount St. Helens, is located approximately 220 km (136 mi) west-southwest of the Hanford Site.

Because of their close proximity, the volcanic mountains of the Cascades are the principal 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). 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). No soils on the Hanford Site are currently classified as prime farmlands because (1) there are no current soil surveys, and (2) the only prime farmland soils in the region are irrigated (Jason Associates 1996).

Hanford Site Quick Facts: Soils

- Fifteen types of soils identified
- Textures range from sand to silty and sandy loam
- Most common soil type: Quincy Sand

4.1.6.1 Soils Within the Hanford Site Geographic Areas. Wind and water erosion have been key factors in modifying developed soil profiles on the Hanford Site, and have resulted in the loss of soil down to parent material in some geographic areas, and the creation of large active sand dunes in other geographic areas. Currently stabilized dune complexes can potentially be reactivated as a result of surface disturbances.

4.1.6.1.1 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.

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

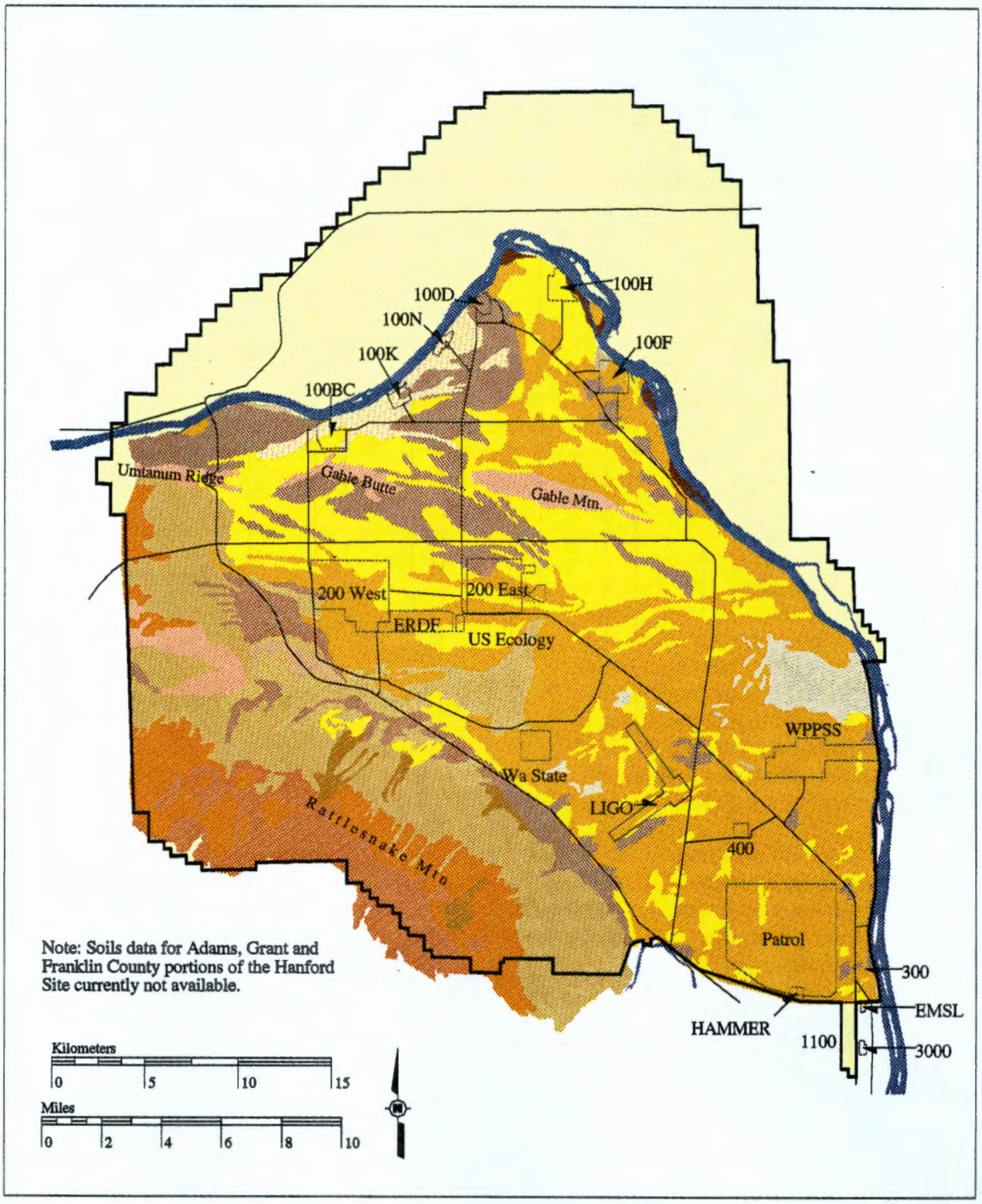


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Figure 4-8. Soil Map of the Hanford Site (Legend).

- Ritzville Silt Loam (Ri)
- Quincy Sand (Qy)
- Hezel Sand (He)
- Koehler Sand (Kf)
- Burbank Loamy Sand (Ba)
- Ephrata Sandy Loam (El)
- Lickskillet Silt Loam (Ls)
- Ephrata Stoney Loam (Eb)
- Kiona Silt Loam (Ki)
- Warden Silt Loam (Wa)
- Scooteney Stoney Silt Loam (Sc)
- Pasco Silt Loam (P)
- Esquatzel Silt Loam (Qu)
- Riverwash (Rv)
- Dunesand (D)

Table 4-1. Soil Types on the Hanford Site (adapted from 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; bedrock may occur at less than 150 cm (59 in.) but greater than 75 cm (30 in.).
Quincy (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 because 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.
Scooteney 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) in elevation. Similar to Kiona series except surface soils are darker. Shallow over basalt bedrock, with numerous basalt fragments throughout the profile.

4.1.6.1.2 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.

4.1.6.1.3 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. Quincy sand is one of the most widely distributed soil types on the Hanford Site (Hajek 1966).

4.1.6.1.4 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.

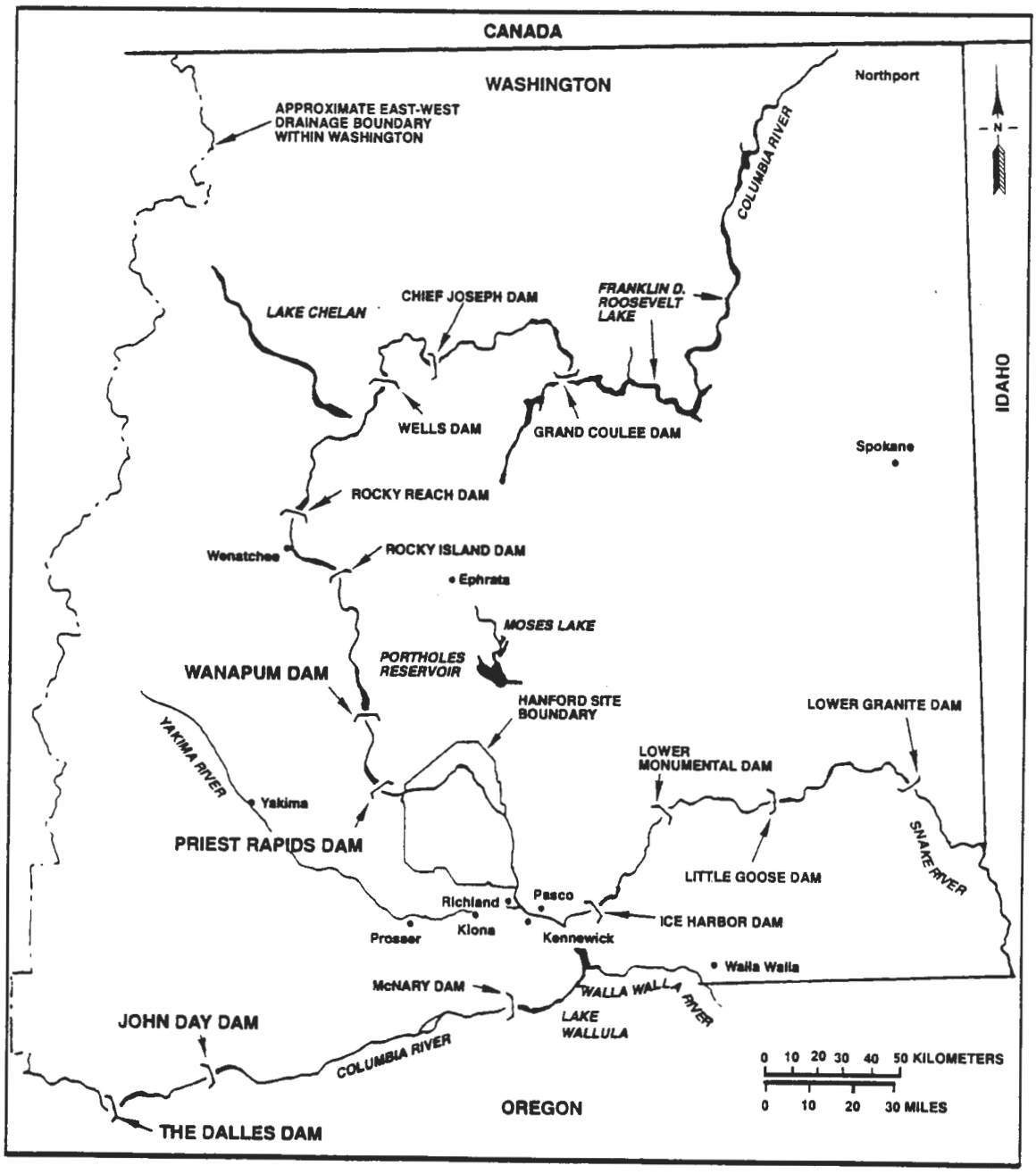
The Hanford Site occupies approximately one-third of the land area within the Pasco Basin. Primary surface-water features associated with the Hanford Site are the Columbia and Yakima rivers. Several surface ponds and ditches, which were generally associated with fuel- and waste-processing activities,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

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 flow of the Columbia River has been inventoried and described in detail by the U.S. Army Corps of Engineers (Corps) (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 in the Hanford Reach have ranged from 4,500 to 18,000 m^3/s ($\sim$158,900 to 635,600 ft^3/s) during the runoff in spring and early summer, and from 1,000 to 4,500 m^3/s (35,300 to 158,900 ft^3/s) during the low flow period of late summer and winter. The average annual Columbia

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



River flow in the Hanford Reach, based on records from 65 years, is about 3,400 m^3/s (120,100 ft^3/s). 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 the river leaves the Hanford 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 1,000 m (984 to 3,281 ft) within the Hanford Site.

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 has been about 104 m^3/s (3,673 ft^3/s), with monthly maximum and minimum flows of 490 m^3 and 4.6 m^3/s (17,305 ft^3/s and 162 ft^3), respectively.

Hanford Site Quick Facts: Surface Water

- Columbia River average annual flow: 3,400 m^3 (120,100 ft^3) per second
- Yakima River average annual flow: 104 m^3 (3,673 ft^3) per second

Cold Creek and a tributary, Dry Creek, are ephemeral streams within the Yakima River drainage system that roughly parallel State Route (SR) 240 through 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 portion of the Hanford Site. Rattlesnake Springs, located on the western portion of the Hanford 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 into the Columbia River has been known to occur for many years. Riverbank seep discharges were documented along the Hanford Reach long before Hanford operations began during World War II (Cushing 1995). These relatively small seeps 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 do not constitute a direct offsite environmental impact (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, located just south of the Hanford Site boundary on the east side of the Columbia River (northeast of the 300 Area), is the only local fish hatchery. In addition to the public hatchery, the Yakama Indian Nation is raising several species of fish in settling pools in the 100-K Area, as part of an experimental program.

Total estimated precipitation over the Pasco Basin is about 9×10^8 m^3 (1.2×10^9 yd^3) annually, averaging less than 20 cm/yr (~8 in./yr). Mean annual runoff from the Pasco Basin is estimated at less than 3.1×10^7 m^3/yr (4.1×10^7 yd^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 evapotranspiration, 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 and 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/s (742,000 ft^3/s). The largest recent flood took place in 1948 with an observed peak discharge of 20,000 m^3/s (706,280 ft^3/s) at the Hanford Site (Cushing 1995). The floodplain associated with the 1948 flood is shown in Figure 4-10. It should be noted that the chance of flooding is decreased greatly because of the construction of dams upstream from the Hanford Site.

The Federal Emergency Management Agency has not prepared floodplain maps for the Hanford Reach because they only prepare maps for areas that are being developed (a criterion that specifically excludes the Hanford Reach).

Evaluation of flood potential is conducted, in part, through the concept of the probable maximum flood, which is determined from the upper limit of precipitation falling on a drainage area, and other hydrologic factors (e.g., 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 at 40,000 m^3/s (1.4 million ft^3/s) (Figure 4-10), and is greater than the 500-year flood. This flood would inundate parts of the portions of the 100 Area that are located adjacent to the Columbia River; the central portion of the Hanford Site would remain unaffected (Cushing 1995). Floodplain issues are further discussed in Appendix J, Floodplain/Wetlands Assessment.

The Corps 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/s (540,000 ft^3/s), and the 100-year regulated flood as 12,400 m^3/s (440,000 ft^3/s).

Hanford Site Quick Facts: Columbia River Floods

- Largest flood on record: 1894 @ 21,000 m^3/s
- Largest recent flood: 1948 @ 20,000 m^3/s
- Probable maximum flood: 40,000 m^3/s

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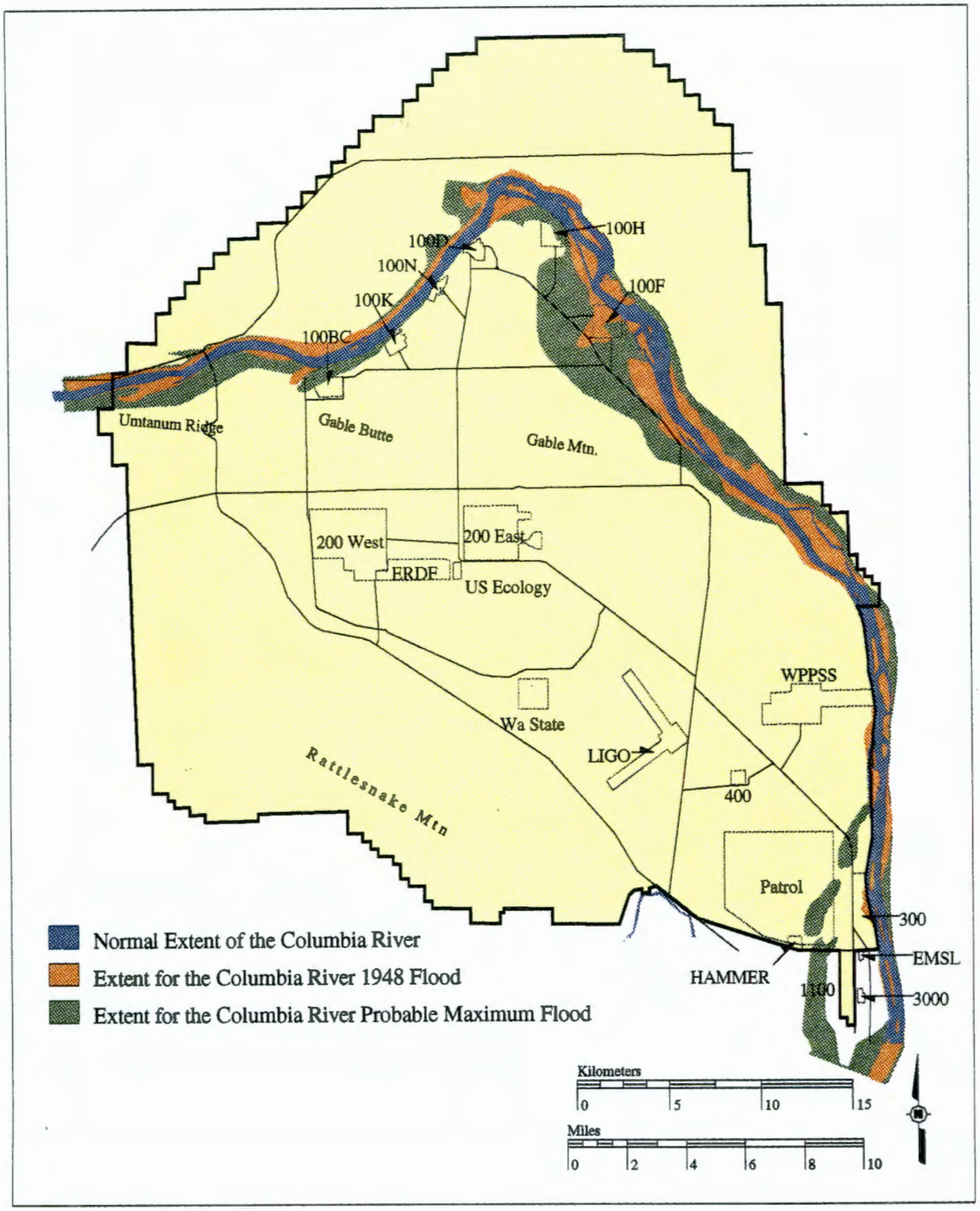
Figure 4-10. Flood Area for the Probable Maximum Flood and the Flood Area of the Columbia River 1948 Flood (adapted from Cushing 1995).



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 Corps evaluated a number of scenarios for failure of the Grand Coulee Dam, and assumed flow conditions of 11,000 m^3/s (400,000 ft^3/s). 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 from such an instantaneous 50% breach at the outfall of the Grand Coulee Dam was determined to be 600,000 m^3/s (21 million ft^3/s) (Figure 4-11). In addition to the areas inundated by the probable maximum flood, 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 (1) failures of dams upstream, (2) associated failures downstream of Grand Coulee, or (3) breaches greater than 50% of Grand Coulee because the 50% scenario was believed to represent the largest realistically conceivable flow that could result from 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. The analysis also assumed that the 50% breach would occur only as the result of direct explosive detonation, not because of a natural event (e.g., 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 landslide area considered was the 75-m (250-ft) -high bluff (generally known as White Bluffs). Calculations were made for an 8×10^5 m^3 (1×10^6 yd^3) landslide volume with a concurrent flood flow of 17,000 m^3/s (600,000 ft^3/s) (a 200-year flood) that results 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 illustrated earlier in this Environmental Impact Statement (EIS) (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. This design work evaluated the Probable Maximum Flood rather than the worst case and/or 100-year flood scenarios. Therefore, in lieu of 100- and 500-year floodplain studies, a probable maximum flood evaluation was made for a reference repository located directly west of the 200 East Area that encompasses the 200 West Area (Cushing 1995). Figure 4-12 identifies 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, between Grand Coulee Dam and the mouth of the river near Astoria, Oregon, as Class A (excellent) (Cushing 1995). Class A waters are suitable for essentially all uses, including drinking water, recreation, and wildlife habitat. State and federal drinking water standards, as well as DOE Order 5400.5, apply to the Columbia River, and are currently being met.

The Pacific Northwest National Laboratory (PNNL) conducts routine monitoring (for both radiological and nonradiological water quality parameters) of the Columbia River. A yearly summary of these monitoring results has been published since 1973 (PNL 1995a). Numerous water quality studies have been conducted on the Columbia River during the past 37 years. Three outfalls, located in the 100-K, 100-N, and 300 Areas of the Hanford Site, are covered by a National Pollutant Discharge Elimination System permit (permit no. WA-000374-3). 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 environmental reports such as

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Figure 4-11. Flood Area of a 50-percent Breach of the Grand Coulee Dam (adapted from Cushing 1995).

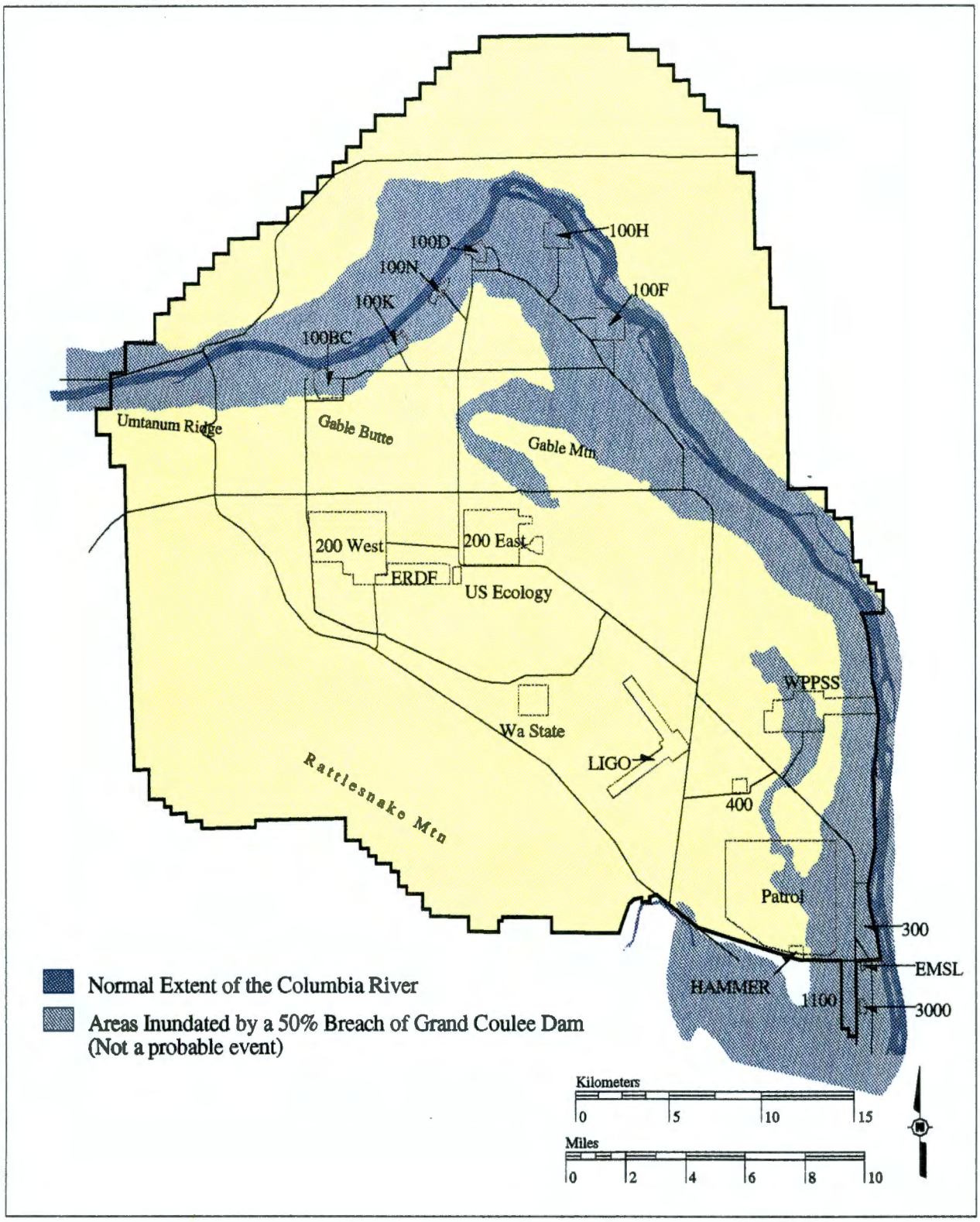
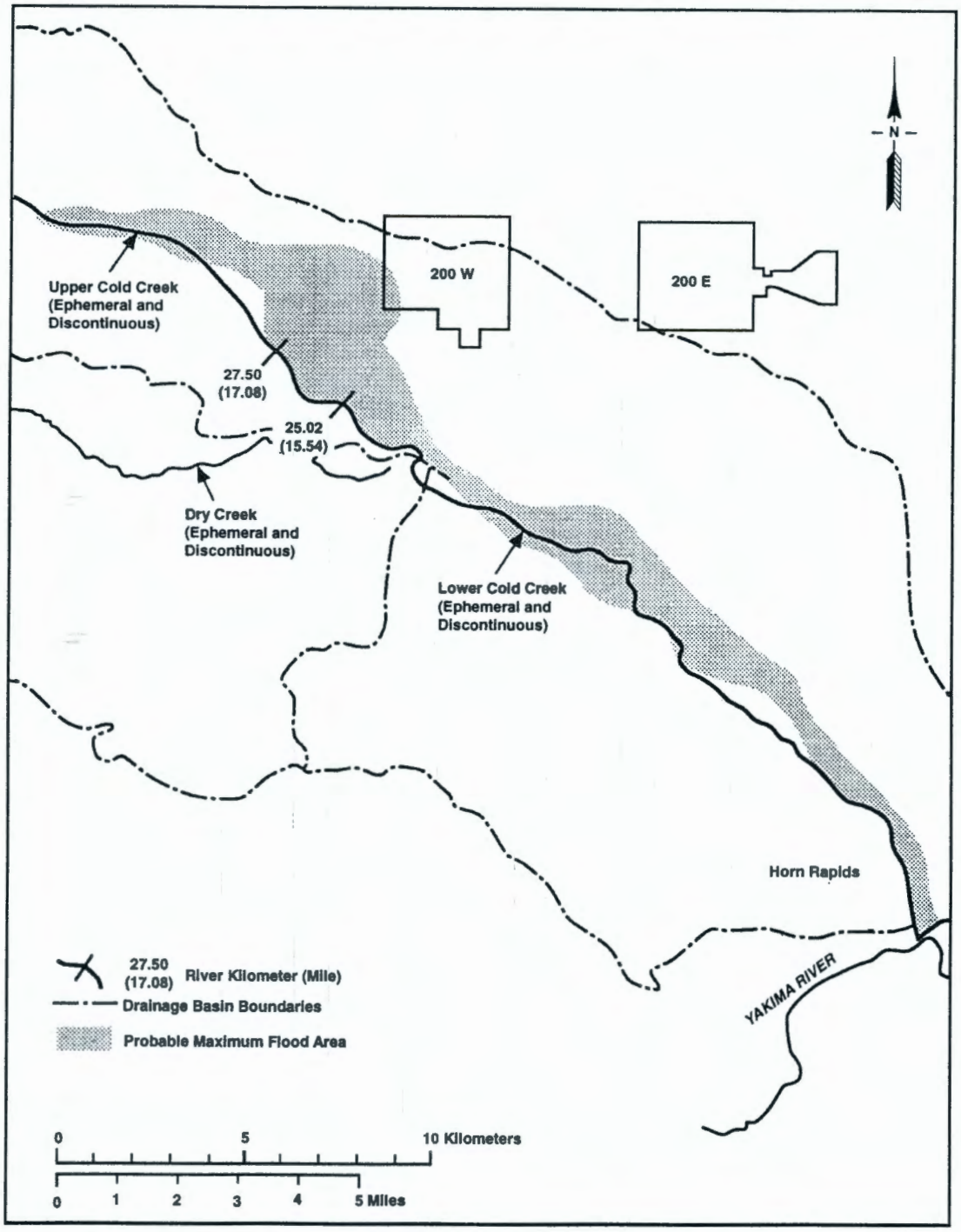


Figure 4-12. Extent of the Probable Maximum Flood in the Cold Creek Area (Cushing 1995).



the *Hanford Site Environmental Report for Calendar Year 1994* (PNL 1995a). In 1994, monitored liquid discharges resulted in a dose of 0.039 mrem to the downstream maximally exposed individual (PNL 1995a).

Radiological monitoring of the Columbia River continues to show low levels of radionuclides. Although radionuclides associated with Hanford operations continued to be identified in Columbia River water in 1994, concentrations remained well below applicable standards at all monitored locations (PNL 1995a).

In 1994, tritium, iodine-129, technetium-99, and uranium concentrations downstream of the Hanford Site were found to be slightly higher than upstream concentrations, but were well below guidelines established by the DOE through DOE Order 5400.5, 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).

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

Radionuclides	Water Concentrations (pCi/L)			Downstream Concentration as Percentage of Drinking Water Standard
	Upstream Concentration (Priest Rapids Dam)	Downstream Concentration (Richland Pumphouse)	EPA Drinking Water Standard	
H-3	38	87	20,000	0.44
Sr-90	0.09	0.09	8.0	1.1
U	0.42	0.49	20.0 (ug/L)*	2.5
Tc-99	0.02	0.05	900	0.01
I-129	4.3×10^{-5}	7.7×10^{-5}	0.48	0.02

*Proposed.

For nonradiological water quality parameters measured in Columbia River water during 1994, concentrations of metals and anions were similar upstream and downstream, and were found to be in compliance with applicable primary drinking water standards. Concentrations of volatile organic compounds (VOC) also were below regulatory standards (PNL 1995a).

4.2.2 Groundwater

The following sections describe the groundwater resources at the Hanford Site. 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. This aquifer is dominated by the Ringold Unit E, 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 Ringold Lower Mud Unit. A semiconfined aquifer occurs in areas where the coarse-grained Ringold Unit A lies between the basalt and the fine-grained Ringold Lower Mud Unit. 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 basalt flow tops or flow bottoms. Figure 4-13 presents a generalized subsurface cross-section of the Hanford Site, and Figure 4-14 presents water table elevations for the unconfined aquifer.

4.2.2.1 Groundwater Hydrology. The multi-aquifer system within the Pasco Basin has been conceptualized as consisting of four geohydrologic units: (1) Grande Ronde Basalt; (2) Wanapum Basalt; (3) Saddle Mountain Basalt; and (4) Hanford and Ringold formation sediments lying above the basalt units (Figure 4-13). 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 is composed of the basalt flows and minor intercalated sediments that are 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). Groundwater in these basalts is confined to semiconfined and is recharged along the margins of the Columbia Plateau where the basalt 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 this system is known to occur. Groundwater within the Grande Ronde Basalt in the eastern Pasco Basin is believed to originate from groundwater inflow from the east and the northeast.

The Wanapum Basalt 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 Wanapum Basalt underlies the entire Pasco Basin and has a maximum thickness of 370 m (1,215 ft). Groundwater within the Wanapum Basalt is confined to semiconfined.

The Saddle Mountain Basalt is composed of the youngest formation of the Columbia River Basalt group and several thick sedimentary beds of the Ellensburg Formation or equivalent sediments, which 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 Saddle Mountain Basalt 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 Basalt 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 sediment (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 sediment is unconfined, with recharge and discharge usually coincident with topographic highs and lows (DOE 1988). The Hanford/Ringold unit is restricted to the Pasco Basin; principal recharge occurs (along the periphery of the basin) from precipitation and ephemeral streams.

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

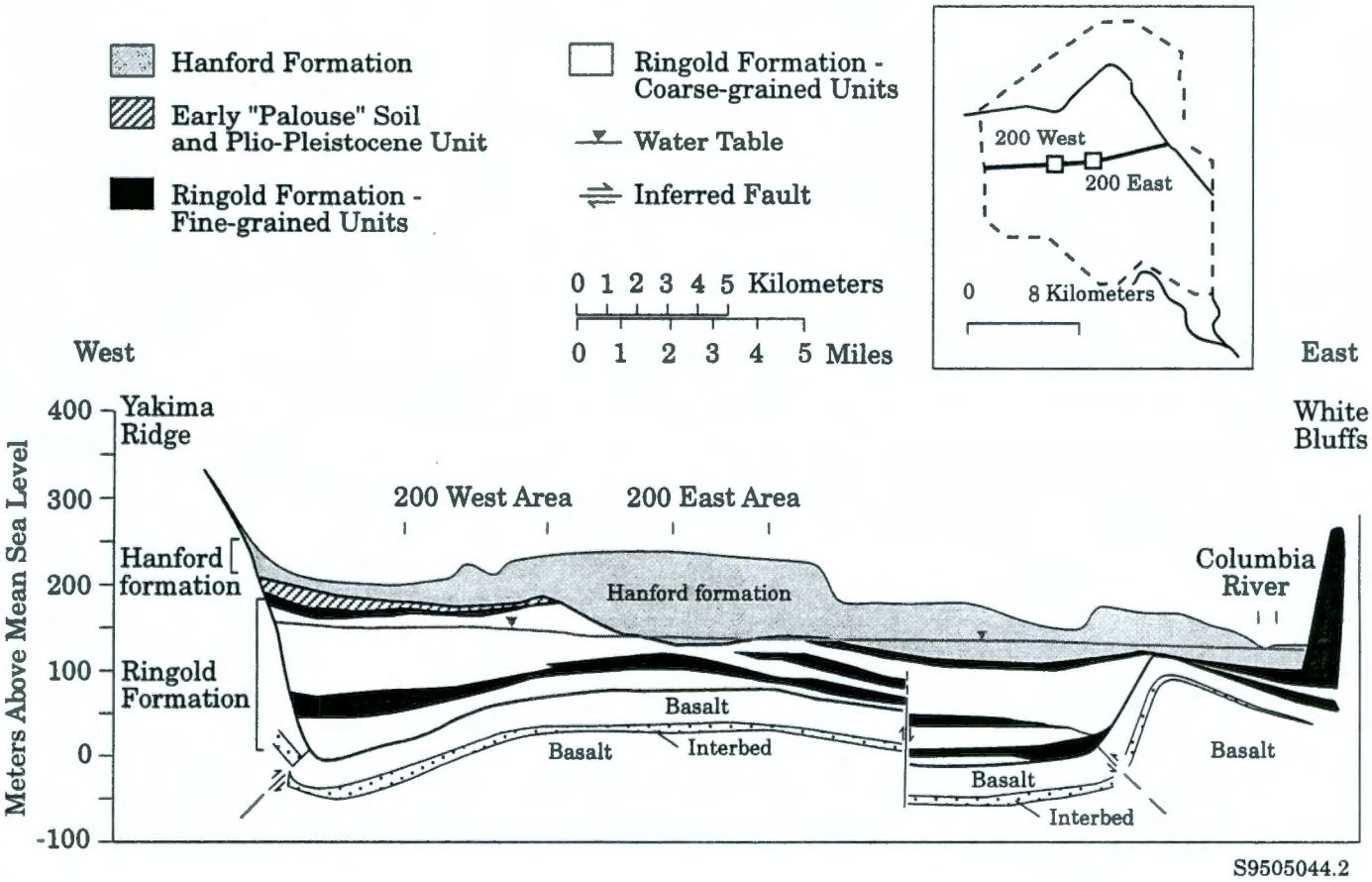
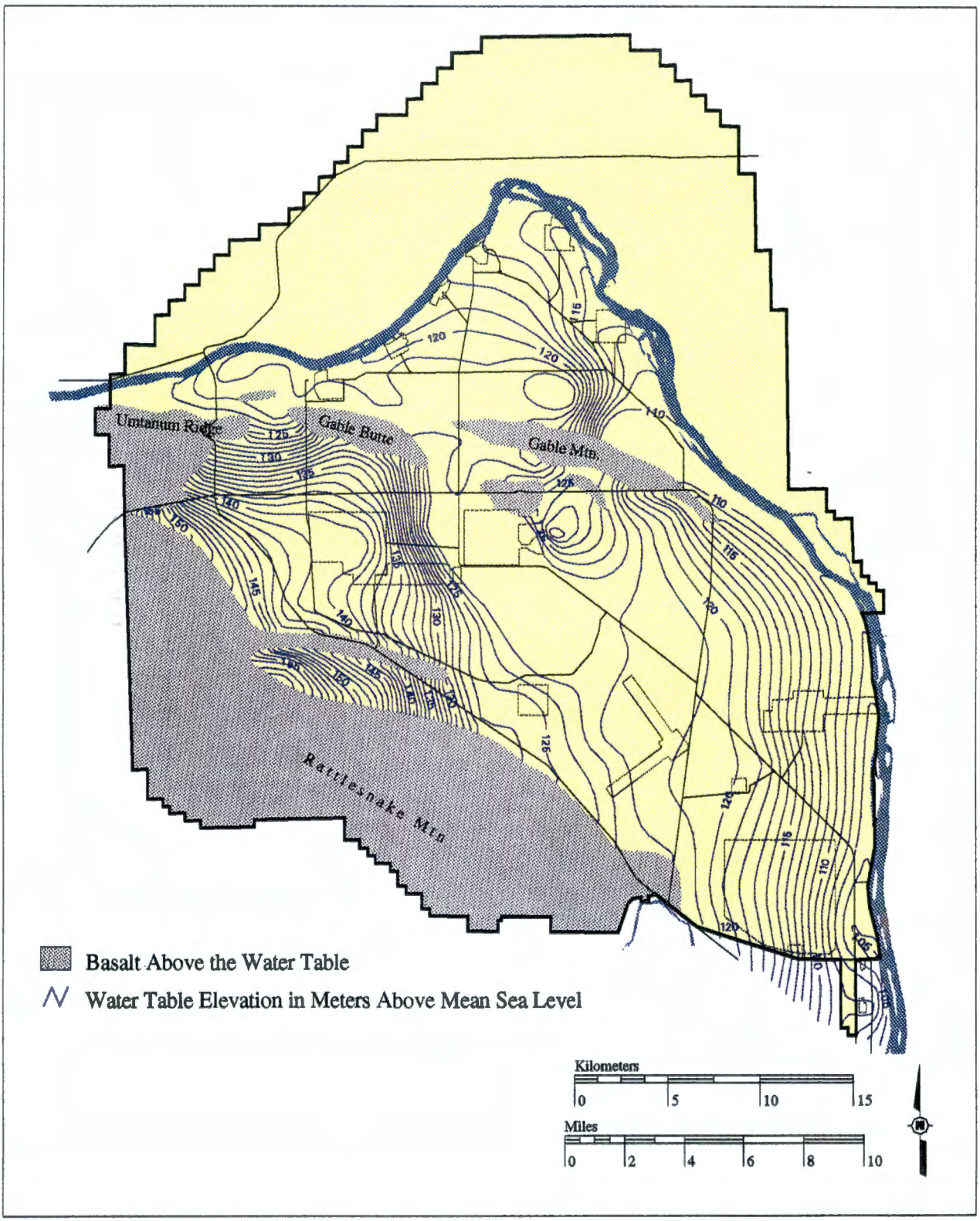


Figure 4-14. Water-Table Elevations for the Unconfined Aquifer at the Hanford Site (adapted from Cushing 1995).



9613459.1991

4.2.2.2 Groundwater Recharge. 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. Within the Pasco Basin, recharge occurs along the anticlinal ridges to the north and west, and from groundwater inflow from the east and northeast (DOE 1988). 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 unsaturated (vadose) zone, the movement of precipitation through the vadose zone has been studied at several locations on the Hanford Site. Conclusions from these studies vary depending on the location studied. Some investigators conclude that no downward percolation of precipitation occurs on the Central Plateau (where soil texture varies, and is layered with depth), and all moisture penetrating the soil is removed by evapotranspiration. In tests conducted near the 300 Area (where soils are coarse textured and precipitation is above normal), downward water movement below the root zone was observed (DOE 1987).

From the recharge areas to the west, 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.

Studies indicate that local recharge to the shallow basalts results 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 that originates northeast and northwest of the Pasco Basin in areas where the Wanapum and Grande Ronde Basalt outcrops are extensive (DOE 1995). Groundwater is discharged from the shallow basalt to the overlying unconfined aquifer and the Columbia River.

4.2.2.3 Groundwater Quality. The quality of the groundwater at the Hanford Site has been affected by many of the activities related to the production of nuclear materials. Due to the arid climate, natural recharge of the groundwater on the Hanford Site is 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 a variety of radionuclides and chemicals that move through the soil column at differing rates, eventually entering the groundwater and forming plumes of contamination.

Hanford Site Quick Facts: Principal Groundwater Contaminants

- chromium
- nitrate
- trichloroethylene
- fluoride
- carbon tetrachloride
- chloroform
- technetium-99
- arsenic
- cobalt-60
- strontium-90
- tritium
- uranium
- cesium-137
- iodine-129
- plutonium

4.2.2.3.1 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 ~350 mg/L 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 geologic strata and irrigation and other agricultural 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 PNNL and the U.S. Geological Survey on the Hanford Site from 1974 to 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.

Radioactive and nonradioactive liquid effluents were discharged to the environment from facilities in the Central Plateau (DOE 1995). The U.S. Department of Energy, Richland Operations Office (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 obtain permits for the waste streams under the "State Waste Water Discharge Permit Program," *Washington Administrative Code* 173-216, by October of 1997. The goal associated with the use of Best Available Technology is to eliminate, minimize, or treat effluents discharged to the ground.

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 through liquid waste disposal cribs. Minor quantities of longer-lived radionuclides also have reached the water table, possibly through a failed groundwater monitoring well casing and through injection wells (DOE 1995). Under the provisions of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), remedial investigations and feasibility studies will be conducted to evaluate and implement remedial actions for groundwater operable units at the Hanford Site. Additional information about Hanford Site groundwater contamination plumes is presented in Section 4.10.

In 1994, 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, and are used for purposes of comparison only. With few exceptions (e.g., the 400 Area, Rattlesnake Mountain, the Yakima Barricade, and the Pistol Range), groundwater beneath the Hanford Site is not used for human consumption or food production. Groundwater utilized for drinking for all of the 400 Area operations contains above-background concentrations of tritium and iodine-129 originating in the 200 East and 200 West Areas; 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. 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. (See Section 4.2.1.2 for a discussion on Columbia River water quality.)

In 1994, 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 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 standard in the 300 Area wells, a result of liquid waste disposal at former fuel fabrication facilities (PNL 1995a).

The occurrence of leaks from waste storage tanks, and of radioactive materials in soils, have been described elsewhere (DOE 1987, DOE and Ecology 1996). These occurrences have not, and should not 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).

4.2.2.3.2 Confined Aquifer. The uppermost confined aquifer (Rattlesnake Ridge) was sampled to determine what extent of groundwater contamination occurred from interaction between the confined and unconfined aquifers. Groundwater samples from selected confined aquifer wells were 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) was 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 in 1991. The 1994 samples from this well also contained 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 constituents are indicators of contamination, only nitrate and technetium-99 were detected at levels greater than drinking water standards.

Elevated levels of tritium were measured in groundwater from the Rattlesnake Ridge interbed in well 699-42-40C, which is located adjacent to B Pond. Samples taken from this well in 1994 contained a maximum of 7,050 pCi/L of tritium. Tritium concentrations were slightly lower than levels detected in 1993, and were well below the drinking water standard.

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 aquifers, but was open to both the unconfined and confined aquifer from 1953 and 1970. Therefore, it is possible that the well provided a conduit for contamination to move downward from the unconfined aquifer. The current extent of contamination in the confined aquifer is unknown.

4.2.2.4 Groundwater Within the Hanford Site Geographic Areas. The following sections describe the groundwater in the Reactors on the River, Central Plateau, and All Other Areas geographic areas of the Hanford Site.

4.2.2.4.1 Reactors on the River. A generalized hydrogeologic column for the Reactors on the River geographic area is presented in Figure 4-15. This representation was developed for the 100-N Area, but the basic units generally are found in the other 100 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 exhibits the responses of a confined system.

The Rattlesnake Ridge interbed is the uppermost confined aquifer within the Columbia River basalt sequence; 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 an upward hydraulic gradient exists 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.

The uppermost aquifer system consists of five hydrostratigraphic units (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 becomes 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 the Reactors on the River geographic area generally is toward the Columbia River. During elevated river stages, however, groundwater flow is away from the river. Groundwater gradients and flow directions were influenced in the past by groundwater mounds, which resulted from discharge of reactor effluent to the subsurface. With the shutdown of the reactors, all groundwater mounds have dissipated.

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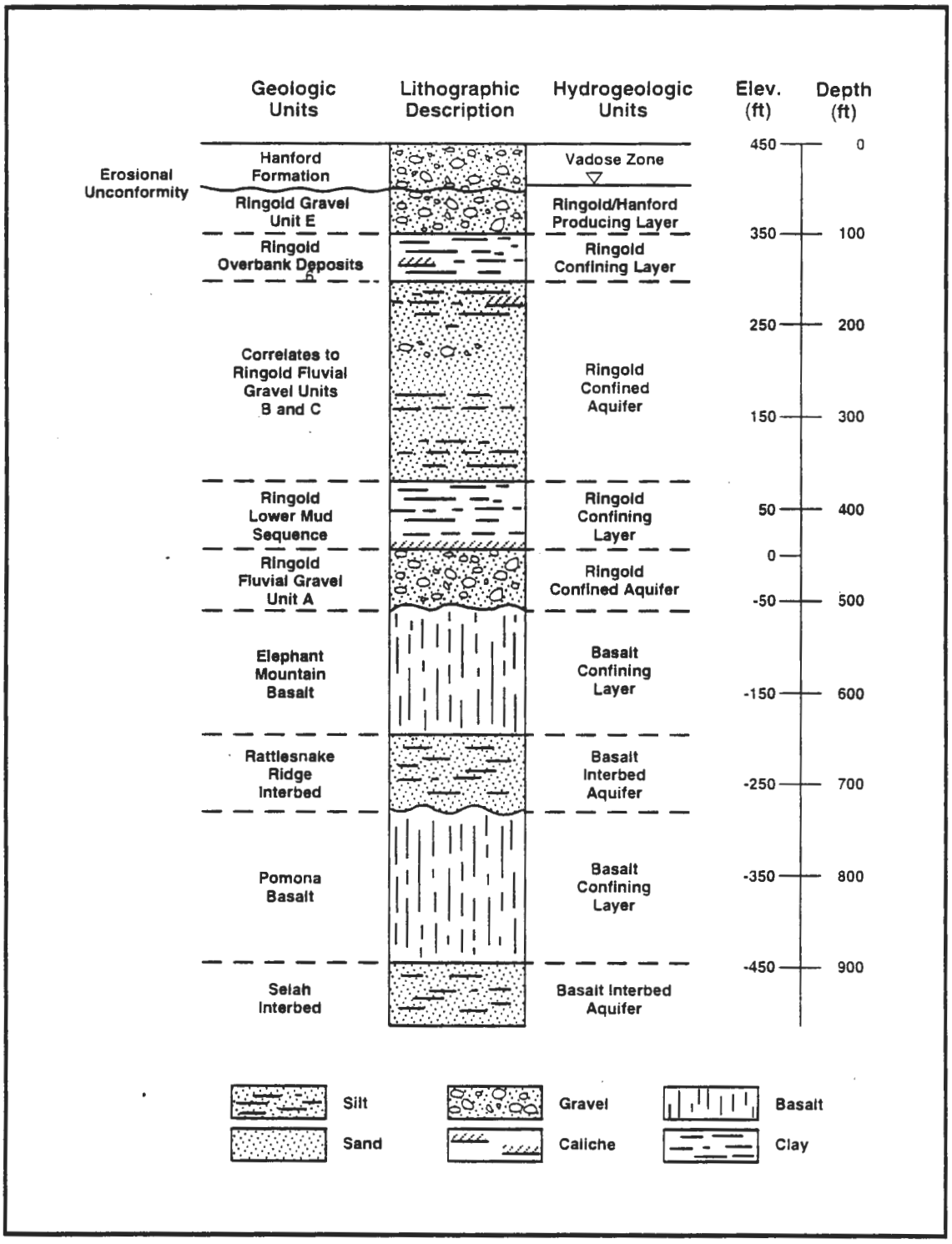
Figure 4-15. Generalized Stratigraphic and Hydrologic Column for the Reactors on the River Geographic Area (WHC 1991b).



4.2.2.4.2 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 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.

The uppermost aquifer system in the Central Plateau primarily occurs within the sediments of the Ringold and Hanford formations. 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 and Hanford formations.

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, unit A and unit E cannot be hydraulically differentiated. The confining zone that overlays 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,

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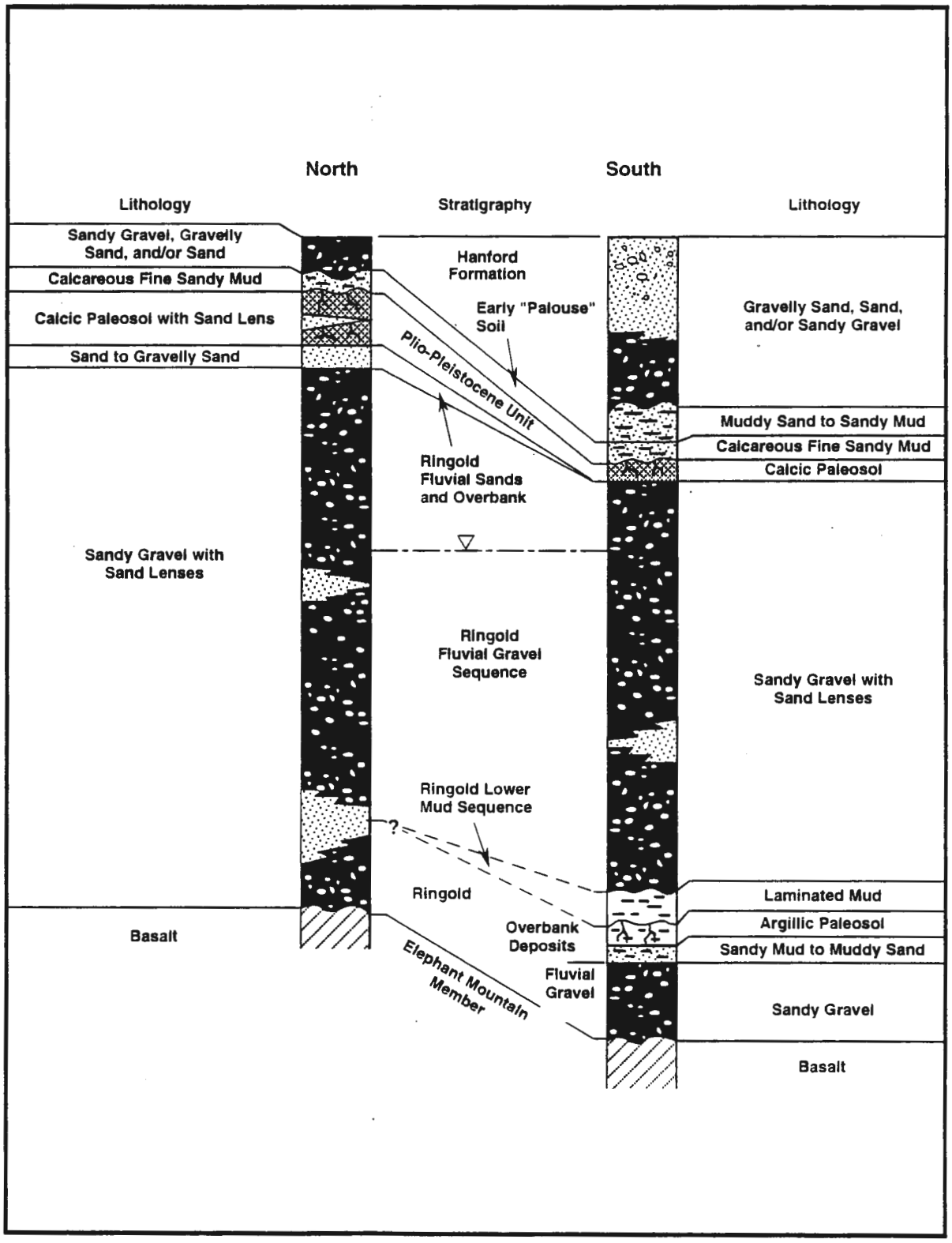
Figure 4-16. Generalized Stratigraphic and Hydrologic Column for the Central Plateau (WHC 1991b).



post-Ringold erosion has removed unit E as well as the entire Ringold Formation. Where this occurs, as well as in areas 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 following three waste ponds have been the major source of artificial recharge in the Central Plateau: 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 is now halted. As a result, the groundwater mound associated with B Pond also is declining.

4.2.2.4.3 All Other Areas. The hydrogeologic system in the All Other Areas geographic area is very complex because of repeated deposition and erosion events. Most available hydrogeologic information is concentrated in the 1100 and 300 Areas; hydrogeologic system descriptions are provided for these areas.

Hydrostratigraphic units in the 1100 Area, in ascending order, 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 and Hanford formations (WHC 1991b) (Figure 4-17).

The uppermost aquifer system occurs within both the Ringold and Hanford formations. The upper aquifer is divided into a semiconfined lower part and an unconfined upper part by a discontinuous site aquitard consisting of overbank deposits of the Ringold Formation. One or more confined to semiconfined zones probably 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 the lateral extent of the aquitard is not known.

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 that occurs 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 downstream from the Horn Rapids Dam (WHC 1991b). Groundwater recharge to the unconfined aquifer below the 1100 Area 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.

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

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

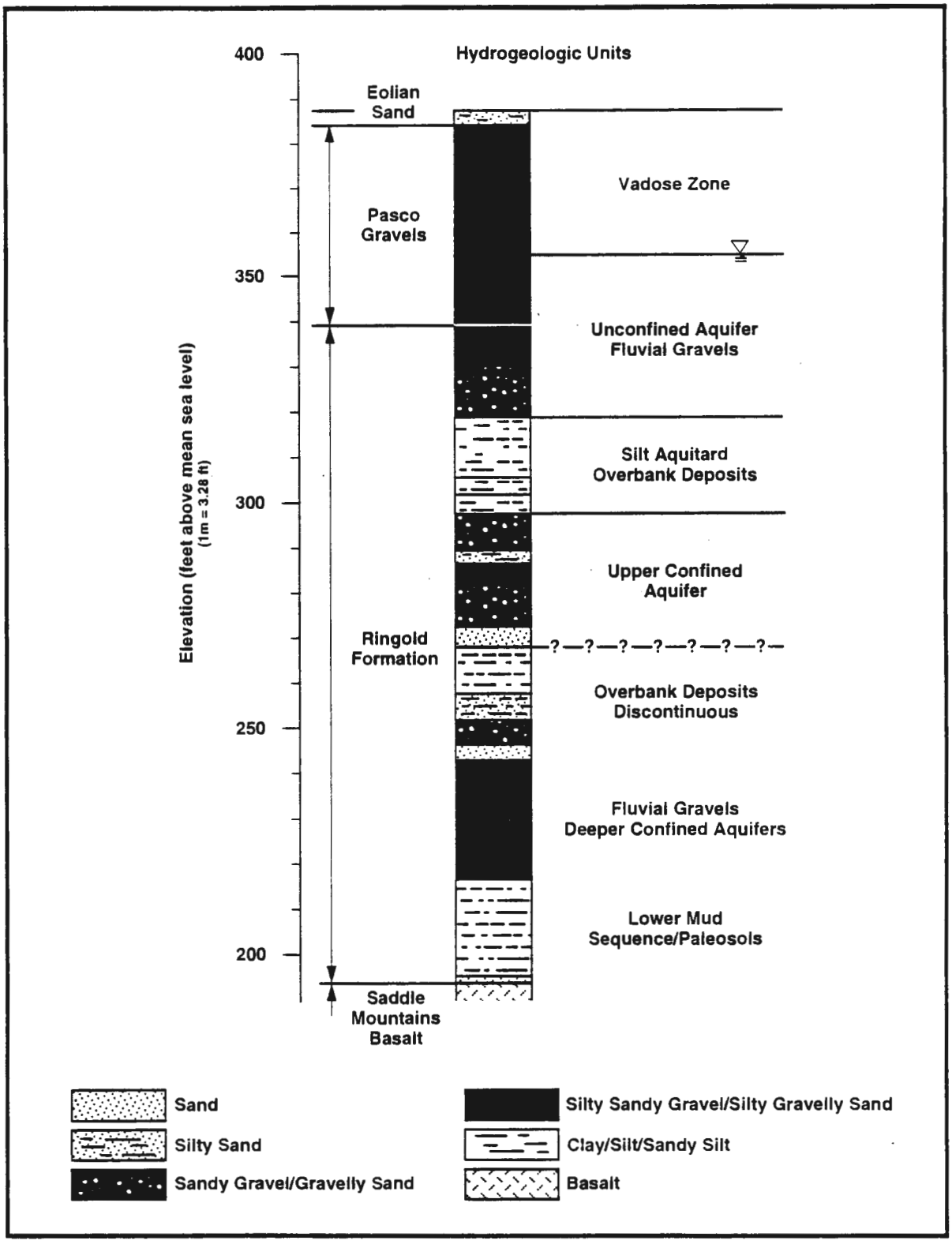
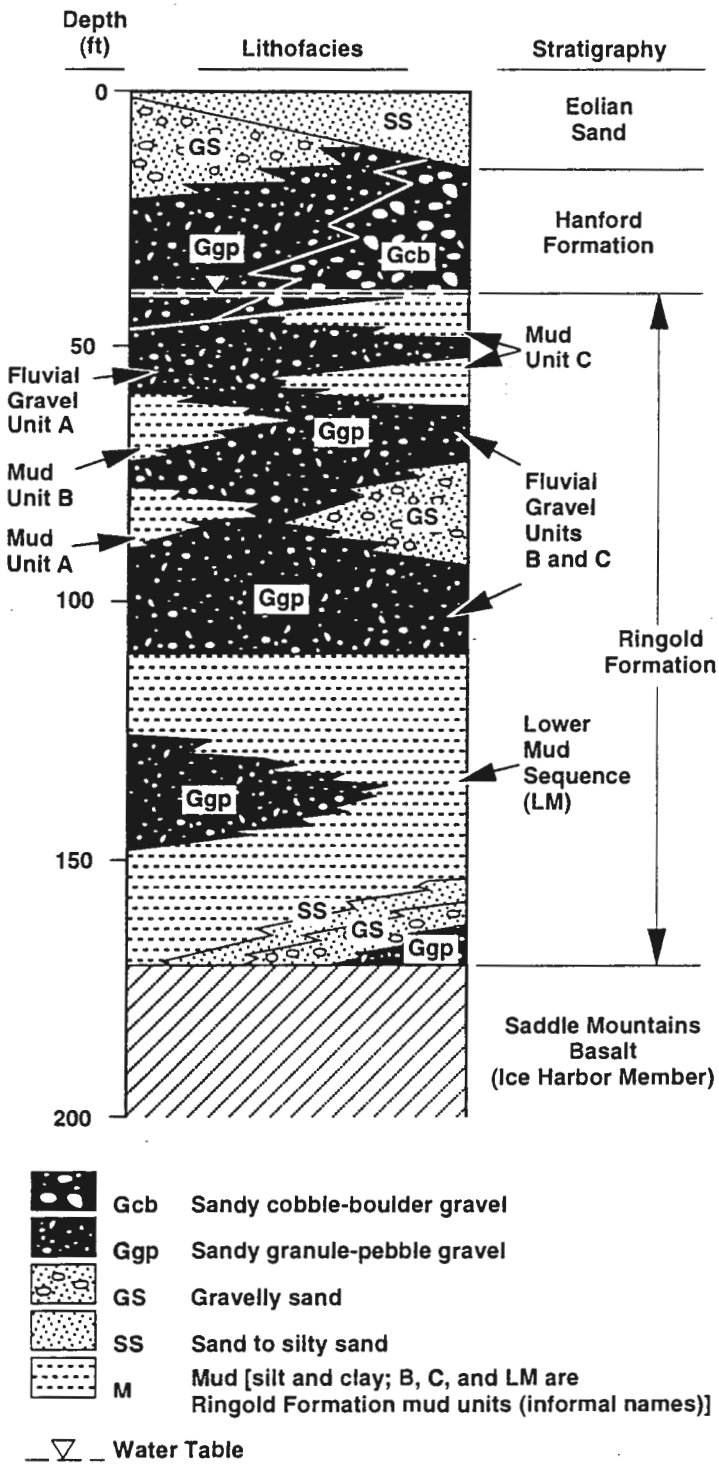


Figure 4-18. Generalized Stratigraphic and Hydrologic Column for the 300 Area (WHC 1991b).



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.

The uppermost aquifer system in the 300 Area is located in the Ringold and Hanford formations. 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 Ringold and Hanford formations, but generally is found in the Ringold Formation (Cushing 1995). The Hanford formation in the 300 Area consists of gravel with cobbles and boulders, and usually only a small part of the lower half of the unit is saturated with water. The vadose zone in this area lies almost entirely within the gravels of the Hanford formation.

Groundwater generally flows across the 300 Area to the southeast. However, in the southern part of the area there is a component of groundwater that flows from the Yakima River (located southwest of the 300 Area) towards 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 eliminated, and the groundwater mounding beneath the trenches has dissipated.

4.2.3 Water Use

Water use in the Pasco Basin is primarily from surface diversion, with groundwater diversions accounting for less than 10% of the total use (DOE 1988). Historically, industrial, agricultural, and municipal usage represented about 32%, 50%, and 9%, respectively. 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 uses, with the Hanford Site accounting for about 41% of the water withdrawn for industrial use (DOE 1995). The first downstream drinking water intake below the Hanford Site is the City of Richland intake.

The largest category of wells in the Pasco Basin are those used for domestic purposes (approximately 50%). 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 use of 142,000 m^3 (37 million gallons) in 1988 from two wells in the lower unconfined aquifer, and the PNNL 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 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 slowed down substantially between 1970 and 1980, when only small increases in water table elevations occurred. Wastewater discharges from the 200 West Area were reduced significantly 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 climate 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, and resulted 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).

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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 collected at this location since 1945 (Hoitink and Burk 1994) 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 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 vectors of each rose represent the directions from which the winds come, and the length of each vector represents the frequency for the wind from that direction.

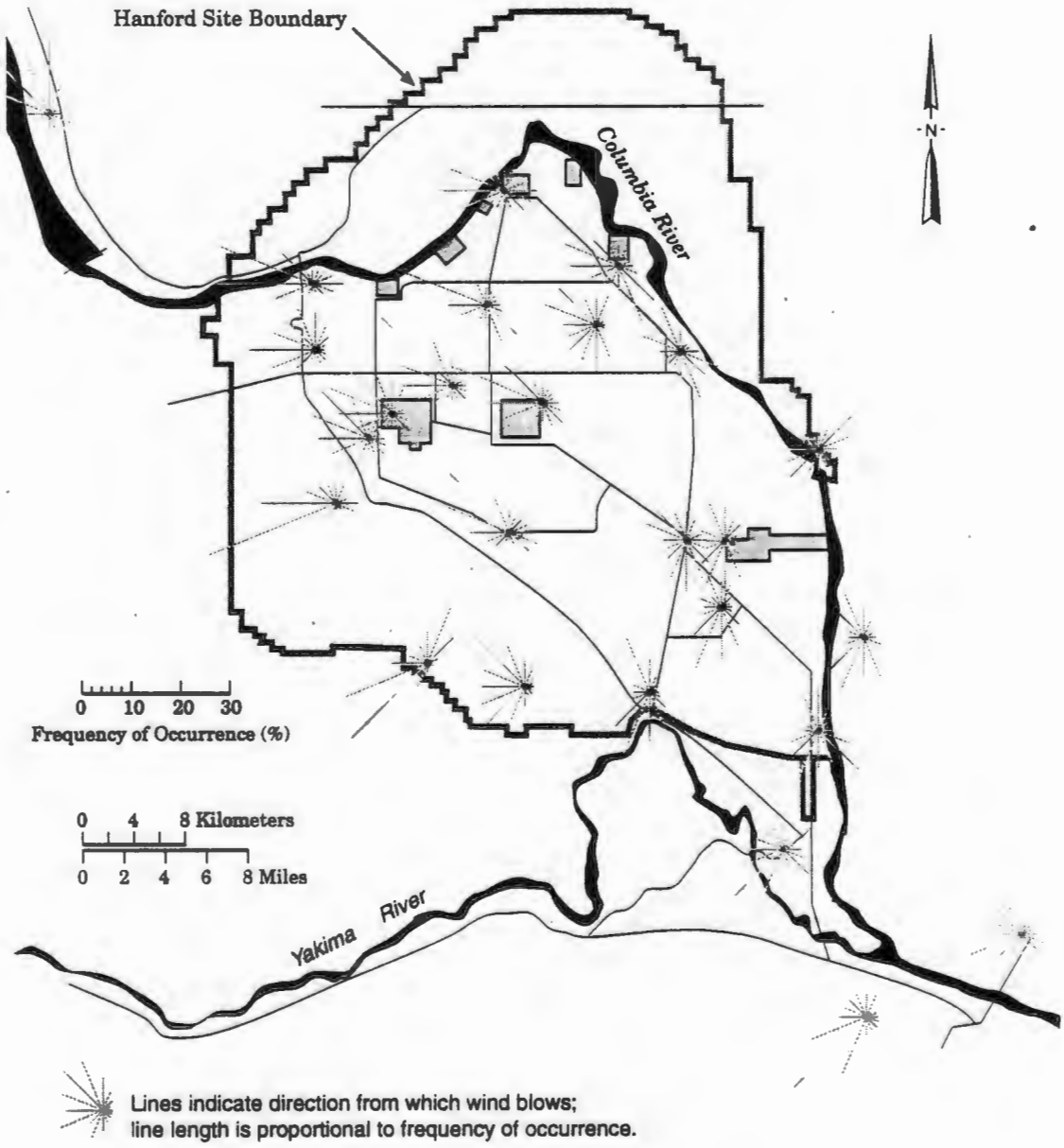
4.3.1.2 Temperature and Humidity. Nine separate temperature measurements are made at the 122-m (400-ft) tower at the HMS. Temperatures also are measured at the 2-m (6.5-ft) level on the twenty-four 9.1-m (30-ft) towers located on and around the Hanford Site. The three 61-m (200-ft) towers have temperature-measuring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

Hanford Site Quick Facts: Meteorology

• Average annual precipitation:	16.1 cm (6.3 in.)
• Prevailing wind direction:	Northwest
• Average monthly temperature:	January: 0.9°C (30°F) July: 24.6°C (76°F)

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 of 1946 through

Figure 4-19. Wind Roses for the Hanford Meteorological Monitoring Network, 1979 to 1994.



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 average lowest temperature 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.

Relative humidity and dew-point temperature measurements are made at the HMS and at the three 61-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%. Fog reduces the visibility to 9.6 km (6 mi) during an average of 42 days/yr, and to less than 0.4 km (0.25 mi) during an average of 25 days/yr (DOE 1995).

4.3.1.3 Precipitation. The average annual precipitation at the HMS is 16.1 cm (6.3 in.). 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). Rainfall intensities of at least 1.3 cm/hr (0.5 in./hr), persisting for 1 hour, has only a 10% probability of occurring in any given year. A rainfall intensity of at least 2.5 cm/hr (1 in./hr) has only a 0.2% probability of occurring in any given year.

4.3.1.4 Severe Weather. Severe weather on the Hanford Site may include a variety of meteorological events, which include severe winds, blowing dust, hail, fog, 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 the extreme western edge), and no damage resulted. The estimated probability of a tornado striking a point at the Hanford Site is 9.6 x 10^{-6}/yr (Cushing 1995). Because tornadoes are infrequent and generally small in the Pacific Northwest (and hurricanes do not reach this area), risk from severe winds normally are associated with thunderstorms or the passage of strong cold fronts. The greatest peak wind gust was 130 km/hr (81 mi/hr), recorded at 15 m (50 ft) above ground level at the HMS. Extrapolations based on 35 years of observations indicate a return period of about 200 years for a peak gust in excess of 145 km/hr (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 generally are 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 might 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 1 hour after sunrise, as a result of ground-based temperature inversions and shallow mixing layers (Cushing 1995).

4.3.2 Air Quality

The EPA has set National Ambient Air Quality Standards (NAAQS) that define levels of air quality that are necessary to protect the public health (primary standards) and the public welfare (secondary standards). Regional air quality is generally good, with the occasional exception due to blowing dust.

4.3.2.1 Regional Air Quality. 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 particulate matter nominally 10 microns or less (PM_{10}) standard. Because the highest concentrations of airborne particulate material are generally a result of natural events, the area has not been designated nonattainment[1] with respect to the PM_{10} standard.

Particulate concentrations can reach relatively high levels in eastern Washington State because of extreme natural events (i.e., dust storms, volcanic eruptions, and large brushfires) that occur in the region. "Rural fugitive dust" from extreme natural events was not considered when estimating the maximum background concentrations of particulates in the area east of the Cascade Mountain crest and when determining Washington State ambient air quality standards. 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 (Cushing 1995).

Ecology conducted the only offsite monitoring (for PM_{10}) near the Hanford Site in 1993 (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 $\mu g/m^3$, was exceeded twice at the Columbia Center monitoring location; the maximum 24-hour concentration at Columbia Center was 1,166 $\mu g/m^3$ (the suspected cause was windblown dust); the other occurrence greater than 150 $\mu g/m^3$ was 155 $\mu g/m^3$. The site did not exceed the annual primary standard, 50 $\mu g/m^3$, during 1993. The arithmetic mean for 1993 was 32 $\mu g/m^3$ at Columbia Center.

During the past 10 years, carbon monoxide, sulfur dioxide, and nitrogen dioxide have been monitored periodically in communities and commercial areas southeast of the Hanford Site. These urban measurements are used to estimate the maximum background pollutant concentrations for the Hanford Site. Because these measurements were made in the vicinity of local sources of pollution, they might overestimate maximum background concentrations for the Hanford Site, or at the Hanford Site boundaries. Concentrations of toxic chemicals, as listed in 40 CFR 60.1, are not measured and, therefore, are not available for the Hanford Site.

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[1]A nonattainment area is an area where measured concentrations of a pollutant are above the primary or secondary NAAQS.

4.3.2.2 Hanford Site Air Quality. A discussion of Hanford Site nonradioactive and radioactive air quality is presented in the following sections.

4.3.2.2.1 Nonradiological Air Quality. The NAAQSs, set by EPA, must be met at the Hanford Site boundary or other publicly accessible locations (e.g., highways on the Hanford 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 particulates (TSP), PM_{10}, lead, and ozone. The standards specify the maximum pollutant concentrations and frequencies of occurrence that are allowed for specific averaging periods (for example, the concentration of carbon monoxide when averaged over 1 hour is allowed to exceed 40 mg/m^3 only once a 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. PSD standards 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 restricted), and Class II areas (where moderate degradation of air quality is allowed). 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. The PSD standards are presented in Table 4-3. The Hanford Site, which is located in a Class II area, operates under a PSD permit (permit no. PSD-X80-14) issued by the EPA in 1980. This permit provides specific limits for emissions of nitrogen oxide from the Plutonium-Uranium Extraction (PUREX) and the Uranium-Trioxide plants.

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}) (ug/m^3)	Annual	4	17
	24 hours	8	30
Sulfur dioxide (ug/m^3)	Annual	2	20
	24 hours	5	91
	3 hours	25	512
Nitrogen dioxide (ug/m^3)	Annual	2.5	25

*PM_{10} is defined as particulate matter nominally 10 microns or less.

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. In addition, Washington has established standards for VOCs, 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).

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 $\mu g/m^3$
Fluoride			
12-hour average			3.7 mg/m^3
24-hour average			2.9 mg/m^3
7-day average			1.7 mg/m^3
30-day average			0.84 mg/m^3
VOCs			source-specific standards

[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.
VOC = volatile organic compound.

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 boundary are reported to Ecology by the DOE (Table 4-5).

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.

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 East Area Boiler	8,760	8	2	232	174	1	64
200 West Area Boiler	8,760	2	0	213	160	1	58
200 East and 200 West Area Fugitive Coal	8,760	107	54	0	0	0	0
200 East Area Fugitive Emissions	8,760	1	0	0	0	0	0
300 Area Fugitive Coal Pile	8,760	4	2	0	0	0	0
300 Area Temp. Boiler Res. Dis.	8,760	15	13	215	43	0	4

CO = carbon monoxide.
NO_x = oxides of nitrogen.
PM_{10} = particulate matter nominally 10 microns or less.
SO_2 = sulfur dioxide.
t/yr = tons per year.
TSP = total suspended particulates.
VOC = volatile organic compounds.

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 sample concentrations were below the detection limit of 50 ng per sample component, which yields air concentrations of less than or equal to 0.03 to 0.1 ng/m^3. The EPA specifies a general detection limit of 1 ng/m^3. 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 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 well within the maximum allowable concentrations of air contaminants, as established in 29 CFR 1910 (Cushing 1995).

4.3.2.2.2 Hanford Site Radiological Air Quality. The DOE received a radioactive air emissions license (license no. FF-01) from the Washington State Department of Health on August 15, 1993, which covers radioactive air emissions from Hanford Site operations. Radionuclide emissions to the atmosphere from the Hanford Site have been steadily decreasing over the last few years as Hanford Site operations have changed from the historical mission of nuclear materials production and processing to environmental restoration and waste management. 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/yr (PNL 1995a), which is substantially less than the current EPA standard of 10 mrem/yr for DOE facilities.

Hanford Site Quick Facts: Air Quality

- Estimated dose from airborne releases of radionuclides in 1994: 0.012 mrem

Ambient air monitoring for radionuclides during 1994 consisted of sampling at 39 onsite and offsite locations. 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, the contribution of these radionuclides to 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 Hanford 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 from direct discharges or releases attributable to the DOE. 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 valuable habitat for aquatic organisms.

4.4.1 Terrestrial Vegetation and Habitats

The Hanford Site has been botanically characterized as a shrub-steppe ecosystem. 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 annual species, 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. Some of the trees died when the farms were abandoned in 1943, 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 a variety of diverse 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 (WDFW 1995). Although Washington State priority habitat designations have no associated legal requirements for habitat protection, DOE Order 430.1, *Life-Cycle Asset Management*, requires that the DOE consider ecosystem management and preservation values during all phases of Hanford Site operations.

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 on much of the Site. 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, ~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. The extent of this fire can be seen in Figure 4-20; much of the southeast quadrant of the Hanford Site consists of still-recovering vegetation.

Bitterbrush shrubs provide important, valuable browse for a resident herd of mule deer. Bitterbrush shrubs are slow to recolonize burned areas because they do not resprout; bitterbrush seedlings must recolonize burned areas and growth is relatively slow.

Figure 4-20. Distribution of Vegetation Types and Cover Classes on the Hanford Site (PNNL database).

Figure 4-20. Distribution of Vegetation Types and Cover Classes on the Hanford Site (Legend).

- Post-Fire Shrub-Steppe on the Columbia River Plain
- Rabbitbrush / Bunchgrasses
- Rabbitbrush / Cheatgrass
- Big Sagebrush / Bunchgrasses –Cheatgrass
- Big Sagebrush –Spiny Hopsage / Bunchgrasses –Cheatgrass
- Threetip Sagebrush / Bunchgrasses
- Spiny Hopsage / Bunchgrasses
- Spiny Hopsage / Cheatgrass
- Black Greasewood / Sandberg's Bluegrass
- Winterfat / Bunchgrasses
- Winterfat / Cheatgrass
- Snow Buckwheat / Indian Ricegrass
- Bunchgrasses
- Cheatgrass –Sandberg's Bluegrass
- Planted Non-native Grass
- Bitterbrush / Bunchgrasses Sand Dune Complex
- Bitterbrush / Cheatgrass
- Alkali Saltgrass –Cheatgrass
- Riparian
- Basalt Outcrops
- Agricultural Areas
- White Bluffs Cliffs
- Buildings / Parking Lots / Gravel Pits / Disturbed Areas
- Abandoned Old Fields and Farms
- Riverine Wetlands and Associated Deepwater Habitats
- Non-Riverine Wetlands and Associated Deepwater Habitats

4.4.1.1 Vegetation Within the Geographic Areas of the Hanford Site. Vegetation communities in the geographic areas exhibit a wide variation, often largely dependant on microclimates and soil types. Additional information is provided below.

4.4.1.1.1 Columbia River. 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 on 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 islands and cobbled shorelines 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 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.

4.4.1.1.2 Reactors on the River. The dominant vegetation type in this geographic area 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 scattered groves of nonnative trees. Ecological investigations within the 100-BC-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).

4.4.1.1.3 Central Plateau. 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 and Sandberg's bluegrass, sagebrush and needle-and-thread grass, and spiny hopsage and 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 waste water feeding the ponds was terminated.

Introduced perennial grasses (i.e., Siberian wheatgrass) have 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 Central Plateau revegetation efforts (WHC 1993).

4.4.1.1.4 All Other Areas. The All Other Areas geographic area contains developed sections of the Hanford Site, including the 300, 400, 1100, and 3000 Areas, and large tracts of undeveloped land. Special topographic features include Gable Butte and Gable Mountain north of the Central Plateau and an extensive series of active sand dunes in the southeast portion of the area. The dominant plant communities are cheatgrass, sagebrush-bitterbrush and Sandberg's bluegrass, sagebrush and cheatgrass-Sandberg's bluegrass, and riparian plant communities (WHC 1992e). Depending on the 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 and 400 Areas (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). These habitat types support a variety of wildlife.

4.4.2.1 Mammals. Approximately 40 species of mammals have been identified on the Hanford Site (Cushing 1995). The largest 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. The most abundant mammal inhabiting the site is the Great Basin pocket mouse. The mouse 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 14 species of bats that are known to be or are potential inhabitants, most of which may be present year-round (PNL 1993c). The pallid bat frequents deserted buildings and is thought to be the most abundant. 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, these elk appear to be very healthy; antler and body size for some 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.

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 other species associated with riparian, riverine, and upland habitats. Approximately 238 species of birds, including migrants and accidental species, have been observed at or near the Hanford Site (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). The nesting species 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 on 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.

Passerine species known to occur in the shrub-steppe vegetation on the Hanford Site 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. Regional sage grouse populations have declined since the early 1800s because of the conversion of shrub-steppe habitat. Surveys conducted by the Washington Department of Fish and Wildlife and the PNNL 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 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 of which are 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 components in the food webs of the local ecosystem. Most species of darkling beetles occur throughout the spring to fall period, although some species are evident 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.

Hanford Site Quick Facts: Wildlife

- 40 species of mammals
- Approximately 238 species of birds
- 12 species of reptiles and amphibians
- Approximately 600 species of insects

4.4.2.5 Wildlife Within the Hanford Site Geographic Areas. The following sections provide information about wildlife in the geographic areas.

4.4.2.5.1 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 species that use grass areas (NPS 1994).

4.4.2.5.2 Reactors on the River. Terrestrial wildlife species found in the Reactors on the River geographic area (100 Areas) generally are the same species found across the Hanford Site (Cushing 1992). 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, and 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).

4.4.2.5.3 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 that occur near the BC Cribs (located south of the 200 East Area) resulted in five species being trapped: Great Basin pocket mouse, deer mouse, northern grasshopper mouse, sagebrush vole, and western harvest

mouse (PNL 1977). The Great Basin pocket mouse represented 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 areas associated with ponds and ditches in the 200 East and 200 West Areas include muskrats, porcupines, and raccoons.

Many common bird 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).

4.4.2.5.4 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).

4.4.3 Species of Concern on the Hanford Site

Species of concern on the Hanford Site include federally-listed threatened or endangered 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 State of Washington. Candidate species occurring on the Hanford Site are currently treated as though they are threatened and endangered, based on guidance provided by the U.S. Fish and Wildlife Service (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.

4.4.3.1 Species of Concern within the Geographic Areas. Information about species of concern in each geographic area is provided below.

4.4.3.1.1 Columbia River. 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. Preferred habitat for Columbia yellowcress is shoreline areas with gently sloping, cobbly, or sandy substrate (PNL 1993b). Wetland species of concern 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

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

Common Name	Scientific Name	Federal Status	State Status
Columbia milk-vetch	*Astragalus columbianus*		T
Columbia yellowcress	*Rorippa columbiae*		E
Hoover's desert parsley	*Lomatium tuberosum*		T
Northern wormwood	*Artemisia campestris borealis* var. *wormskioldii*		E
White eatonella	*Eatonella nivea*		T
Bristly coneseed	*Pectocarya setosa*		S
Suksdorf's monkeyflower	*Mimulus suksdorfii*		S
Kittitas larkspur	*Delphinium multiplex*		M3
Bristly cryptantha	*Cryptantha interrupta*		M2
Columbia River mugwort	*Artemisia lindleyana*		M3
Crouching milkvetch	*Astragalus succumbens*		M3
Dense sedge[1]	*Carex densa*		S
Desert evening primrose	*Oenothera caespitosa*		S
False pimpernel	*Lindernia anagallidea*		S
Fuzzy-beard tongue penstemon	*Penstemon eriantherus*		M3
Gray cryptantha	*Cryptantha leucophaea*		S
Medic milkvetch[1]	*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

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 species are designated 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, Taxa with unresolved taxonomic questions.

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

S = Sensitive, 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 in WAC 232-12-011.

[1]May inhabit the Hanford Site, but have not been recently collected, or the known collections are questionable in terms of location and/or identification.

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

Common Name	Scientific Name	Federal Status	State Status
Molluscs			
Columbia pebble snail	*Fluminicola (= Lithoglyphus) columbiana*		C
Shortfaced lanx	*Fisherola (= Lanx) nuttalli*		C
Birds			
Aleutian Canada goose[b]	*Branta canadensis leucopareia*	T	E
American white pelican	*Pelecanus erythrorhynchos*		E
Bald eagle	*Haliaeetus leucocephalus*	T	T
Ferruginous hawk	*Buteo regalis*		T
Peregrine falcon[b]	*Falco peregrinus*	E	E
Prairie falcon	*Falco mexicanus*		M
Sandhill crane[b]	*Grus canadensis*		E
Black-crowned night heron	*Nyctricorax nycticorax*		M
Black tern[b]	*Chlidonias niger*		M
Burrowing owl	*Athene cunicularia*		C
Caspian tern	*Sterna caspia*		M
Clark's grebe	*Aechmophorus clarkii*		M
Common loon	*Gavia immer*		C
Flammulated owl[b]	*Otus flammeolus*		C
Forster's tern	*Sterna forsteri*		M
Golden eagle	*Aquila chrysaetos*		C
Great blue heron	*Ardea herodias*		M
Green-backed heron	*Butorides striatus*		M
Horned grebe	*Podicips grisegena*		M
Lewis' woodpecker[b]	*Melanerpes lewis*		C
Loggerhead shrike	*Lanius ludovicianus*		C
Long-billed curlew	*Numenius americanus*		M
Northern goshawk[b]	*Accipiter gentilis*		C
Sage sparrow	*Amphispiza belli*		C
Sage thrasher	*Oreoscoptes montanus*		C
Swainson's hawk	*Buteo swainsoni*		C
Western bluebird[b]	*Sialia mexicana*		C
Western grebe	*Aechmophorus occidentalis*		M
Western sage grouse[b]	*Centrocercus urophasianus*		C
Insects			
Columbia River tiger beetle[b]	*Cicindela columbica*		C
Oregon silverspot butterfly[a]	*Speyeria zerene hippolyta*	T	T
Reptiles			
Striped whipsnake	*Masticophis taeniatus*		C

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

Common Name	Scientific Name	Federal Status	State Status
Mammals			
Long-legged Myotis	*Myotis volans*		M
Merriam's shrew	*Sorex merriami*		C
Northern grasshopper mouse	*Onychomys levcogaster*		
Pacific western big-eared bat[b]	*Plecotus townsendii townsendii*		C
Pallid bat	*Antrozus pillidus*		M
Pygmy rabbit[a]	*Brachylagus idahoensis*		E
Sagebrush vole	*Largus curtatus*		M

C = Candidate. A native species that the state or federal Departments of Fish and Wildlife has enough substantial information on biological vulnerability to support proposals to list them as endangered or threatened species.

E = Endangered. A species that is seriously threatened with extinction throughout all or a significant portion of its range. Endangered species are designated in WAC 232-12-014 or 50 CFR 17.

M = Monitor. A native species whose population requires monitoring because (1) there is insufficient population data, (2) special habitat requirements, (3) the species is an indicator of environmental quality, or (4) the species have significant popular appeal.

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 in WAC 232-12-011 or 50 CFR 17.

[a]Likely not occurring on the Hanford Site.

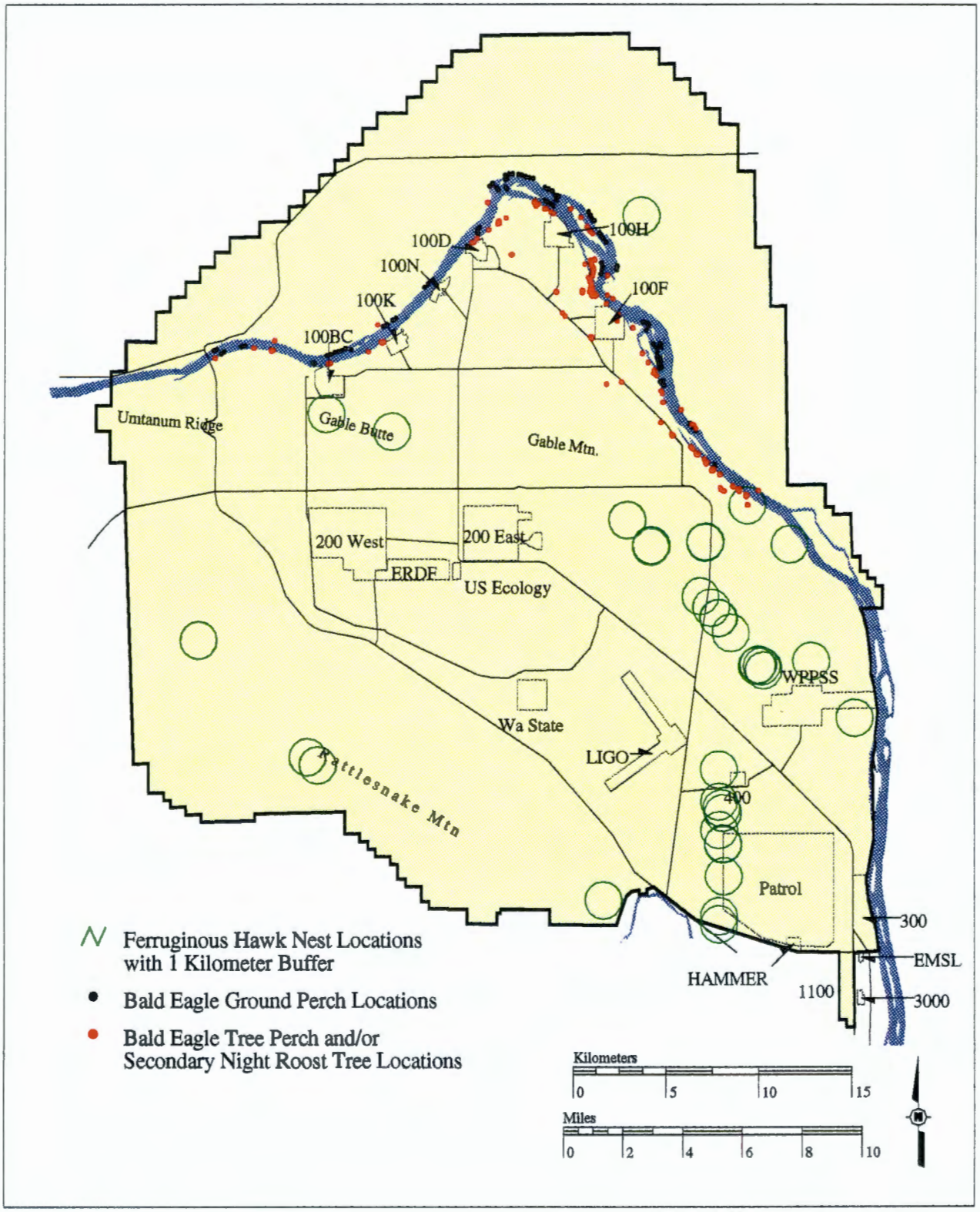
[b]Reported as possibly occurring on the Hanford Site.

(PNL 1993b). 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).

4.4.3.1.2 Reactors on the River. A state endangered plant species, the northern wormwood, may occur in the 100 Areas, although it has not yet been identified. 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). Southern mudwort, false pimpernel, dense sedge, and shining flatsedge occur in wetland areas, while northern wormwood and Piper's daisy are upland species.

The bald eagle, a federal and Washington State threatened species, is the only federally listed wildlife species known to regularly use the 100 Areas (Figure 4-21). 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, which are state monitor species. During 1993, three great blue heron rookeries were located on the Hanford Site within the Hanford Reach (Cushing 1995). Long-billed curlews also nest in the 100 Areas near the 100-D, 100-F, and 100-H Areas (WHC 1992i).

Figure 4-21. Bald Eagle Nest, Roost, and Perch Sites, and Ferruginous Hawk Nest Sites (PNNL database).



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

4.4.3.1.3 Central Plateau. No federal or state listed threatened or endangered plant or animal species occur in the Central Plateau. Piper's daisy 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 has been found on disturbed areas near the Wye Barricade (Cushing 1995) and might also be found on the Central Plateau.

Wildlife species of concern occurring in the 200 East and 200 West Areas include the loggerhead shrike and sage sparrow. Both species nest in undisturbed sagebrush habitat in the Central Plateau (PNL 1993b). Known ferruginous hawk nests are presented in Figure 4-21. Other bird species of concern that may occur in shrub-steppe habitat in the Central Plateau are the burrowing owl, golden eagle, long-billed curlew, and Swainson's hawk. Reptile species of concern using the Central Plateau include the striped whipsnake and the desert night snake (PNL 1977).

4.4.3.1.4 All Other Areas. Plant species of concern include the Columbia milk-vetch and Hoover's desert-parsley. These species also are listed as state threatened plants. State sensitive species in this area include dense sedge, gray cryptantha, Piper's daisy, and dwarf evening-primrose. Dense sedge is 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 and loggerhead shrike (PNL 1993b). Sensitive wildlife species include the long-billed curlew, burrowing owl, sage sparrow, sage thrasher, Swainson's hawk, and golden eagle. All of these species except the golden eagle nest on the Hanford Site (Fitzner and Gray 1991).

4.4.4 Aquatic Species and Habitat

There are two primary types of natural aquatic habitats on the Hanford Site: the Columbia River, which flows along the northern and eastern edges of the Hanford Site, and 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 Central Plateau and is not fed by surface flow; thus, the pond is alkaline and has low species diversity.

Forty-four species of fish representing 13 families are known to occur in 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). 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) (Figure 4-22).

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 (e.g., 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 a major flash flood 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 transitional lands occurring between terrestrial and aquatic ecosystems (Figure 4-23) 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, including the B Pond Complex located near the 200 East Area and a small cooling and wastewater pond 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 halted. One lobe of the pond received cooling water until very recently; the rest of the B Pond Complex is slowly reverting to a shrub-steppe ecosystem.

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Figure 4-22. Key Fall Chinook Salmon Spawning Areas.

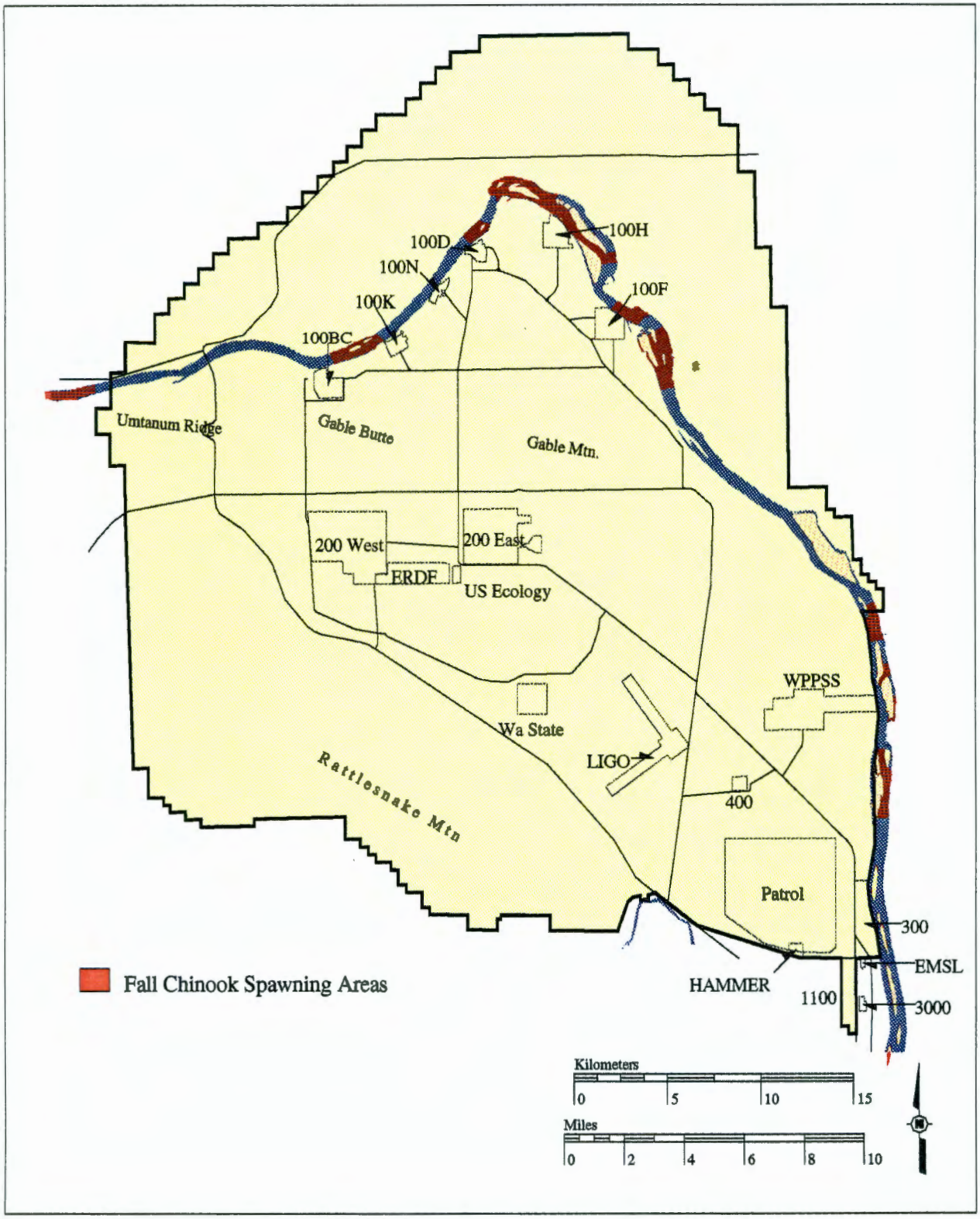
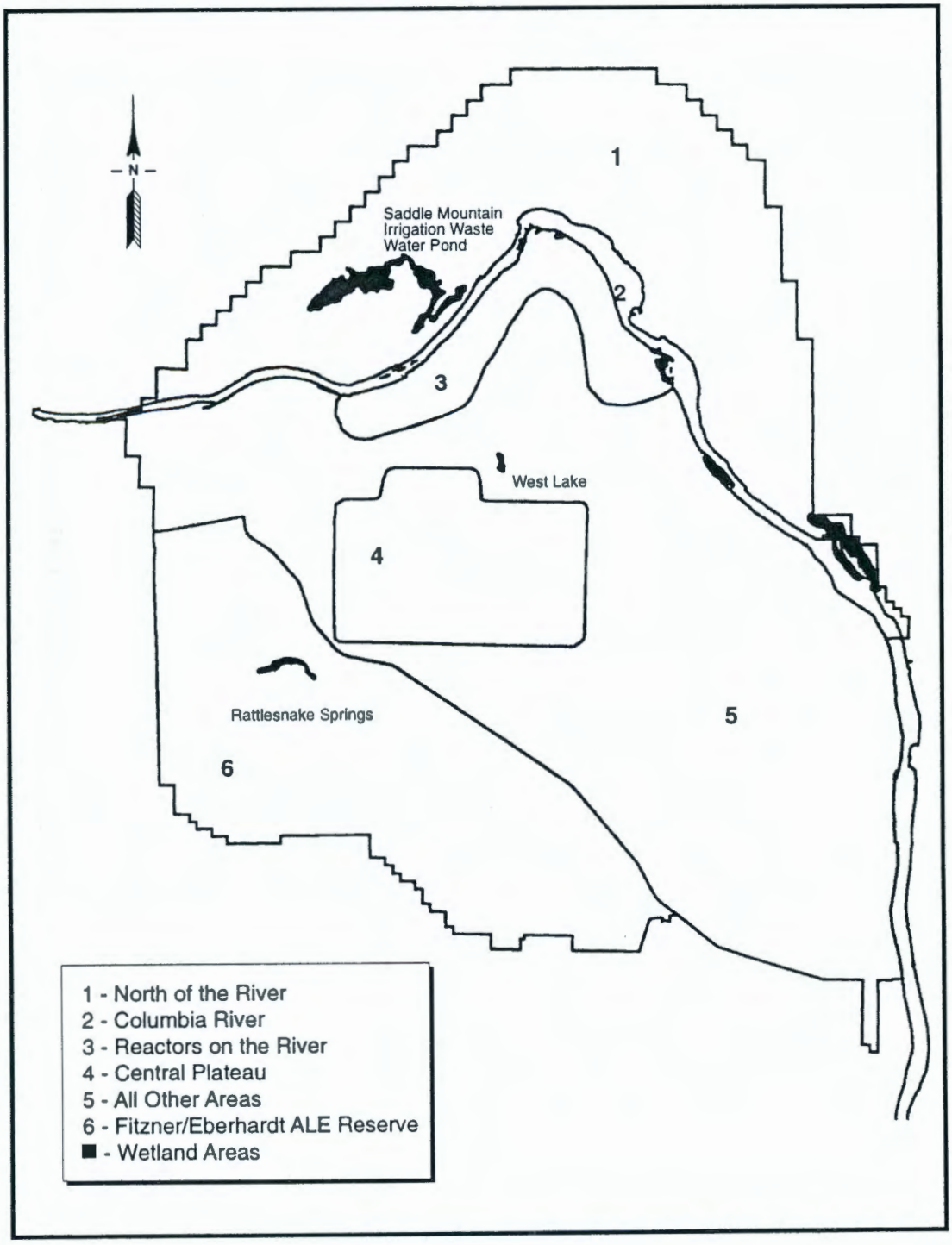


Figure 4-23. Wetlands on the Hanford Site.



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 2 ha (5 acres) 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.

4.4.6 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).

Features 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 influencing 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 most important, 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. The inventory, which was conducted from March 1994 to March 1995, showed 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. Additional inventories may be performed of the main part of the Hanford Site and may 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 represents 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 the Hanford Site, 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 region.

4.5 Cultural Resources

The Hanford Site is known to be rich in cultural resources. The Hanford Site 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 the Hanford Site's cultural resources follows the *Hanford Cultural Resources Management Plan* (PNL 1989), and is conducted by the Cultural Resources staff of the Environmental Restoration Contractor (ERC) Team in partnership with Westinghouse Hanford Company's (WHC) staff Historian and the Hanford Cultural Resources Laboratory (HCRL) of PNNL.

The *Hanford Cultural Resources Management Plan* (PNL 1989), which was approved by the State Historic Preservation Office (SHPO) in 1989, was developed to establish guidance for the identification, evaluation, recordation, curation, and management of archaeological, historic, and traditional cultural resources as individual entities or as contributing properties within a district. The Plan specifies methods of consultation with affected Tribes, government agencies, and interested parties, and includes strategies for the preservation and/or curation of representative properties, archives, and objects.

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 other reasons. For the purpose of this EIS, these resources are divided into several categories: prehistoric archaeological resources, historic archaeological resources, historic architectural resources, and traditional (Native American) cultural resources. Significant cultural resources are those that are eligible or potentially eligible for listing in the *National Register of Historic Places* (National Register) (NPS 1988).

> ***Hanford Site Quick Facts: Cultural Resources***
>
> About 6% of the Hanford Site has been surveyed. From those surveys, 645 cultural resource sites and isolated finds have been recorded to date. Forty-nine properties are listed on the National Register.

Consultation is required to identify the traditional cultural properties that are important to maintaining the cultural heritage of Native American Tribes. Under separate treaties signed in 1855, the Confederated Tribes and Bands of the Yakama Indian Nation and the Confederated Tribes of the Umatilla Indian reservation ceded lands to the United States that include the present Hanford Site. Under the treaties, the tribes reserved the right to fish at usual and accustomed places in common with the citizens of the territory, and retained the privilege of hunting, gathering roots and berries, and pasturing horses and cattle upon open unclaimed land. The Treaty of 1855 with the Nez Perce Tribe includes similar reservations of rights, and the Nez Perce have identified the Hanford Reach as the location of usual and accustomed places for taking fish. The Wanapum People are not signatory to any treaty with the United States, and are not a federally recognized tribe; however, the Wanapum People were historical residents of the Hanford Site, and their interests in the area have been acknowledged.

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.

In 1994, 645 cultural resource sites and isolated finds were recorded in the files of the HCRL (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. While many significant cultural resources have been identified, only a small portion of the Hanford Site has been surveyed by cultural resource specialists and few of the known sites have been evaluated for their eligibility for listing in the National Register. Many additional cultural resources may remain unidentified. Cultural resource reviews are conducted when projects are proposed in areas that have not been previously surveyed. About 100 to 120 reviews were conducted annually through 1991; this figure rose to more than 500 reviews during 1994 (Cushing 1995).

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 the remainder of the resources. 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 archaeological districts 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 and kill sites in lowland stabilized dunes, and small temporary camps near perennial sources of water located away from the river (Cushing 1995).

Table 4-8. Hanford Site Archaeological Districts and Historic Properties that are Listed on the National Register of Historic Places (Cushing 1995).

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 45BN151
Paris Site	45GR317
Rattlesnake Springs A.D.	45BN170, 45BN171
Snively Canyon A.D.	45BN172, 45BN173
Hanford B Reactor	105-B

A.D. = Archaeological District.
NA = Not Applicable.

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. The Society has 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 other work. Test excavations have been conducted by the HCRL at several sites, with results supporting 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. However, a HCRL effort is underway to inventory a 10% sample of the entire Site. The 100 Areas were surveyed in 1991 through 1993, revealing a large number of new archaeological sites (DOE 1995).

Table 4-9. Historic Properties on the Hanford Site Nominated, or Prepared for Nomination, to the National Register of Historic Places (Cushing 1995).

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.

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 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 east bank of the river (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 culture. The Washani, or Seven Drums religion, which has ancient roots and originated among the Wanapum 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 an interest in renewing their use of these resources in accordance with the Treaties of 1855. The DOE is attempting to address tribal concerns by allowing access for the purposes of religious activities and gathering foods and medicines to the extent that these activities are consistent with the DOE's missions. Tribal spiritual values collectively pose a marked contrast to the dominant "white" culture of the region. Nature is intrinsically spiritual, as sacredness is embedded in natural phenomena, landforms, plants, and animals. People are one of thousands of species in a single interconnected system of species relationships. This system of relationships is considered to be based on a sense of reciprocity, and a threat to the land or environment can be perceived as a threat to the entire culture, and impacts to the natural landscape also might be considered impacts to a tribal community's self-identify.

Spirituality is expressly interwoven in the tribal community's life-way. This attachment to land and water means that sacred sites are not always confined or precisely located and are numerous and diverse in form (DOI 1995).

The Hanford Site possesses traditional cultural significance for Native Americans. Certain sites demonstrate traditional cultural significance in that:

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

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

- Native American groups traditionally carry out economic, artistic, or other cultural practices important in maintaining their historical identity (adapted from Parker and King 1990).

4.5.3 Historic Archaeological and Architectural 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 to 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 original Hanford Engineer Works in the early 1940s (DOE 1995; Cushing 1995).

A total of 201 historic archaeological sites have been recorded by the HCRL on the Hanford Site. Of these sites, one is included in the National Register as an historic site, and 56 are listed as archeological sites. Figure 4-24 presents generalized information from the PNNL HCRL database about historic resource areas on the Hanford Site. 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 HCRL since 1987. Minor test excavations have been conducted at some of the historic sites, including the Hanford townsite locality. In addition to the recorded sites, numerous unrecorded 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.

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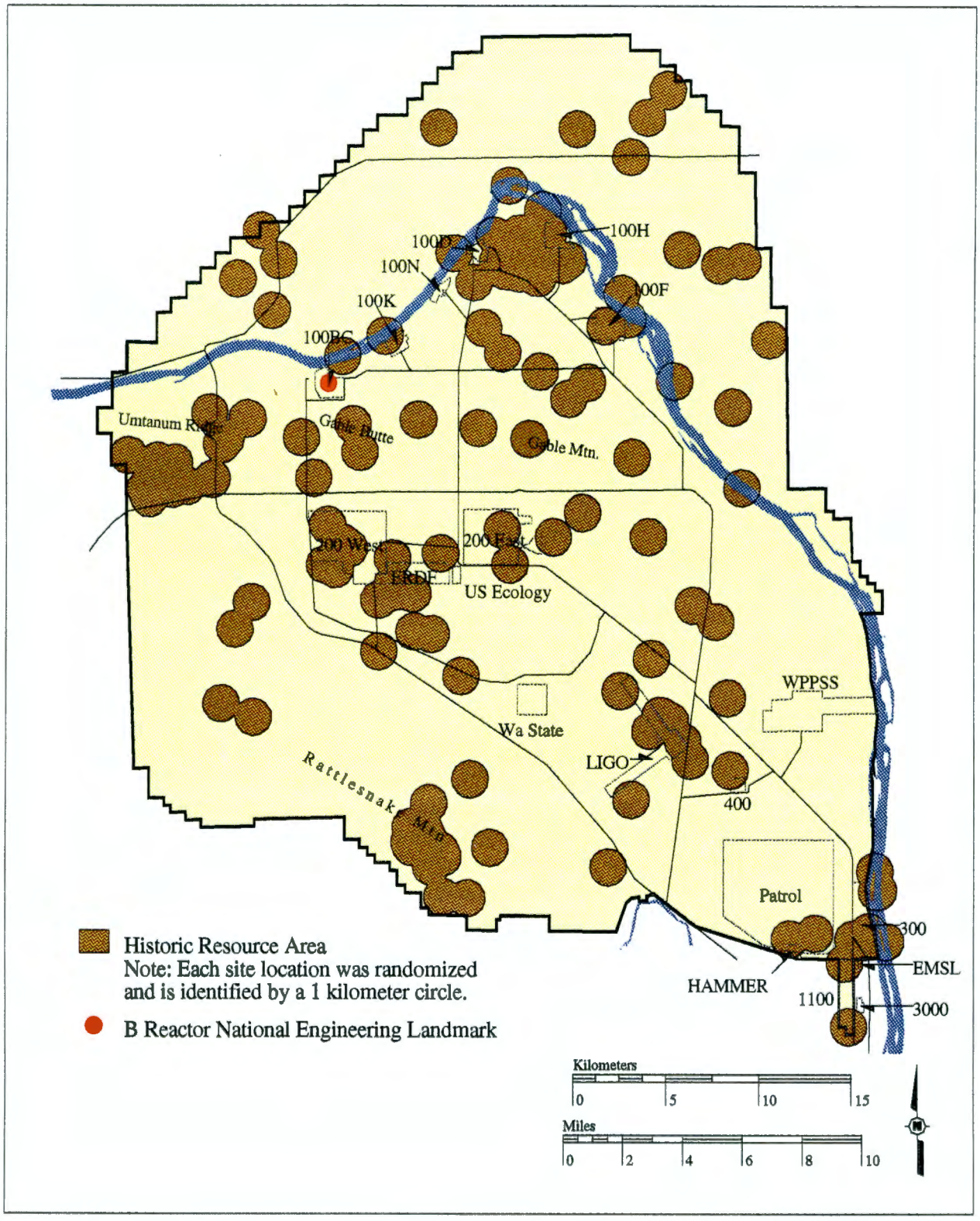
Figure 4-24. General Locations of Historic Areas on the Hanford Site.



More recent historic structures are the defense reactors and associated materials processing facilities that are present on 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 is listed on the National Register and was given the National Historic Landmark Award (Cushing 1995). About 45 other buildings have been evaluated for National Register eligibility by the SHPO. 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 preparation of historic contexts for the Manhattan Project and Cold War eras (Cushing 1995). An Historic Buildings Task Force has been established to coordinate evaluations among the contractors. This task force has established the Hanford Site Historic District, provisionally identified all contributing and noncontributing buildings and structures within the District, and prepared an Historic Buildings Programmatic Agreement and Sitewide Mitigation Plan to direct the documentation of the contributing properties. These actions have been, or are being, reviewed by the SHPO. Once these action have been accepted, building-by-building measures will be replaced by programmatic treatments. Acceptance is anticipated in 1996.

4.5.4 Cultural Resources Within the Hanford Site Geographic Areas

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

4.5.4.1 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, without providing 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 100 Area buildings and structures will be completed during fiscal year 1996 and a National Register evaluation for each will be finalized.

100-B/C Area. Several 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. An archaeological site and the remains of the small community of Haven lie on the opposite bank of the Columbia River. Sites related to tribal hunting and religious activities are located at the west end of Gable Butte, south of the 100-B/C Area. These sites are part of the proposed Gable Mountain/Gable Butte Cultural District nomination.

Two archaeological sites located near the 100-B/C Area 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. The second site is considered to be eligible for listing in the National Register, in part, because it may contain new information about the Frenchman Springs and Cayuse Phases of prehistory.

The B Reactor was the first full-scale plutonium production reactor and is designated as a National Historic Mechanical Engineering Landmark. The reactor, which is 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, which will be inventoried and evaluated for National Register eligibility.

100-D Area. Sixty-six known archaeological sites lie within 2 km (1.2 mi) of the 100-D/DR reactor compound; three sites are on the northern bank and sixty-three are on the southern bank of the Columbia River. 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 Euro-American 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-D and 189-D buildings and adjoining facilities, all part of the 190-D complex, were determined eligible for the National Register and were documented prior to demolition. The other buildings and structures in this area will be inventoried and evaluated for National Register eligibility.

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 seasonally until 1943 when the Wanapum people were relocated to Priest Rapids (Cushing 1995).

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.

Six other prehistoric archaeological sites are located within 2 km (1.2 mi) of this area. These sites 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. 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 at this site. A log cabin, thought by some to have been a blacksmith shop in the mid-19th century, still stands. 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 soon. Two Manhattan Project buildings, 105-F and 108-F, remain in the 100-F Area. Both will be inventoried and evaluated in the near future.

100-H Area. There are 10 recorded archaeological sites within 2 km (1.2 mi) of the area, including 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. The village appears to have been occupied from 2,500 years ago to historic times. All of 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 HCRL 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 of the sites have 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 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. In the mid-19th century, 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 not been 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 from the 100-K Reactor Compound downstream to the 100-N Area. Three archaeological sites are present, including two village sites and one cemetery. These sites are listed in the National Register (NPS 1988).

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. The Historic Buildings Task Force has recommended that the 105-KW Reactor, and the 1706-KE and 1706-KER water recirculation study facilities, be listed in the National Register.

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.

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.

Test excavations were conducted at one site in 1973 (Cushing 1995). During that excavation, which consisted of excavating two trenches and two smaller pits, evidence of habitation during four periods of prehistory was found. 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 this material, dense artifact deposits and remains of pithouses dating after 1,862 BP were found and 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.

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 the 100-N buildings, their role in the Cold War, and their eligibility for listing in the National Register, has been documented through *The Hanford Site N Reactor Buildings Task Identification and Evaluation of Historic Properties* (BHI 1996), which was conducted during fiscal year 1995. Buildings 105-N, 109-N, 155-N, 185-N, and 1112-N have been determined eligible for the National Register by the DOE and the SHPO. Additional determinations for contributing buildings have been submitted to the SHPO, as well as a mitigation plan for the 100-N Reactor complex.

4.5.4.2 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 and 200 West Area boundaries (DOE 1995a). 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 and 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) restricted zone has been created to protect the road from uncontrolled disturbance. In addition, approximately 20 buildings in the 200 East and 200 West Areas have been evaluated for National Register eligibility. The remaining buildings associated with the Manhattan Project and Cold War eras have been evaluated by the Historic Buildings Task Force; recommendations for contributing and noncontributing buildings will be reviewed by the SHPO during 1996.

4.5.4.3 All Other Areas Cultural Resources. This area represents the largest portion of land on the Hanford Site, comprising 624 km^2 (241 mi^2). The area includes developed operations in the 300, 400, and 1100 Areas, and the predominantly undeveloped tracts of land in the 600 Area.

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 riverbank, 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 and 21 sites are within 2 km (1.2 mi) of the 300 Area perimeter. Although the areas have been only minimally surveyed, historic sites have been documented and additional historic sites 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 of Historic Places.

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 1996.

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, *Sekema* may correspond to any or all of the previously recorded archaeological sites in or around the 300 Area.

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). The FFTF and its associated structures have been evaluated by the Historic Buildings Task Force. Buildings 405, 4703, and 4710 have been recommended as contributing properties to the Hanford Site Historic District.

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. These properties include pithouse villages, various types of open campsites, cemeteries, spirit quest monuments, hunting camps, game drive complexes, and hunting (kill) sites in lowland stabilized dunes. 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. The Central Shops Complex, in the 600 Area, was determined to be ineligible for the National Register in 1995 (Cushing 1995).

1100 Area. Historic cultural resources have been identified in or near the 1100 Area. These resources 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

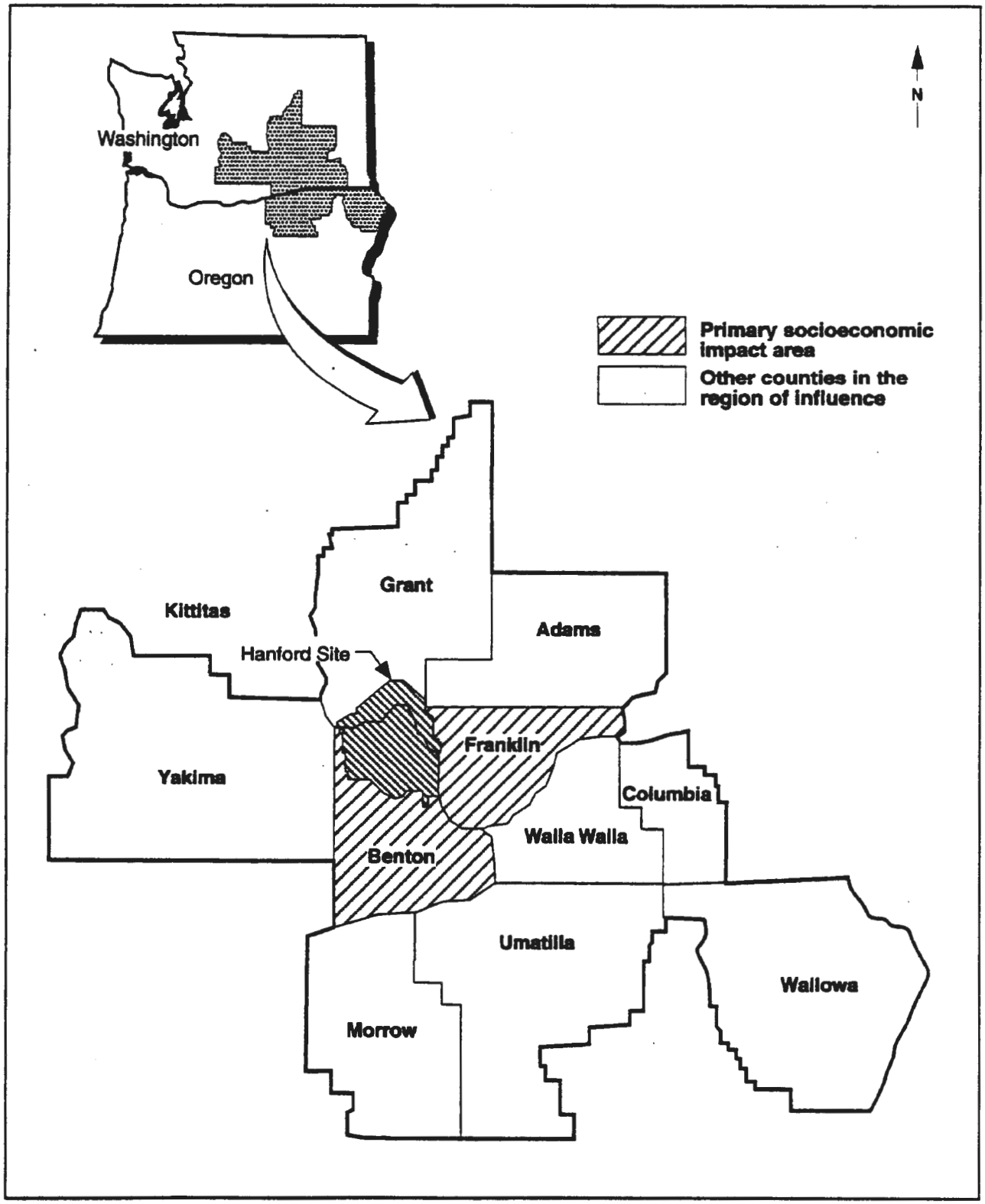
Activity on the Hanford Site plays a dominant role in the socioeconomics of the Tri-Cities and other parts of Benton and Franklin counties. The Tri-Cities serves as a market center for a much broader area of eastern Washington, including Adams, Columbia, Grant, Walla Walla, and Yakima counties. The Tri-Cities 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 (and Yakima County to a lesser extent) (PNL 1984, 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 (Figure 4-25). Table 4-10 summarizes the regional (Benton and Franklin counties) nonagricultural jobs from 1993 to 1994.

Table 4-10. Nonagricultural Workers in Benton and Franklin Counties, 1993 and 1994 (Cushing 1995).

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.

Figure 4-25. Areas of Washington and Oregon Where Socioeconomic Resources Might Be Affected (DOE 1995a).



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.

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).

Hanford Site Quick Facts: Populations (1994 Estimates)

- Kennewick: 46,960
- Richland: 35,430
- Pasco: 22,170

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 were quite similar to those found within the State of Washington. In 1994, 55% of the population of Benton and Franklin counties was under the age of 35, compared to 52% for the State of Washington. Within the State of Washington, 30- to 39-year olds constituted 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 section 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 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 the procurement of equipment, supplies, and business services.

1. ***The DOE and 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). Since 1994, the Hanford workforce has declined to 15,200 (Hanford Reach 1996). The Hanford 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 Washington Nuclear Plant-Two (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 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 Washington Nuclear Plants (One and Four) is expected to begin in the next few years. 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' net income 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 of 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/hr to $5.80/hr, with an average of $5.44/hr (Cushing 1995).

The area's farms and ranches generate a sizable number of jobs in supporting sectors, such as agricultural services (e.g., 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 the three major employment sectors, five other employers are readily identified as contributors to the economic base of the Tri-Cities economy: (1) Siemens Nuclear Power Corporation in north Richland, (2) Sandvik Special Metals in Kennewick, (3) Boise Cascade Paper in Wallula, (4) Burlington Northern Railroad in Pasco, and (5) Iowa Beef Processors in Wallula. Approximately 3,500 were employed by these businesses 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 was up 40% from levels reported in 1993, while the dollar volume generated by visitors was 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 2,300 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 (~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 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).

Table 4-11. Government Retirement Payments in Benton and Franklin Counties in 1991 ($ million) (Cushing 1995).

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

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).

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 household 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. Hanford Site employment was approximately 15,200 employees (including full-time, part-time, and temporary workers) as of October 1, 1995 (Hanford Reach 1996). A future down-turn in Hanford Site employment is anticipated, although the extent of this down-turn is unknown at this time.

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. 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).

Hanford Site Quick Facts: Economic Multipliers

Each Site job supports:

- 1.2 jobs in the local service sector
- 1.5 jobs in the state service sector

Each Site dollar supports:

- 2.1 dollars in total local incomes
- 2.4 dollars in total state incomes

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. Available information 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 employees.

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 governments in Benton, Franklin, and Yakima counties in local taxes and fees (DOE 1995).

Table 4-12. Hanford Employee Residences by County (DOE 1995).

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

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, operated by the WHC for the DOE, with 155 firefighters, is trained to dispose of hazardous waste and to fight chemical fires in addition to fire fighting duties. During the 24-hour duty period, the 1100 Area has 5 firefighters; the 300 Area has 7; the 200 East and 200 West Areas have 7; the 100 Areas have 6; and the 400 Area, which includes WPPSS, 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 DOE is currently involved in discussions with the City of Richland regarding the possibility of contracting 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 and 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 and 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, which provides a significant amount of outpatient and home health services. For the fiscal year ending June 30, 1994, Our Lady of Lourdes had a total of 4,449 admissions of which 32.8% were non-Medicare and Medicaid admissions. An average acute care length of stay of 3.1 days was reported (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%. Mobile homes, which represent 11% of the housing unit types, 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, 1994 Estimates (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

Recent Hanford Site downsizing has resulted in lower occupancy rates throughout the Tri-Cities. Statistics from February 1996 indicated that Tri-Cities apartment occupancy rates are significantly lower: Richland apartment occupancy was 80.2%; Kennewick apartment occupancy was 85.4%; and Pasco apartment occupancy was 83.7% (TCH 1996).

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 Tri-Cities 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 8,665 from the Richland School District, 8,739 students from the Pasco School District, 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 to alleviate 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 1,300 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 the regional infrastructure. These facilities are located on the 525-km- (325.5-mi-) long commercial waterway, which includes the Snake and Columbia river and 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 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 (Figure 4-26) 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. Interstate-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. SR 224, south of the Hanford Site, serves as a 16-km (10-mi) link between I-82 and SR 240.

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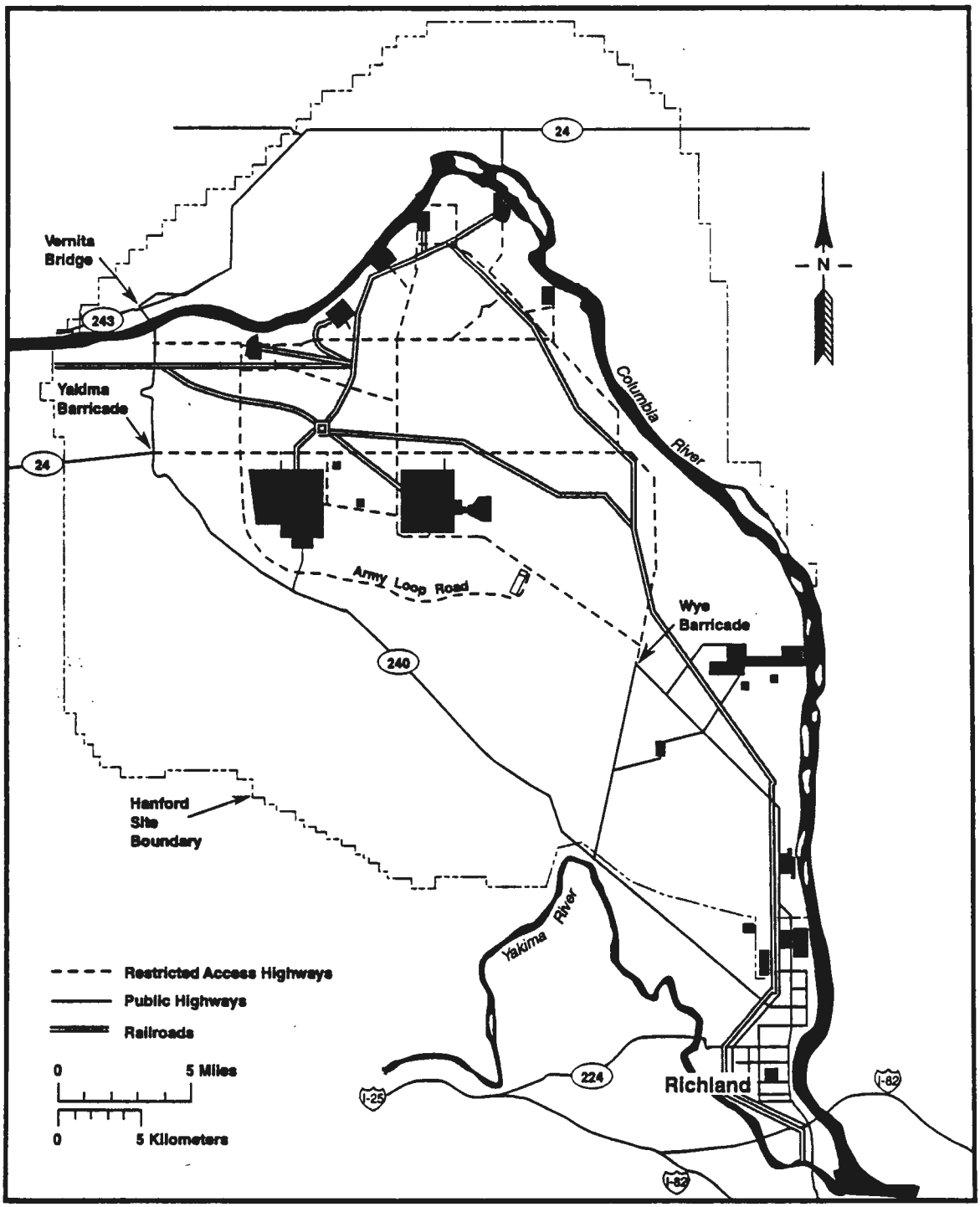
Figure 4-26. Transportation Routes in the Vicinity of the Hanford Site.



SR 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. SR 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. SR 14 connects with I-90 at Vantage, Washington, and provides ready access to I-84 at several locations along the Oregon and Washington border. SRs 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 potable water systems of Richland, Pasco, and Kennewick drew 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 the water used from the Columbia River, while the remainder is split between a well field in North Richland and other 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 water from the Columbia River. In 1994, Pasco consumed 8.6 billion L (2.27 billion gal). The Kennewick system uses two wells and the Columbia River as a water 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. The Kennewick system similarly has significant excess capacity; with a treatment capability 83.2 million L/d (22 million gal/d) and 1994 usage of 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).

Natural gas, provided by the Cascade Natural Gas Corporation, serves a small portion of Tri-Cities residents, with 6,000 residential customers in December 1994.

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 provided by these utilities 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.

In the Pacific Northwest, hydropower, and to a lesser extent, coal and nuclear power, constitute the regional 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 (WNP-2) 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 regional 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 megawatts under critical water conditions to 20,000 average megawatts in record high-water years. The reliance on hydroelectric power in the Pacific Northwest means that the system is more constrained by 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 a surplus of electric power. This surplus has been exhausted, however, and the system only supplies enough power 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 (Cushing 1995).

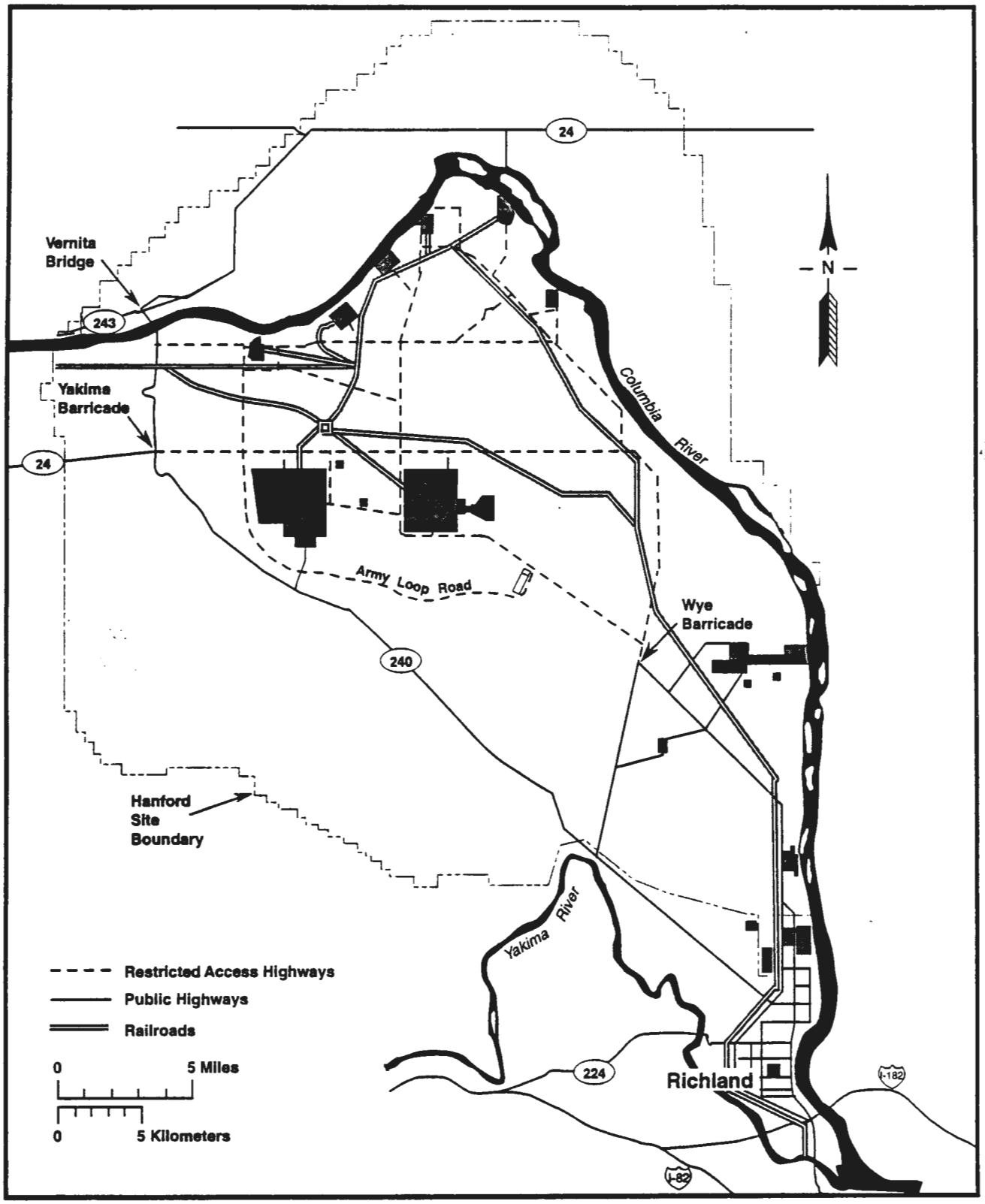
4.6.10 Site Infrastructure

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 1994b).

4.6.10.1 Facilities. Onsite programmatic (60%) and general purpose facilities (40%) provide 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 (R&D) laboratories. Many of these facilities are over 30 years old; however, upgrades and expansion of some facilities could occur as remediation 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 4-27). SR 24 crosses the Hanford Site primarily in the North of the River geographic area. SR 240 crosses the Hanford Site on the southwest and serves as the boundary between the ALE Reserve and the All Other Areas geographic areas. A new site access road from SR 240 to the 200 West Area was completed in December 1994. Upgrades are planned for road capacities north of the Wye Barricade and the road network in the 300 Area. The 1100 Area roads were recently upgraded to improve traffic circulation and access.

Figure 4-27. Transportation Network on the Hanford Site (DOE-RL 1990a).



There are about 204 km (127 mi) of rail line on the Hanford Site (see Figure 4-27). The rail 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.

4.6.10.3 Utilities. The Hanford Site water system includes numerous buildings, pumps, valve houses, reservoirs, wells, and a distribution piping system 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 4-28). The 300 Area and the WPPSS also draw water directly 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 draw 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 4-29). The systems are located in the 100, 200, 300, and 400 Areas. 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 Hanford remediation 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 DOE is reviewing proposals to replace the existing steam systems with a range of alternative measures to provide heat and process steam.

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 was recently 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.

4.6.10.4.3 Telecommunications. A new fiber optic communications network was recently installed on the Hanford Site. This system provides a fully connected internal network of shared computing resources and capabilities to support future voice and data communication requirements.

Figure 4-28. Export Water System for the Hanford Site (DOE-RL 1990a).

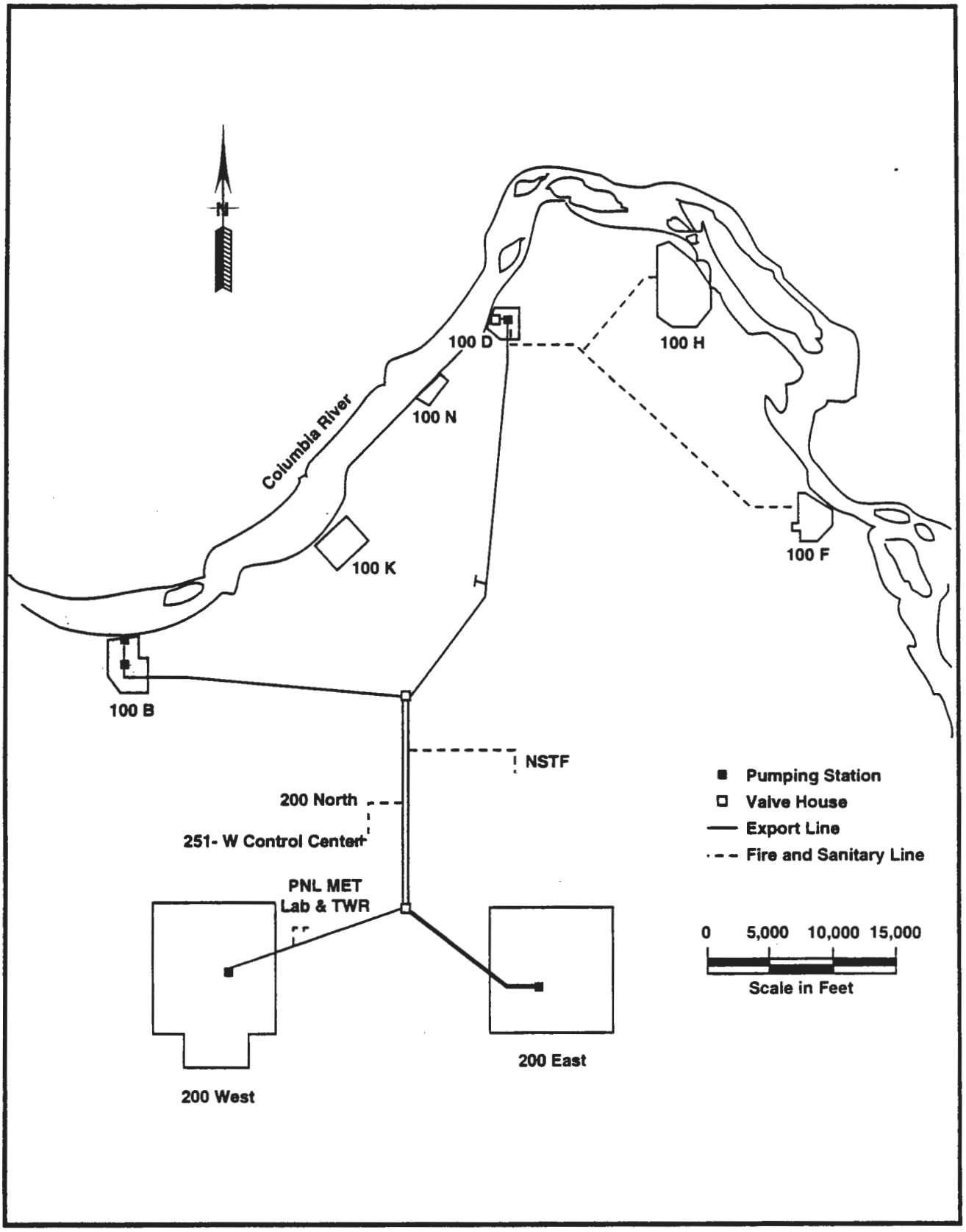


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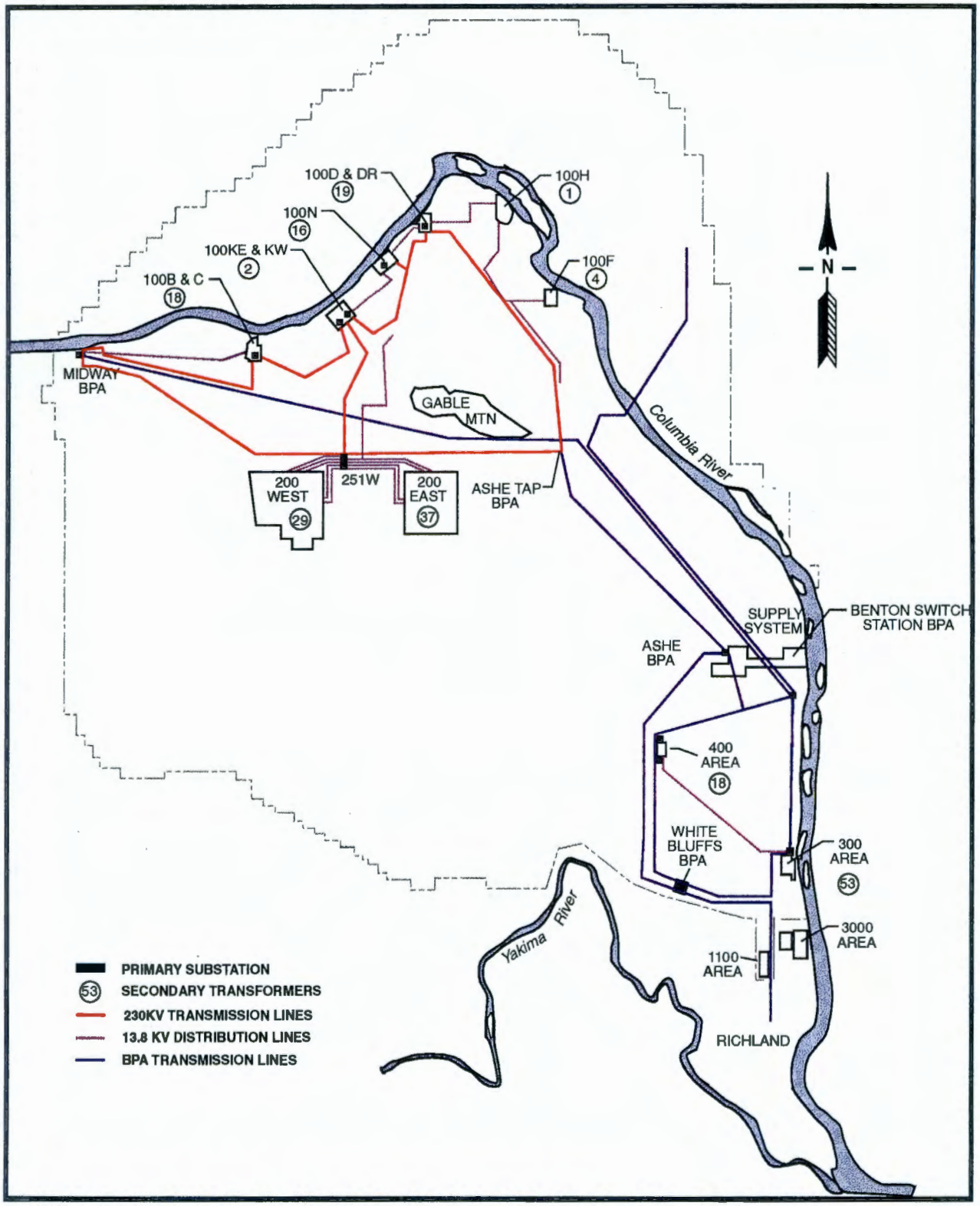
Figure 4-29. Electrical System for the Hanford Site (DOE-RL 1990b).



4.6.10.4.5 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 can be expanded as needed, to a maximum of 414 ha (1.6 mi^2).

4.6.10.4.6 Safeguards and Security. A security force is employed onsite and a number of systems are in place to control site access.

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 southeastern boundary of the Hanford Site. Gable Mountain and Gable Butte are the highest land forms within the Hanford Site. The view towards Rattlesnake Mountain is visually pleasing, especially in the springtime when wildflowers are in bloom. Large rolling hills are located to the west and 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 natural 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.

Hanford Site Quick Facts: Visual and Aesthetic Resources

Prominent Natural Features include the Columbia River, Saddle Mountains, Gable Butte, Rattlesnake Mountain, White Bluffs, and Gable Mountain

SR 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 often 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, vegetation cover. There are no key observation points along the road, only a few small turnouts along the shoulder.

SR 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 also is usually considered 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 traffic on 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 performed 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 1995a). 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 performed 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 EIS addressing the siting of a proposed New Production Reactor (Cushing 1995). While the EIS 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: SR 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.

To provide noise data for the Hanford WPPSS plants, 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 levels 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.

To support the Basalt Waste Isolation Project, 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.

In addition to the project-driven studies described above, the Hanford Environmental Health Foundation has monitored noise levels resulting from several routine operations performed in the field at the Hanford Site. 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 regional 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 the 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 presented in annual reports, such as the *Hanford Site Environmental Report for Calendar Year 1994* (PNL 1995a).

4.10 Contamination

Four operating areas of the Hanford Site (the 100, 200, 300, and 1100 Areas) have been included on the EPA's National Priorities List. These operating areas are located within the boundaries of the Reactors on the River, All Other Areas, and Central Plateau geographic areas. Radioactive and hazardous materials have been disposed to the ground throughout the period of active Hanford Site operations, resulting in extensive contamination of the vadose zone and groundwater. Table 4-16 presents information showing the relationship between past Hanford Site operations and groundwater and vadose zone contamination.

Table 4-16. Relationship Between Groundwater Contaminants and Hanford Site Operations.

Facilities Type	Area	Constituents
Reactor Operations	100	Tritium, Co-60, Sr-90, Chromium, Sulfate
Irradiated Fuel Processing	200 East 200 West	Tritium, Cs-137, Sr-90, I-129, Tc-99, Nitrate, Chromium, Cyanide, Fluoride, U, Pu
Plutonium Purification	200 West	Carbon tetrachloride, Chloroform, Pu
Uranium Recovery	200 West	U, Tc-99, Nitrate
Fuel Fabrication	300	U, Tc-99, Chromium, Nitrate, Trichloroethylene

Under the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989), the more than 1,000 inactive waste disposal and unplanned release sites were grouped into groundwater and source operable units, based on geographic proximity or similarity of waste disposal history. In addition, a number of *Resource Conservation and Recovery Act of 1976* treatment, storage, and/or disposal (TSD) units are included in the Tri-Party Agreement, which will be closed or permitted to operate in accordance with the State of Washington's "Dangerous Waste Regulations," (WAC 173-303). These waste sites and TSD units are sources of environmental contamination. Appendix K presents information about Hanford waste sites.

The DOE holds interim status for the operation of hazardous waste management facilities by virtue of having submitted a RCRA Part A application to the EPA on November 18, 1980. On November 6, 1985, the DOE submitted a RCRA Part B application to Ecology and the EPA Region 10 for the treatment, storage, and disposal of hazardous wastes at Hanford. Supplemental and revised RCRA applications have been submitted either to Ecology, to the EPA, or to both as appropriate. A final status permit covering several units at the Hanford Site was issued in August 1994. This permit will be amended over a period of years to add additional interim status TSD units.

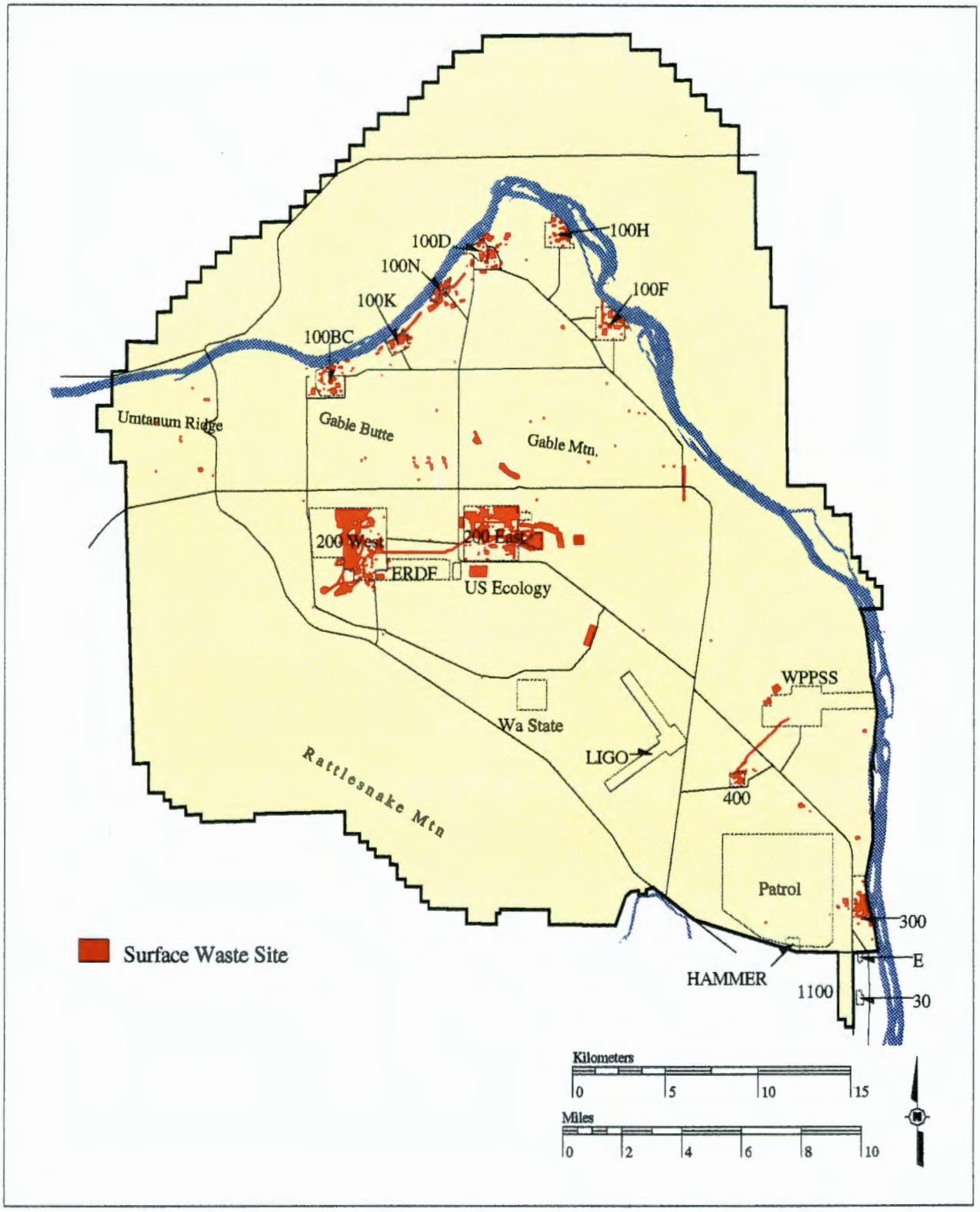
Vadose zone contamination, primarily in the 100, 200, and 300 Areas (Figure 4-30), is a result of the disposal of wastes to surface disposal structures such as:

- **Tanks and Vaults**--used to store radioactive liquid wastes generated by uranium and plutonium processing activities in the 200 Areas. Tanks include catch tanks, settling tanks, and storage tanks. The catch tanks are generally associated with diversion boxes and other transfer units and were designed to accept overflow and spills; wastes collected in catch tanks were transferred to storage tanks. Settling tanks were used to settle particulates in liquid wastes prior to transfer to cribs. Storage tanks were used to collect and store large quantities of liquid wastes. Storage tanks include single-shell tanks and double-shell tanks.

- **Vaults**--typically are deep underground concrete structures that contain tanks as well as associated pumps, valves, and agitators. Vaults do not hold wastes but provide containment for other types of storage features and associated plumbing.

- **Cribs and Drains**--were designed to percolate low-level radioactive process waste into the ground without exposing the waste to the open air. Cribs and drain fields are shallow excavations that were either backfilled with permeable material or held open by wood structures, both of which are covered with an impermeable layer. Water flows directly into the backfilled material or covered open space and percolates into the soil. French drains generally deliver wastewater at a greater depth (up to 40 ft) and are constructed of steel or concrete pipes that are either left open or filled with gravel.

Figure 4-30. Hanford Surface Waste Sites (HGIS and Waste Information Data System database).



- **Ponds, Ditches, and Trenches**--were designed to percolate high volumes of low-level liquid wastes into the soil. Ditches are long, unlined excavations used to convey wastes to the ponds. Trenches are generally open, unlined, shallow excavations used for disposal of low-liquid discharges, such as sludge, which has a high salt content. Trenches were used for short periods and were deactivated when the discharge rate exceeded the soil infiltration rate.

- **Burial Grounds**--were used for disposal of solid wastes. Burial grounds received a variety of contaminated debris and solid wastes packed in barrels and boxes.

There are a variety of contaminants present in the groundwater of the Hanford Site (Figures 4-31 and 4-32 and Table 4-17). Tritium, iodine-129, and nitrate plumes originating in the Central Plateau geographic area are quite widespread, reaching the Columbia River to the east. Other contaminants are not as widespread, but exist in the groundwater at many different locations. Examples of these contaminants include strontium-90, uranium, technetium-99, and chromium. Contaminant plume migration is affected in part by the degree to which individual contaminants are mobile in groundwater and in part on hydrogeologic conditions. Natural groundwater flow at the Hanford Site has been altered in some areas due to past Hanford Site operations. This alteration is due in large part to groundwater mounds which were created by extensive artificial recharge at some wastewater disposal facilities. Although these groundwater mounds are dissipating, groundwater flow patterns are still affected by past wastewater discharges on the Hanford Site.

4.10.1 Contamination Within the Hanford Site Geographic Areas

Specific waste information and characteristics for each geographic area are presented below.

4.10.1.1 Columbia River. The Columbia River has received radiological and chemical contamination as a result of past operations at the Hanford Site. Columbia River water that was used to cool the Hanford Site nuclear production reactors subsequently was contaminated with chemical and radiological constituents. The contaminated water entered the Columbia River primarily through direct effluent discharge. In addition to direct discharges of contaminated cooling water, the Columbia River received and continues to receive contaminants indirectly through soil column waste disposal units, leaks from pipelines, and groundwater discharge, often through springs and seeps along the shoreline (DOE 1993).

Sediments in the Columbia River contain low levels of Hanford radionuclides and metals, and radionuclides from nuclear weapons testing fallout, which collect in slack water habitats. Studies have found that radiological contaminants in sediments were very low or below the minimum detection levels at all sites sampled. Analyses of metals showed detectable, though low, levels of metals in Columbia River sediments. Chromium concentrations in sediment along the Hanford Reach appeared to be slightly elevated when compared to upstream samples (PNL 1995a).

4.10.1.2 Reactors on the River. The Reactors on the River geographic area includes nine retired plutonium production reactors, effluent lines from each reactor complex, 33 surplus facilities, more than 200 Waste Information Data System past-practice waste sites, and 6 TSD units. Extensive contamination exists in some areas of surface soils, subsurface soils, and groundwater (EPA 1995). Strontium-90, tritium, nitrate, and chromium are detected at many of the 100 Area operable units.

Figure 4-31. Distribution of Hazardous Chemicals in Groundwater Within the Hanford Site (PNL 1995b and BHI data).

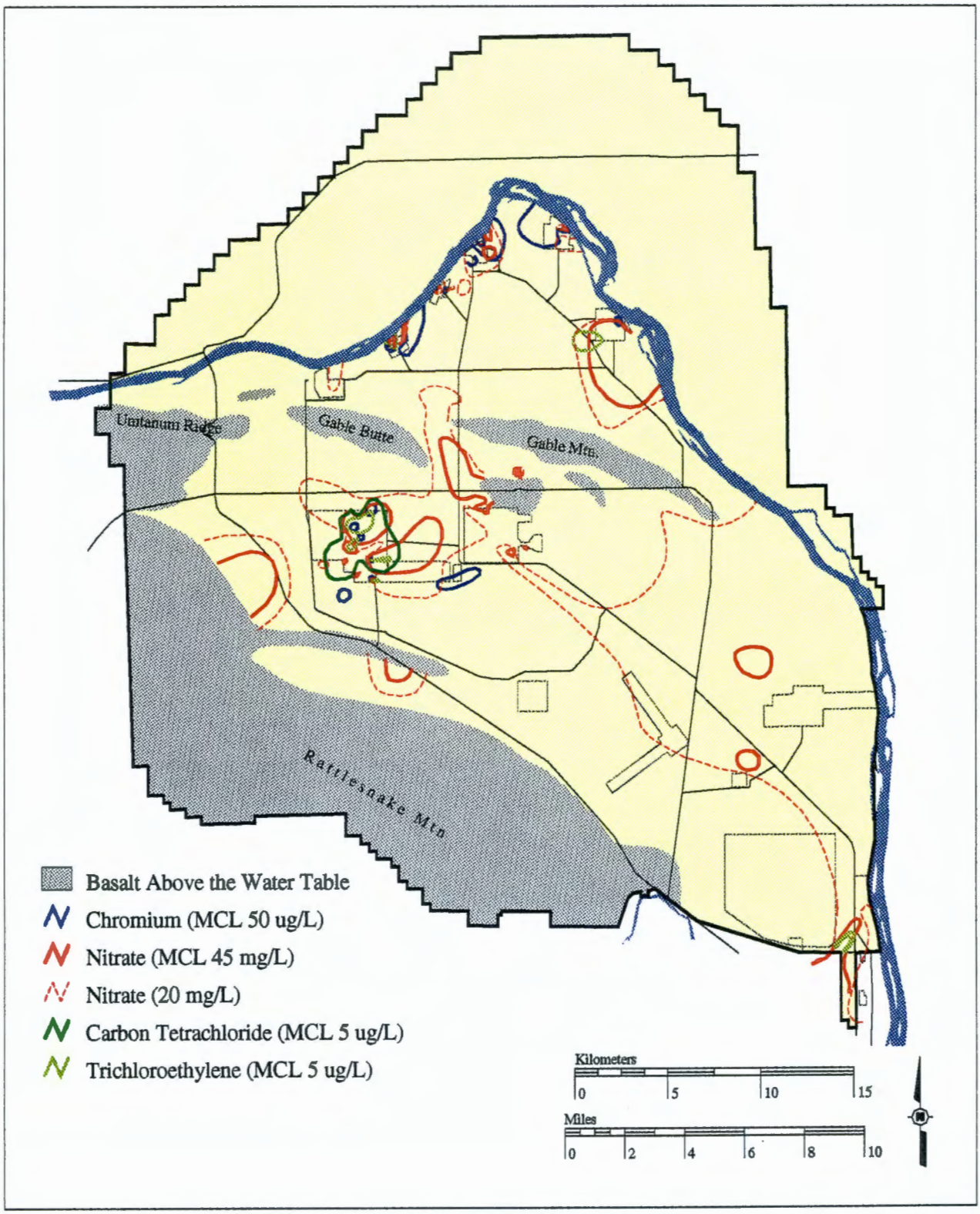


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Figure 4-32. Distribution of Radionuclides of Concern in Groundwater Within the Hanford Site (PNL 1995b and BHI data).

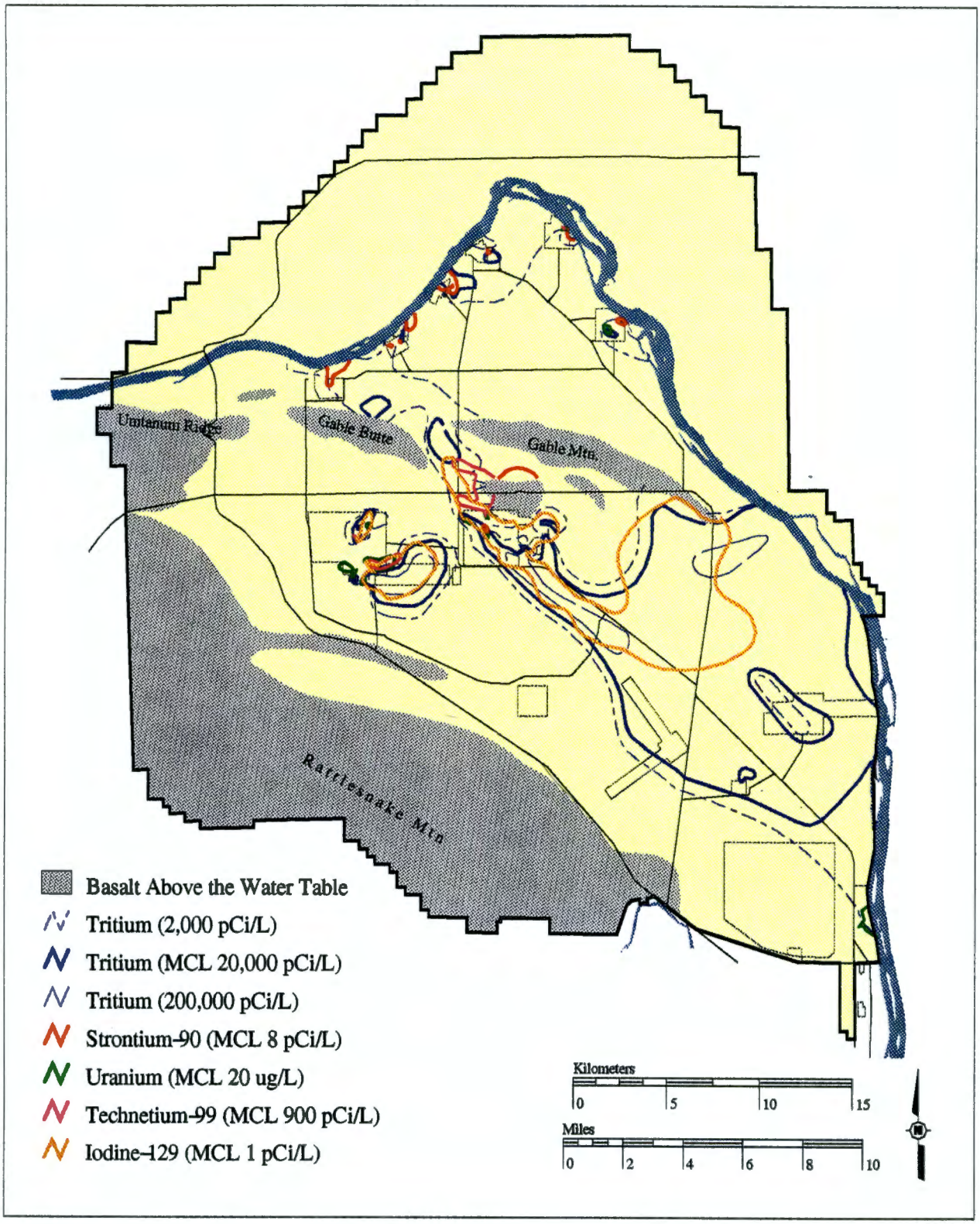

Table 4-17. Maximum Detected Plume Concentrations: 1994 Groundwater Sampling Rounds (adapted from PNL 1995b). (2 sheets)

Area Name	Plume Constituent	Units	Maximum Plume Concentration	EPA DWS	Washington Water Quality Standard
100-B/C	Chromium	ug/L	>50.0	100	50
	Strontium-90	pCi/L	56.7	8	8
	Tritium	pCi/L	28,000	20,000	20,000
100-D/DR	Chromium	ug/L	1,360	100	50
	Nitrate	mg/L	205	45	45
	Strontium-90	pCi/L	44.0	8	8
	Tritium	pCi/L	69,000	20,000	20,000
100-F	Chromium	ug/L	82.4	100	50
	Nitrate	mg/L	110.0	45	45
	Uranium	ug/L	133.0	20	20
	Strontium-90	pCi/L	20.5	8	8
	Tritium	pCi/L	98,300	20,000	20,000
	Trichloroethylene	ug/L	27.0	5	N/A
100-H	Chromium	ug/L	300.0	100	50
	Nitrate	mg/L	730.0	45	45
	Strontium-90	pCi/L	28.0	8	8
100-KE/KW	Chromium	ug/L	210.0	100	50
	Nitrate	mg/L	110.0	45	45
	Strontium-90	pCi/L	803.0	8	8
	Tritium	pCi/L	1,040,000	20,000	20,000
	Trichloroethylene	ug/L	20.0	5	N/A
100-N	Chromium	ug/L	200.0	100	50
	Cobalt-60	pCi/L	732.0	100	N/A
	Nitrate	mg/L	65	45	45
	Strontium-90	pCi/L	4,030	8	8
	Tritium	pCi/L	74,200	20,000	20,000
200 East	Chromium	ug/L	73.0	100	50
	Nitrate	mg/L	120.0	45	45
	Cyanide	ug/L	39.5	200	200
	Strontium-90	pCi/L	9,740	8	8
	Cesium-137	pCi/L	2,310	10	10
	Tritium	pCi/L	3,370,000	20,000	20,000
	Cobalt-60	pCi/L	40.1	100	N/A
	Iodine-129	pCi/L	11.8	1	1
	Plutonium-239/240	pCi/L	2,670	1	N/A
	Technetium-99	pCi/L	3,700	900	900
	Uranium	ug/L	64.3	20	20

Table 4-17. Maximum Detected Plume Concentrations: 1994 Groundwater Sampling Rounds (adapted from PNL 1995b). (2 sheets)

Area Name	Plume Constituent	Units	Maximum Plume Concentration	EPA DWS	Washington Water Quality Standard
200 West	Cesium-137	pCi/L	21.8	10	10
	Cobalt-60	pCi/L	13.2	100	N/A
	Cyanide	ug/L	20.0	200	200
	Chromium	ug/L	500.0	100	50
	Nitrate	mg/L	1,700	45	45
	Fluoride	mg/L	5.1	4	4
	Tritium	pCi/L	2,400,000	20,000	20,000
	Iodine-129	pCi/L	86.1	1	1
	Technetium-99	pCi/l	23,700	900	900
	Uranium	ug/L	2,720	20	20
	Carbon Tetrachloride	ug/L	5,200	5	0.3
	Chloroform	ug/L	107.0	100	7
	Strontium-90	pCi/L	14.5	8	8
	Trichloroethylene	ug/L	44	5	N/A
300 Area	Chromium	ug/L	<100.0	100	50
	Uranium	ug/L	150	20	20
	Trichloroethylene	ug/L	6.1	5	N/A
600 Area	Cyanide	ug/L	110.0	200	200
	Chromium	ug/L	>100.0	100	50
	Nitrate	mg/L	100	45	45
	Strontium-90	pCi/L	994.0	8	8
	Technetium-99	pCi/L	4,310	900	900
	Tritium	pCi/L	257,000	20,000	20,000
	Trichloroethylene	ug/L	25	5	N/A

DWS = drinking water standard.
EPA = U.S. Environmental Protection Agency.
N/A = not available.

4.10.1.3 Central Plateau. The Central Plateau has been used for fuel reprocessing, waste management and disposal activities and is the most extensively contaminated area at the Hanford Site. More than 400 Waste Information Data System past-practice waste sites, 13 TSD units, and numerous groundwater contaminant plumes occur in the 200 Areas. This area is the site of the Hanford Central Waste Complex and the Tank Waste Remediation System facilities, which support present and future Hanford waste management activities (EPA 1995). Contaminants include extensive groundwater plumes of technetium-99, iodine-129, nitrate, tritium, uranium, and chlorinated hydrocarbons, such as carbon tetrachloride, chloroform, and trichloroethylene. Carbon tetrachloride in particular poses a complex remediation problem; it is estimated that about 580 to 920 metric tons (640 to 1,014 tons) of carbon tetrachloride have been disposed to the vadose zone.

4.10.1.4 All Other Areas. The All Other Areas geographic area presents a diverse range of existing contamination. Parts of the 600 Area vadose zone are essentially uncontaminated, while operating areas such as the 300 Area present significant environmental remediation challenges. Several small, isolated surface waste sites have been remediated as Expedited Response Actions under CERCLA. Extensive groundwater contamination (nitrate, tritium, technetium-99, and iodine-129) occurs in the All Other Areas geographic area.

4.11 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 4-33). Currently, the DOE is developing a comprehensive land use plan for the Hanford Site (Comprehensive Plan), which recommends more specific land-use designations (Appendix M). The Comprehensive Plan identifies development and resource protection opportunities and constraints through evaluation of features of the natural and social environment at the Hanford Site.

4.11.1 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. The total area 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.

4.11.2 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 (Figure 4-34). 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.

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Figure 4-33. Geographic Areas Developed by the Hanford Future Site Uses Working Group.

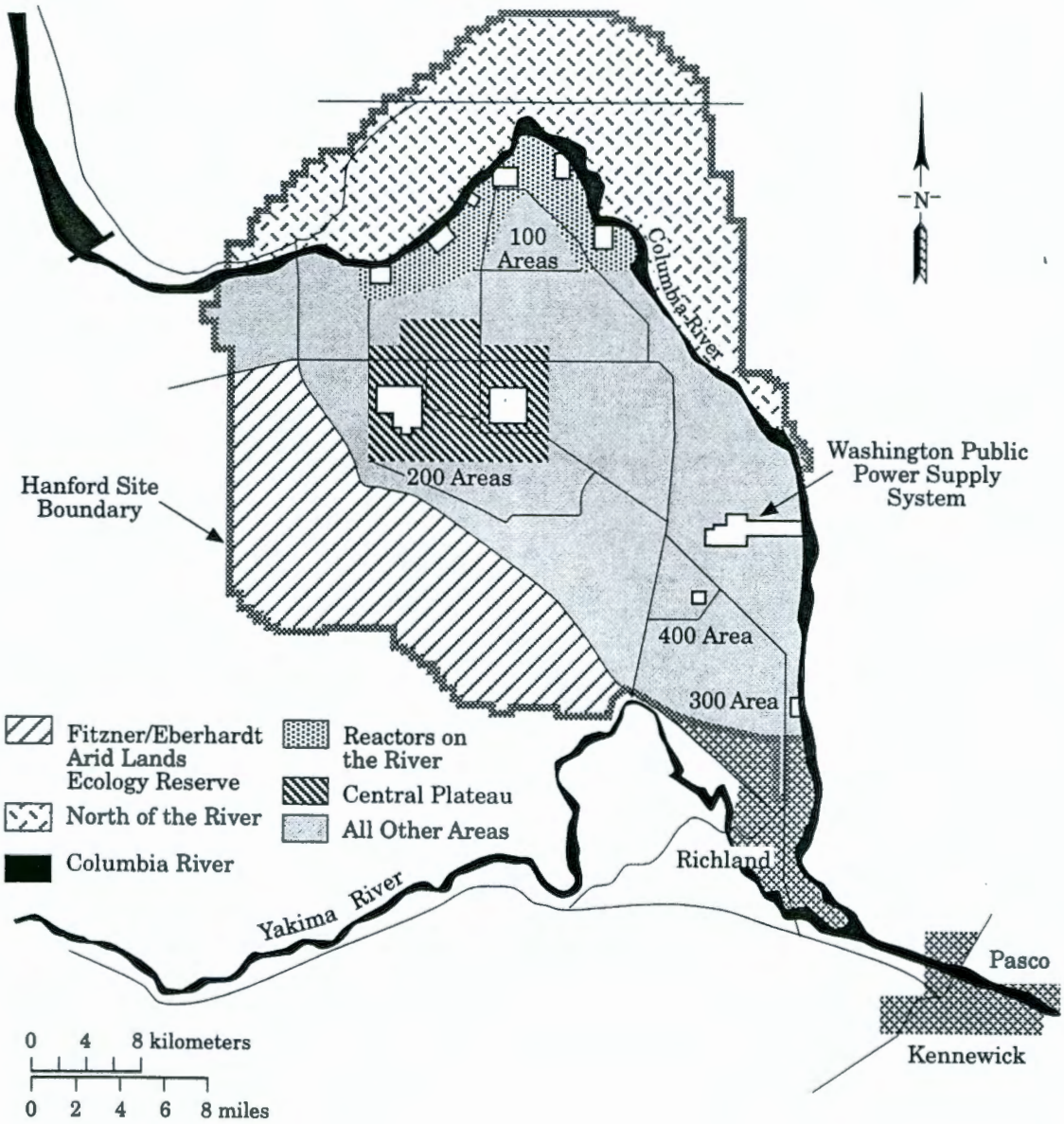
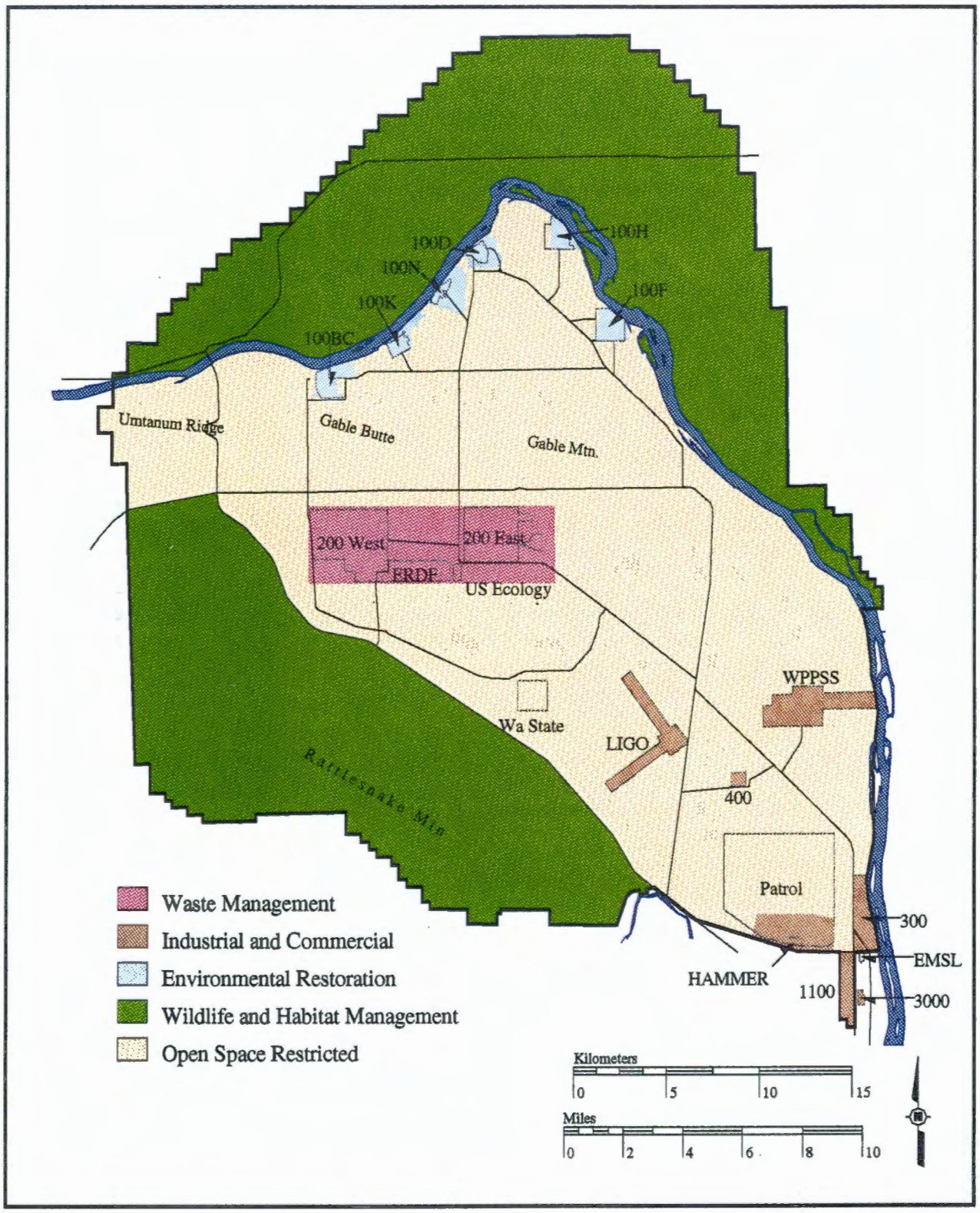


Figure 4-34. Existing Land Uses at the Hanford Site.



The *Hanford Site Development Plan* (DOE-RL 1994b) 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 sensitive cultural and ecological resources (DOE-RL 1994b).

4.11.2.1 Land Uses Within the Hanford Site Geographic Areas. A description of land uses in the six Hanford Site geographical areas identified by the Working Group is provided below.

4.11.2.1.1 Fitzner/Eberhardt Arid Lands Ecology Reserve. The ALE Reserve encompasses 315 km^2 (120 mi^2) in the southwestern portion of the Hanford Site and is managed as a habitat and wildlife reserve and environmental research center under the federal Research Natural Area program. A Research Natural Area is a classification utilized by federal land management agencies to designate lands on which various natural features are preserved in an undisturbed state solely for research and educational purposes. The Rattlesnake Hills Research Natural Area (ALE Reserve) remains the largest Research Natural Area in the State of Washington (PNL 1993a). Because public access to the ALE Reserve has been restricted since 1943, the shrub-steppe habitat is virtually undisturbed, and is one of the few remaining large tracts of shrub-steppe vegetation in the state retaining a predominant pre-European settlement character. This geographic area contained a number of small contaminated sites that were remediated in 1994 and 1995 and have been revegetated. The DOE does not anticipate changes in the existing land use of this geographic area.

4.11.2.1.2 North of the River. The area north of the Columbia River encompasses approximately 365 km^2 (140 mi^2) of relatively undisturbed or returning shrub-steppe habitat. The northwest portion of the area is managed by the USFWS under a permit issued in 1971 as the Saddle Mountain National Wildlife Refuge. The permit conditions require that the refuge remain closed to the public as part of a security zone for the N Reactor. The closure has benefitted migratory birds, especially ducks and geese. The Washington State Department of Fish and Wildlife operates the Wahluke Slope Wildlife Recreation Area, which was established in 1978 in the northeast portion of the geographic area. The area is open to the public for recreational uses during daylight hours. The North of the River geographic area also contained small, nonradioactively contaminated sites that the DOE remediated in 1994 and 1995. Revegetation using native species occurred during 1995.

The DOE is not planning to alter the current land use of the North of the River geographic area and is specifically prohibited from causing any adverse impacts on the values for which the geographic area is under consideration for Wild and Scenic River or National Wildlife Refuge status.

4.11.2.1.3 Columbia River. The Columbia River, which is adjacent to and runs through the Hanford Site, is used by the public for boating, water skiing, fishing, and hunting of upland game birds and migratory waterfowl. Public access is allowed on certain islands, while other areas are considered sensitive because of unique habitats and the presence of cultural resources.

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 Conservation Study of the Hanford Reach of the Columbia River*, 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 proposed action is to designate the Hanford Reach as a recreational river under the Wild and Scenic Rivers system.

4.11.2.1.4 Reactors on the River. The Reactors on the River geographic area occupies about 68 km^2 (26 mi^2) along the southern shoreline of the Columbia River. The area contains all the facilities in the 100 Areas, including nine retired plutonium production reactors, associated facilities, and structures. The primary land uses are reactor operations and undeveloped areas. The facilities in the 100 Areas are being placed in a stabilized state for eventual decommissioning.

4.11.2.1.5 Central Plateau. 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. The primary land uses are waste operations and operations support.

The Environmental Restoration Disposal Facility (ERDF) is currently under construction and will provide disposal capacity for environmental remediation waste generated during remediation of the 100, 200, and 300 Areas of the Hanford Site. The facility is currently about 65 ha (160 acres), and can be expanded to up to 414 ha (1.6 mi^2) if additional waste disposal capacity is required.

4.11.2.1.6 All Other Areas. 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 areas of undeveloped land between the developed operational areas described in the following sections.

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 R&D facilities serving the Hanford Site. 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. The Environmental and Molecular Sciences Laboratory (under construction in the southern part of the 300 Area) and associated research programs will provide quality research capability to advance technologies in support of the DOE mission of environmental remediation and waste management.

400 Area. The 400 Area, located southeast of the 200 East Area, is the site of the FFTF, used in the testing of breeder reactor systems. In December 1993, the Secretary of Energy ordered the FFTF to be shut down. The goal is to reach a radiologically and industrially safe shutdown condition in about 5 years (Cushing 1995). The primary land use is reactor operations and operations support.

600 Area. Land uses in the 600 Area include the following:

- The Hazardous Materials Management and Emergency Response (HAMMER) Training Center, which will be used to train hazardous materials response personnel. The HAMMER Training Center is being constructed north of the 1100 Area and is expected to cover about 32 ha (80 ac).

- Land was leased to the WPPSS to construct three commercial power reactors in the 1970s. One plant, WNP-2, was completed and is operating.

- In 1964, 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 U.S. 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 ERDF on this tract (see Section 4.11.2.1.5).

- 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 SR 240, for the purpose of extremely hazardous waste disposal. This parcel is uncontaminated (although the underlying groundwater is contaminated) and undeveloped. The deed requires that 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 LIGO Facility will detect cosmic gravitational waves for scientific research. When complete, the facility will consist of two underground optical tube arms arrayed in an "L" shape. The facility will be sensitive to vibrations in the vicinity, which can be expected to constrain nearby land uses.

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.

4.11.3 Hanford Site Protective Safety Buffer Zones

Existing and planned waste disposal sites, waste processing facilities, and hazardous or radiological materials storage 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 protective buffer zones surrounding the waste remediation, processing, and disposal areas must be used. These 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. 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 hazardous or radioactive material could pose an unacceptable risk to human health.

Buffer zones necessary to protect human health and safety are divided into two main components--an inner Exclusive Use Zone (EUZ) and an outer 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 facility and ends at a distance for which special planning and preparedness efforts are no longer required. Access restrictions are not required within an EPZ; however, the DOE would be responsible for ensuring adequate planning and preparedness requirements for every person within the zone.

The protective buffer zones for the Hanford Site (Figure 4-35), were established using boundaries calculated for individual limiting facilities (i.e., facilities with accidents of maximum potential public health impact). Information about the limiting facilities, controlling contaminants, and credible accidents is presented in Table 4-18. The boundaries provide a conservative buffer zone that is expected to be sufficient to address protective 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 U.S. Nuclear Regulatory Commission procedures, the WPPSS WNP-2 Reactor requires a 16-km (10-mi) EPZ and 1.9-km (1.2-mi) EUZ.

Within portions of the EUZ, certain types of public access would be restricted, while other types of public access within that same area might be acceptable. Criteria are needed to evaluate, on a case-by-case basis, the types of public access possible within an EUZ. Six different types of public access have been defined for the EUZ. 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 Maximally Exposed Individual (MEI)[2] would spend in this area is estimated to be about 100 hr/yr.

[2]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 dose.

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Figure 4-35. Protective Safety Buffer Zones.

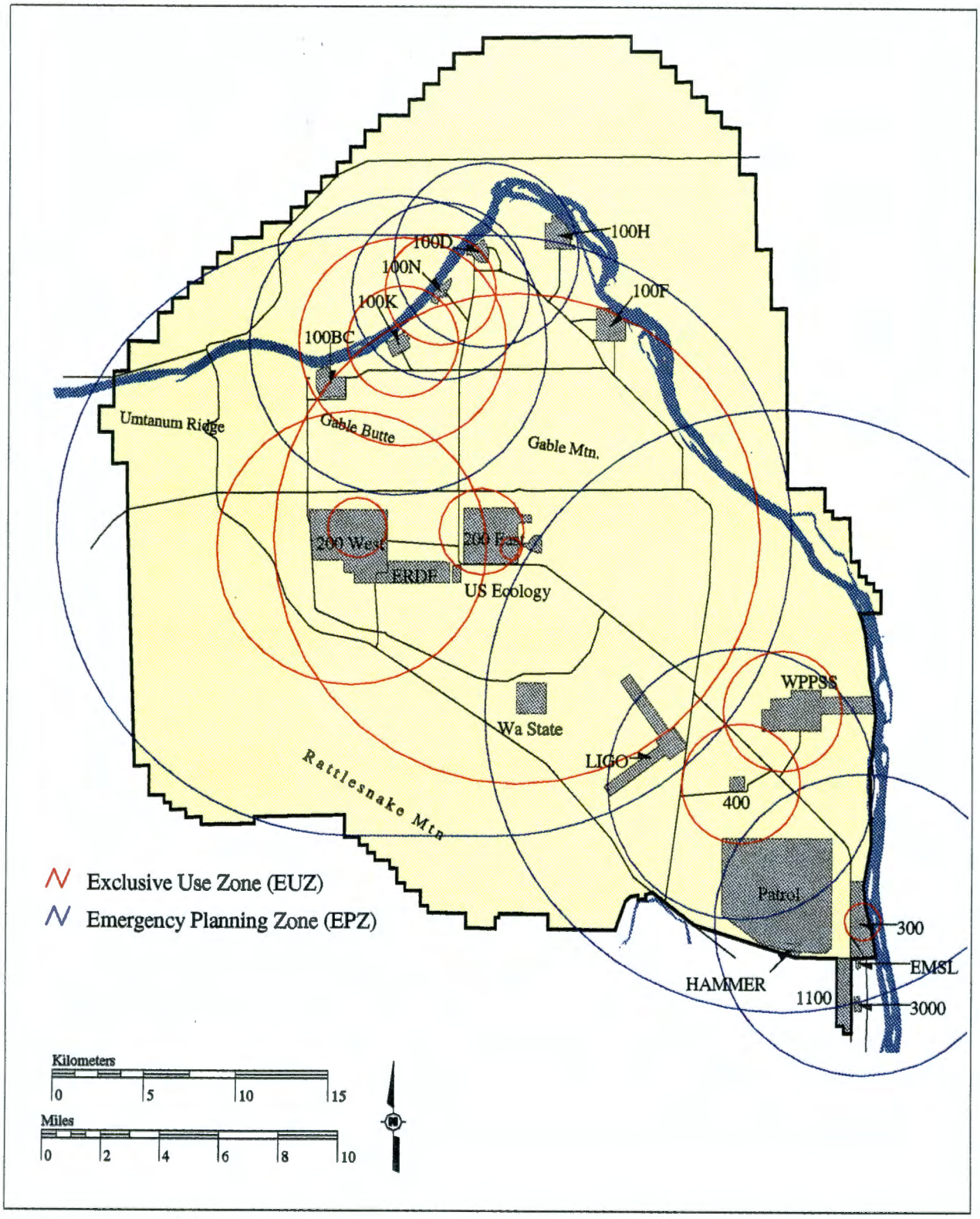


Table 4-18. Protective Safety Buffer Zones (Exclusive Use Zones and Emergency Planning Zones).

Limiting Facility	Coordinates WASP-X	Coordinates WASP-Y	EUZ Boundary (meters)	Credible Accident	Controlling Contaminant	EPZ Boundary (meters)	Limiting Accident	Controlling Contaminant
100-D Area								
D-Reactor Complex	573510	151595				5,000	Sodium Spill	Sodium hydroxide
100-K Area								
K-Basin	569184.3	146717	3,000	Chlorine Cylinder Valve Failure	Chlorine	8,100	Sabotage	Chlorine, Pu, Cs-137
			5,600[b]	Fuel Processing for Dry Storage	Cs-137			Sr-90, Am-241
100-N Area								
N-Reactor Complex	571215.9	149516.3	3,000	Chlorine Cylinder Valve Failure	Chlorine	5,000	150 lb. Chlorine Incident	Chlorine
200 West Area								
PFP	566474.3	135652.7	7,300	Seismic Event with Ventilation	Pu	16,100	Waste Tank Sabotage and PFP Seismic Accident	Pu, Am-241
Tank Farms	566777	136734.1	1,600	SST Hydrogen Deflagration	Cs-137	16,100	Waste Tank Sabotage and PFP Seismic Accident	Pu, Am-241
200 East Area								
B Plant/WESF	573504.9	136548.1	2,300	Cross Contamination from K-3 to K-1 Filter Banks	Sr-90, Cs-137	16,100	Waste Tank Sabotage	Pu, Am-241
Tank Farms	575422.2	136203.9	13,150	Double-Shell Tank Filter Blowout	Cs-137	16,100	Waste Tank Sabotage	Pu, Am-241
Limiting Proposed Facility - Tank Waste Vitrification Plant	575118.1	135636.9	600	Earthquake	Am-241	16,100	Waste Tank Sabotage	Pu, Am-241
300 Area								
324 Bldg B-Cell[c]	594247.4	115784.7	1,000	Earthquake 324 Bldg w/o B-Cell Upset	Sr-90		(315 Bldg Accident Dominates)	
315 Bldg[c]	594480.3	115761.7		(324 Bldg Accident Dominates)		8,100	1,920 lb. Chlorine Incident in the 315 Bldg	Chlorine
400 Area								
FFTF	587604.9	123117.5	3,200	Sodium Storage Safety Class 2	Sodium hydroxide	7,300	Sodium Sabotage	Sodium hydroxide

[a]Sodium spill/fire is considered an incredible accident (frequency, less than 1 E-06), and no credible accident with significant impacts was identified. Thus, no EUZ was determined.

[b]If K-Basin fuel is not stable enough to move to 200 Area before processing for dry storage, this larger EUZ may be needed.

[c]The 324 B-cell accident dominated the credible ($>10^{-6}$ probability) accident calculations for the 300 Area EUZ; the 315 Bldg chlorine accident dominated the incredible ($<10^{-6}$ probability) accident calculations for the 300 Area EPZ.

EPZ = Emergency Planning Zone.
EUZ = Exclusive Use Zone.
FFTF = Fast Flux Test Facility.
PFP = Plutonium Finishing Plant.
WESF = Waste Encapsulation and Storage Facility.

- ***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 hr/yr.

- ***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 200 hr/yr.

- ***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 hr/yr.

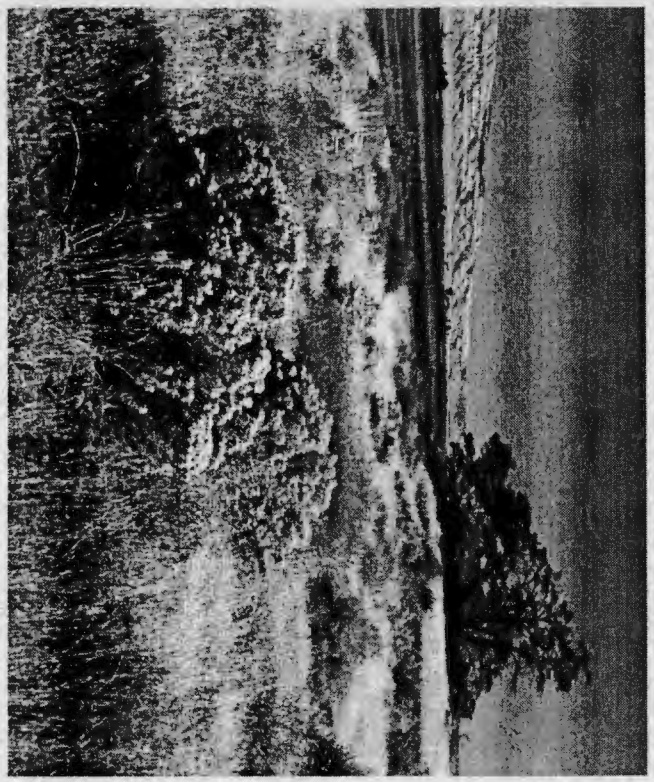
- ***Moderately Restricted Occasional Access***. This type of access area would allow for more diverse activities for a longer, but controlled, periods of time than those defined for the Moderately Restricted Periodic Access areas. For example, overnight stays for short periods would be allowed. The 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 hr/yr.

- ***Minimally Restricted Access***. This type of access require only minimal access 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 is estimated to be about 8,700 hr/yr.

4.11.4 Native American Treaty Rights

Under separate treaties signed in 1855, lands occupied by the present Hanford Site were ceded to the United States by the Confederated Tribes and Bands of the Yakama Indian Nation and by the Confederated Tribes of the Umatilla Indian Reservation. Under these treaties, the tribes retained the right to fish in their usual and accustomed places in common with the citizens of the Territories. Additionally, the treaties retained to the tribes the privilege of hunting, gathering roots and berries, and pasturing horses and cattle on open unclaimed lands. The 1855 Treaty with the Nez Perce also retained the right to fish at usual and accustomed places, and the Hanford Reach has been identified as containing such locations. The Wanapum People did not sign a treaty with the United States, and are not a federally recognized tribe. However, the Wanapums were historical residents of the Hanford Site when it was created in 1943, and their interests in the area have been acknowledged.

The tribal fishing rights reserved under the treaties have been recognized as effective within the Hanford Reach. However, the privilege of gathering foods and medicines and of hunting and pasturing horses and cattle are, by the terms of the treaties, applicable to open unclaimed lands. Open and unclaimed lands are lands held in public ownership that are not reserved for uses inconsistent with the exercise of the treaty rights. The Hanford Site's past mission of nuclear materials production and its current mission of waste management have both been deemed by the DOE to be purposes inconsistent with the exercise of the treaty reserved privileges. Although tribal members have expressed interest in exerting the treaty rights on the Hanford Site, full exercise of such rights would not be consistent with Hanford's continuing waste management mission.



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Environmental Consequences

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5.0 Environmental Consequences

This chapter describes the potential environmental consequences associated with the No-Action Alternative and other future land-use alternatives in the Columbia River, Reactors on the River, Central Plateau, and All Other Areas geographic areas of the Hanford Site. The analysis focuses on the resource categories described in Chapter 4.0, "Affected Environment." The potential environmental consequences and mitigation measures presented in this chapter are summarized in Section 3.5 of this Environmental Impact Statement (EIS).

5.1 Analysis Approach

The environmental consequences analysis estimated 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.

5.1.1 Geographic Information System Analysis

Analyses of the effects of remediation activities on geological resources, soils, vegetation, floodplains, wildlife habitat, and cultural resources were performed using a geographic information system (GIS). The GIS provided rapid analysis of large volumes of data for natural resources, waste site remediation, and facilities decommissioning. This analysis generated tables and figures that present 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.

The following data were obtained and incorporated into the GIS database:

- 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) units
- 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. The use of this coordinate system 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 potential excavation areas, capping areas, and the associated trample zones caused by soil excavation, soil stockpiling, and cap construction under each future land-use alternative. The resulting impact areas were integrated into a single, discrete layer of information[1]. This layer was then overlaid and passed through each resource layer (e.g., vegetation, wetlands, and cultural resources). The information associated with each resource layer then could be examined. The impacts on the potentially affected resource (e.g., acres of shrub-steppe habitat affected) were tabulated, and the percentage of resource type disturbed was calculated for each of the geographic areas relative to the Hanford Site. Figure 5-1 depicts how the GIS data layers were used to generate tabulated impacts.

5.1.2 Human Health Risk Assessment Methodology

This section provides a brief description of the human health risk assessment methodology used in 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. The total cancer risk in this EIS was determined by summing the radionuclide and chemical carcinogen risk. The resulting values can be compared to the 10^{-4} to 10^{-6} (1 in 10,000 to 1 in 1,000,000) range suggested by the U.S. Environmental Protection Agency (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.

Why is a Risk Range Used?

The 10^{-4} to 10^{-6} risk range provides flexibility in determining appropriate remediation levels for contaminated sites. The 10^{-6} risk level is presented as a "point of departure," that is, the starting point for acceptable exposure levels. After factors such as uncertainty, population sensitivities, and technical limitations to remediation have been considered, the target risk may be revised upward within the risk range.

Noncancer risks were estimated using the hazard quotient, which is the ratio of the estimated exposure to a threshold value below which toxic effects are not expected, and the hazard index, which is the sum of hazard quotients for individual chemicals. Further discussion of the concepts of the hazard quotient and the hazard index is presented in Appendix B5. The risk to human health is considered *de minimis* if the ILCR to an individual is no greater than 10^{-6}, or if the hazard index is less than 1.0.

5.1.2.1 Human Health Risk Assessment. A human health risk assessment was used to evaluate the potential threat to human health and the environment in the absence of any remedial action. This human health risk assessment describes the risk conditions under the No-Action Alternative, and provides the basis for determining whether remedial action is necessary (DOE-RL 1993a). Under the No-Action Alternative, potential risks were estimated for the Reactors on the River, Central Plateau, and All Other Areas geographic areas for agricultural, residential, industrial, and recreational

[1]Disturbance areas associated with groundwater remediation systems were not included in this analysis because the proposed locations of wells and treatment units have not been determined; proposed locations would be determined through the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) process. This does not affect comparison of the future land-use alternatives because the groundwater remediation system footprint would be similar, and would have similar impacts, under each alternative.

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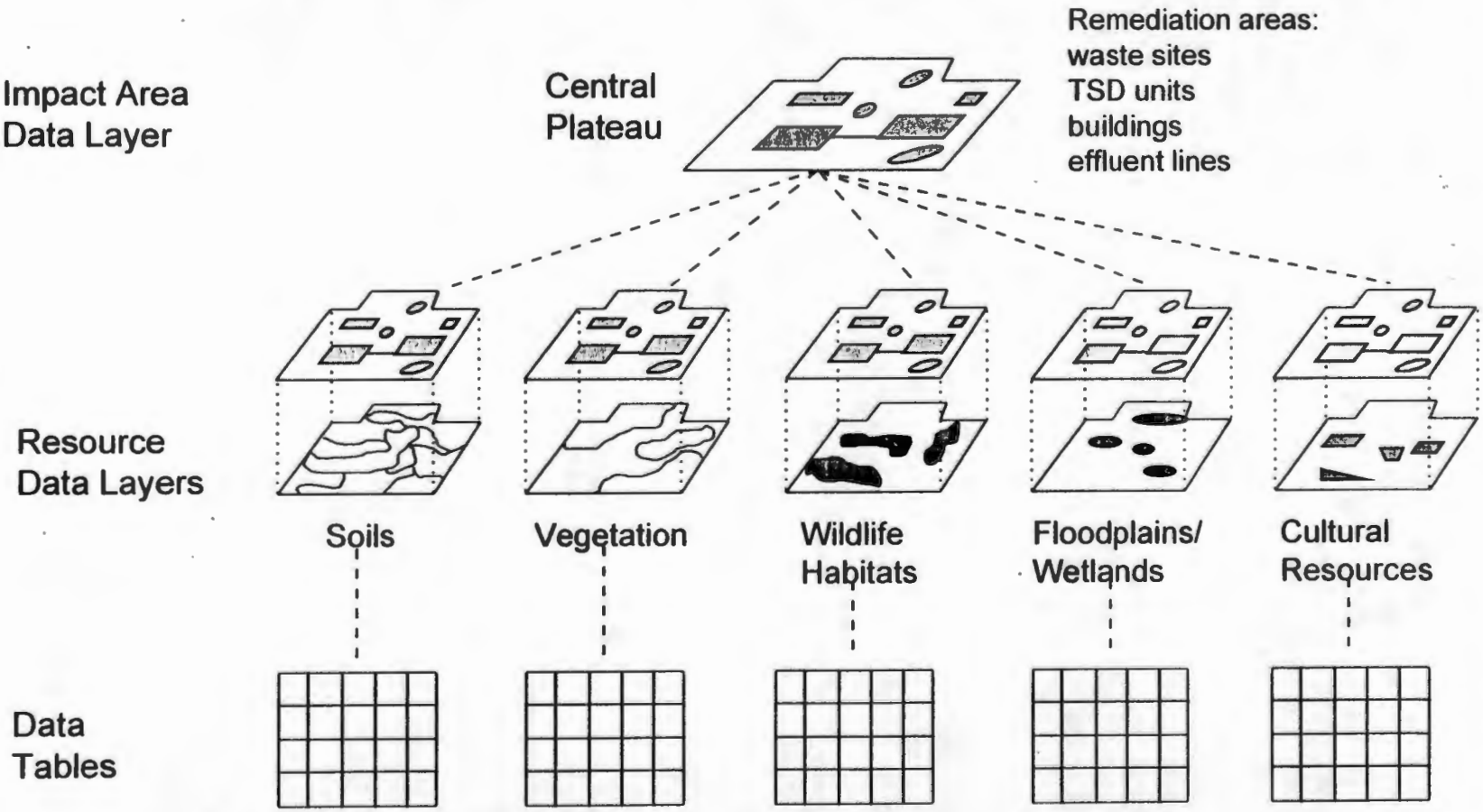
Figure 5-1. Geographic Information System Analysis Process.



exposure scenarios. Assumptions concerning the type and magnitude of contact with contaminated media (e.g., soil, water, air, and food) were made for each of these scenarios (Appendix B4). In addition, for purposes of analysis, current restrictions or institutional controls were assumed to be no longer in effect.

Because of the sheer magnitude of information needed to assess risk at every waste site on the Hanford Site, an approach that groups the waste sites and integrates the effects of potential releases was necessary. This was accomplished by grouping waste sites by medium (e.g., soils, groundwater), then aggregating the waste sites into 1-km^2 (0.4-mi^2) cells in a grid overlaid on the Hanford Site. The potential contaminant release and transport through the environment from each 1-km^2 (0.4-mi^2) cell was estimated using the Multimedia Environmental Pollutant Assessment System (MEPAS) computer model (Droppo 1991), which was developed by the Pacific Northwest National Laboratory (PNNL). Modeling results from multiple cells were combined to estimate the contaminant 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, Solid Waste Information Tracking System (SWITS), and Hanford Environmental Information System 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. These modules include the source (waste) terms, contaminant transport mechanisms, exposure scenarios, and the variables used to calculate risk or hazard index from a given exposure. The MEPAS model was used to estimate risk.

5.1.2.2 Accident and Routine Conditions 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 from daily activities and processes associated with the remediation efforts required to achieve a desired future land-use objective. Accident risk refers to the risk to workers and the general public from accidents that could occur as a result of remediation activities.

The risks associated with routine remediation activities are presented in Section 5.7. Because this EIS does not discuss specific remediation technologies, which would be identified through the CERCLA process, risks associated with routine operations were based on actual worker exposure data from 1995. During 1995, several large environmental restoration projects were conducted, including activities with a wide range of radiological exposures to workers. The radiation doses received by workers during these environmental restoration projects were monitored and reported by Bechtel Hanford, Inc. (BHI 1995a). In the future, risks from remediation operations would be evaluated through the CERCLA process in a site-specific manner.

The risk associated with four accident scenarios that could result in the release of hazardous and radioactive materials to the environment is presented in Section 5.8. These scenarios include a shoreline excavation accident, a range fire, a soil dispersion accident, and a fire in a groundwater ion-exchange unit. A shoreline excavation accident, which could occur during remediation of the Columbia River geographic area, would release contaminated sediments into 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 an ion-exchange unit used for treating groundwater also would release contaminants into the air.

In addition to accidents resulting from remediation activities, the range fire accident was evaluated for the No-Action Alternative. This accident was selected because of the high likelihood of occurrence and applicability to any of the alternatives being considered.

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 are expressed as the hazard index. The ecological hazard index 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. U.S. Department of Energy (DOE) Order 5400.5, *Radiation Protection of the Public and the Environment*, (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 Conservatism and Uncertainty in the Impact Analyses

This EIS used conservative assumptions for calculating waste volumes generated by remediation, acreage of disturbance, and remediation costs, in order to provide bounding analyses of impacts. The use of conservative assumptions in the analysis of impacts leads to an associated level of uncertainty.

Estimates of **waste volumes** generated by remedial activities were largely based on information from several databases that characterize waste disposal at the Hanford Site. Field characterization to determine the actual nature and extent of contamination at any particular site was not always available to refine the estimates. In general, the extent of excavation of waste sites was assumed to be sufficient to maintain a slope of 34° to the bottom of the excavation, thus excavating some uncontaminated material around each waste site. In this way, lateral migration of contaminants as well as safety are addressed. However, other assumptions can be made in other documents. For

example, waste volume estimates presented in the *Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington* (EPA 1995a) are assumed, for the most part, to be equal to the dimensions of the waste sites. Waste volume estimates do not address lateral or vertical migration of contaminants or the use of side slopes during excavation. For this reason, the comparison of waste volume estimates presented in different documents must be done with caution.

The assumed waste volume directly affects the estimation of the **area disturbed** by remedial activities, including the contaminated area, laydown areas, and associated transportation routes. Because the waste volume estimates tend to be conservative, the associated footprint of disturbance might overstate the area that actually would be disturbed by remedial activities.

For purposes of analysis in this EIS, conservative estimates of waste volumes and disturbed areas produce conservative estimates of remediation **costs**. Cost estimates will continue to be refined based on site-specific information through the CERCLA process, with the intent of providing an accuracy of +50 to -30%, as indicated as the target for the cost estimate in EPA's guidance for conducting Remedial Investigations/Feasibility Studies (RI/FS).

This EIS provides bounding (i.e., worst case) estimates for waste volumes, areas of disturbance, and costs. These parameters continue to evolve through the CERCLA process from conservative engineering studies, through more refined baseline planning estimates, to site-specific estimates based on solid characterization data. Estimates will continue to be refined through the CERCLA process, but are not anticipated to exceed the bounding estimates presented in this EIS.

5.1.5 Topics Covered in this Chapter

This chapter provides information on excavation volumes, areas of disturbance, and costs. This chapter also describes the potential impacts of each alternative on 11 different resource areas, for each geographic area, as follows:

- geology
- soils
- air
- ecology
- water resources
- noise
- cultural resources
- visual and aesthetic resources
- human health risk
- occupational health and safety
- excavation volumes, material requirements, and costs

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Later sections of this chapter address:

- socioeconomic impacts
- human health risk assessment
- 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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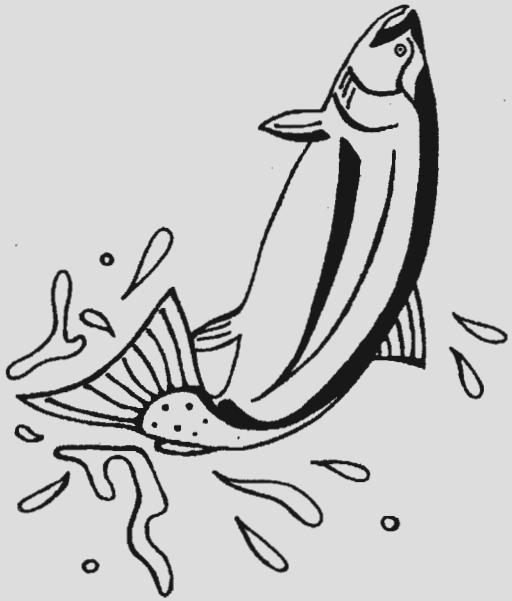

Columbia River

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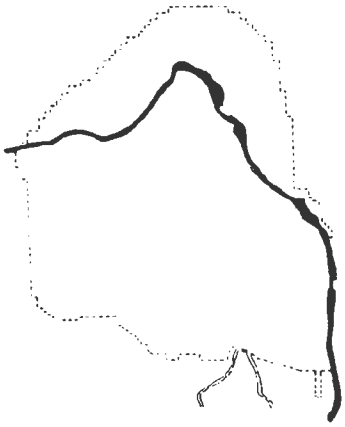
5.2 Columbia River Geographic Area



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 riparian (riverside) ecology characteristics of the Columbia Basin ecosystem before construction of hydroelectric dams on the river.

The Hanford Reach comprises the last undisturbed stretch of the nontidal portion of the Columbia River in the United States. Nearly 60% of the Columbia River's entire native wild stock of fall chinook salmon spawn in the Hanford Reach (NPS 1994). River water downstream from the Hanford Site is used by both Washington and Oregon residents for drinking water, agriculture, industry, transportation, and recreation. The riverbanks and islands in the Hanford Reach provide habitat for several species of state-threatened or endangered plants and animals (NPS 1994).

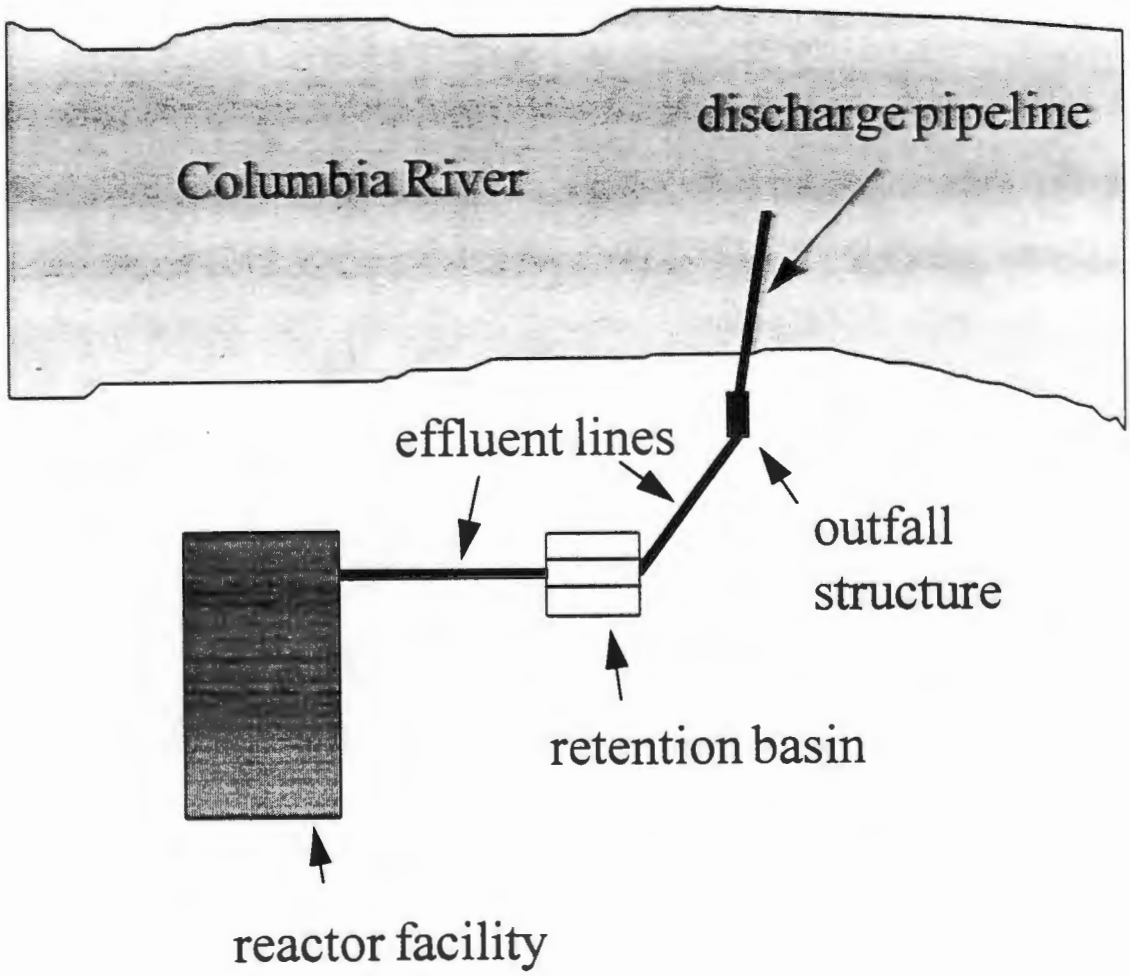
Future public access to the Columbia River raises concerns because groundwater contamination from the Hanford Site reaches the river (through springs and seeps) at several locations. Contamination sources also include reactor effluent lines that protrude into the river. These structures were used to 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 is another potential source of contamination (DOE-RL 1993a, PNL 1994). 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, the radiological contaminants in the river water are well below State of Washington and EPA drinking water standards (PNL 1995).

The scope of proposed actions in the Columbia River geographic area includes contaminated riverbank, riverbottom, and river island sediments, and river discharge pipelines. 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 5-2). The effluent lines that extend from the reactors to the outfall structures, and the outfall structures themselves, are presented in Section 5.3, "Reactors on the River Geographic Area." Potential impacts of the No-Action and future land-use alternatives are described in the following sections.

5.2.1 Geology

This section describes the impacts of the No-Action, Unrestricted, and Restricted Future Land-Use Alternatives on the geological resources of the Columbia River. As described below, none of the future land-use alternatives are expected to result in short- or long-term impacts to geologic resources in this geographic area.

Figure 5-2. Reactor Discharge Pipeline Schematic.



5.2.1.1 Impacts on Geological Resources from the No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments (placement of riprap to prevent human access), and the continuation of current environmental monitoring and maintenance activities. Under this alternative, the river discharge pipelines and the contaminated sediment would be left in place, and current public access restrictions for exploration or exploitation of mineral deposits in the Hanford Reach would continue. No mining is being conducted in this area, and historical mining activities were very limited. No known mineral leases exist 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 is not expected to result in significant short- or long-term adverse impacts. Continued environmental monitoring and maintenance activities probably would not have significant impact on the geologic resources of the Hanford Reach.

5.2.1.2 Impacts on Geological Resources from the Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve the complete excavation and removal of river discharge pipelines and contaminated riverbank, riverbottom, and island sediments. The extent of excavation required would be determined through site characterization under the CERCLA process. Up to 17 km (11 mi) of shoreline where groundwater plumes enter the river could be affected by excavation activities; however, recent studies indicate that the area potentially disturbed would be less than this bounding estimate (PNL 1995). 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.

Under this alternative, restrictions on public access in the Hanford Reach would continue during remediation. 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. Complete removal of all contamination under this alternative could allow for the eventual relaxation of these access restrictions.

5.2.1.3 Impacts on Geological Resources from the Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would involve in-place stabilization of the river discharge pipelines, and the continuation of institutional controls. Approximately 339,000 loose cubic meters (LCM) (446 loose cubic yards [LCY]) of riprap would be required for stabilization of the pipelines.

The Restricted Future Land-Use Alternative would require mining of riprap from quarry and borrow sites for use as pipeline stabilization material. 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 and borrow sites. This impact is discussed in Section 5.10 as an irreversible and irretrievable commitment of geologic resources. Appendix E of this EIS provides additional details on potential quarry and borrow sites.

Institutional controls implemented under the Restricted Future Land-Use Alternative would involve long-term continuation of existing restrictions on public access in the Hanford Reach. As in the No-Action Alternative, such access restrictions are not expected to adversely affect the development of geologic resources.

5.2.2 Soils

This section describes the potential impacts on soils in the Columbia River geographic area. This geographic area includes the numerous islands between the City of Richland and the Vernita Bridge and shoreline areas along the river. The predominant soil types are Quincy sands and riverwash. Impacts to soil types are presented in Table 5-1.

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	148.0 (370)	4.0 (10)

*Areal impact information was generated from the GIS, and includes area disturbed for excavation, outfall capping, trample zones, and discharge pipeline disposition.
GIS = geographic information system.

5.2.2.1 Impacts on Soils from the No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, and the continuation of current environmental monitoring and maintenance activities. Stabilization would be limited to spot-contaminant locations, and is not expected to result in significant impacts on soils. Continued environmental monitoring and maintenance activities are not expected to adversely impact soils.

5.2.2.2 Impacts on Soils from the Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve the complete excavation and removal of river discharge pipelines, and contaminated riverbank, riverbottom, and island sediments. This alternative would disturb approximately 148 ha (370 ac) of soils (see Table 5-1). The largest extent of soil disturbance would develop from using heavy equipment to haul contaminated sediments from shoreline and island sites. These disturbances would occur primarily within the trample zone around work areas. 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; Quincy sand and Burbank loamy sand are susceptible to wind erosion (Brincken 1994). Although these impacts are considered potentially significant, long-term impacts could be reduced if appropriate mitigation measures were implemented.

5.2.2.2.1 Potential Mitigation Measures. Potential mitigation measures for soils disturbed under the Unrestricted Future Land-Use Alternative would include:

- 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

- reseeding disturbed areas with native vegetation to reduce long-term soil loss from wind and water erosion.

5.2.2.3 Impacts on Soils from the Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would involve in-place stabilization of the river discharge pipelines, and the continuation of institutional controls. 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 to, but less extensive than, those presented in the Unrestricted Future Land-Use Alternative because the river discharge pipelines and contaminated sediments would be left in place. The largest extent of soil disturbance would develop from using heavy equipment to haul stabilization materials to shoreline and island sites. These disturbances would occur primarily within the trample zone around work areas. Short-term impacts could include soil compaction and increased potential for erosion. Although these impacts are considered potentially significant, long-term impacts could be reduced if appropriate mitigation measures were implemented.

5.2.2.3.1 Potential Mitigation Measures. Potential mitigation measures for soils disturbed under the Restricted Future land-Use Alternative would include:

- 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

- reseeding disturbed areas with native vegetation to reduce long-term soil loss from wind and water erosion.

5.2.3 Water Resources

This section identifies potential impacts to Hanford Site surface water and water quality from the proposed action and No-Action Alternatives. None of the alternatives would adversely affect groundwater in the Columbia River geographic area.

5.2.3.1 Impacts on Water Resources from the No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, and the continuation of current environmental monitoring and maintenance activities.

5.2.3.1.1 Surface Water Flow Characteristics. The No-Action Alternative would not affect the existing flow characteristics of the Columbia River.

5.2.3.1.2 Water Quality. Under the No-Action Alternative, the river discharge pipelines and contaminated sediments 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, and is expected to diminish

with time. However, increased contaminant releases could occur from natural scouring, which might expose and detach portions of the buried river discharge pipelines. Potentially significant impacts could be avoided if appropriate mitigation measures are taken. Natural shoreline erosion also could mobilize contaminated sediment; however, this process is very slow, and is not expected to adversely affect water quality.

Elevated concentrations of iodine-129, tritium, and strontium-90 have been identified in the Columbia River. Tritium, uranium, technetium-99, and iodine-129 are found in higher concentrations at the Richland Pumphouse compared to Priest Rapids Dam, which indicates an influence from Hanford Site operations (PNL 1995). However, current radionuclide concentrations in the Columbia River are well below applicable drinking water standards. Downstream surface water supplies for municipal and other uses would not be affected. Surface water quality impacts from the No-Action Alternative are not expected to be significant.

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 (ug/L)*
Tc-99	0.02	0.05	900
I-129	4.3×10^{-5}	7.7×10^{-5}	0.48

*Proposed.

5.2.3.1.2.1 Potential Mitigation Measures. The risk of contaminants being released from river discharge pipelines could be reduced by periodically inspecting the pipelines and stabilizing exposed sections with riprap.

5.2.3.1.3 Floodplains. The No-Action Alternative would not involve significant disturbance of the Columbia River floodplain.

5.2.3.2 Impacts on Water Resources from the Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve the complete excavation and removal of river discharge pipelines, and contaminated riverbank, riverbottom, and island sediments.

5.2.3.2.1 Surface Water Flow Characteristics. The removal of contaminated riverbank sediments could require use of a cofferdam along the Columbia River to de-water the area and enable excavation. The temporary use of a cofferdam would constrict the river channel; this could cause a rise (backwater effect) in the river stage just upstream of the cofferdam. The increase in river stage could be approximately 10 to 20% above existing baseline conditions (Table 5-2). Increases in river stage could increase flow velocity by approximately 15%, and could result in additional local scouring near the cofferdams. This scouring could resuspend and transport potentially contaminated sediments from the riverbottom and island areas during riverbank excavation.

Temporary changes in the Columbia River stage could change adjacent alluvial groundwater levels by an amount equal to the changes in river stage. These changes in river stage could temporarily increase or decrease groundwater gradients, and might alter the direction and rates of

Table 5-2. Estimated Stage Increase on the Columbia River from use of a Cofferdam.

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 a steady flow, with a Manning's roughness factor of 0.025, and a friction slope of 0.0002 for the Columbia River (Barnes 1967).

contaminant migration in the groundwater system adjacent to the Columbia River. Studies indicated that the effects of seasonal river-stage fluctuations were noticeable up to 300 m (984 ft) inland; daily river level fluctuations could be seen up to 230 m (750 ft) inland (Gilmore et al. 1990, Gilmore et al. 1991). Changes to the groundwater system from the temporary increase in river stage would be noticeable a slightly greater distance inland than normal. Because these changes would occur only when the cofferdam is in place, no long-term impacts on groundwater are expected.

5.2.3.2.2 Water Quality. The activities conducted under the Unrestricted Future Land-Use Alternative could result in increased turbidity and radiological contamination in the Columbia River. The quantities of contaminant releases or increases in concentrations have not been estimated because the extent of sediment contamination is not well documented. Site-specific evaluations of potential water quality effects would be performed as part of the CERCLA process. Mitigation measures could be taken to minimize water quality degradation. Monitoring would be performed to identify problem areas and determine the need for additional corrective measures.

5.2.3.2.2.1 Potential Mitigation Measures. Potential mitigation measures for protecting water quality under the Unrestricted Future Land-Use Alternative include:

- installing runoff barriers to prevent contaminated sediments from entering the river when remediation activities that disturb soil or sediment along the Columbia River are being conducted
- limiting areas of disturbance below the high-water mark to minimize resuspension of disturbed materials
- using riprap, biodegradable geotextiles, and other suitable materials to stabilize disturbed areas
- supplying alternate municipal water if radiological and chemical concentrations downstream of the remediation activities indicate substantial water quality degradation.

5.2.3.2.3 ***Floodplains***. This alternative could affect 140 ha (346 ac) of the Columbia River floodplain, which is approximately 3% of the floodplain in the Columbia River geographic area and roughly 2% of the Columbia River floodplain on the entire Hanford Site (Figure 5-3). Excavation activities conducted under the Unrestricted Future Land-Use Alternative could result in the eventual widening of the Columbia River floodplain. The extent to which the floodplain is widened would depend on the areal extent and depth of excavations. Remediation activities are not expected to adversely affect floodplain functions.

> 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.

5.2.3.3 Impacts on Water Resources from the Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would involve in-place stabilization of the river discharge pipelines, and the continuation of institutional controls.

5.2.3.3.1 Surface Water Flow Characteristics. Remediation activities conducted under the Restricted Future Land-Use Alternative would not require the use of a cofferdam, and are not expected to affect the existing flow characteristics of the Columbia River.

5.2.3.3.2 Water Quality. The activities conducted under the Restricted Future Land-Use Alternative could result in short-term releases of small amounts of contaminants to the Columbia River. These releases are not expected to adversely affect water quality.

5.2.3.3.2.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative are the same as for the Unrestricted Future Land-Use Alternative.

5.2.3.3.3 Floodplains. The Restricted Future Land-Use Alternative would affect 7 ha (17 ac) of the 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 5-4). Effects on the floodplain would be limited to locations where sediment excavation and pipeline removal is required to protect human health and safety. Remediation activities are not expected to adversely affect floodplain functions.

Figure 5-3. 100-Year Floodplain and Wetland Areas Impacted under the Columbia River Unrestricted Future Land-Use Alternative.

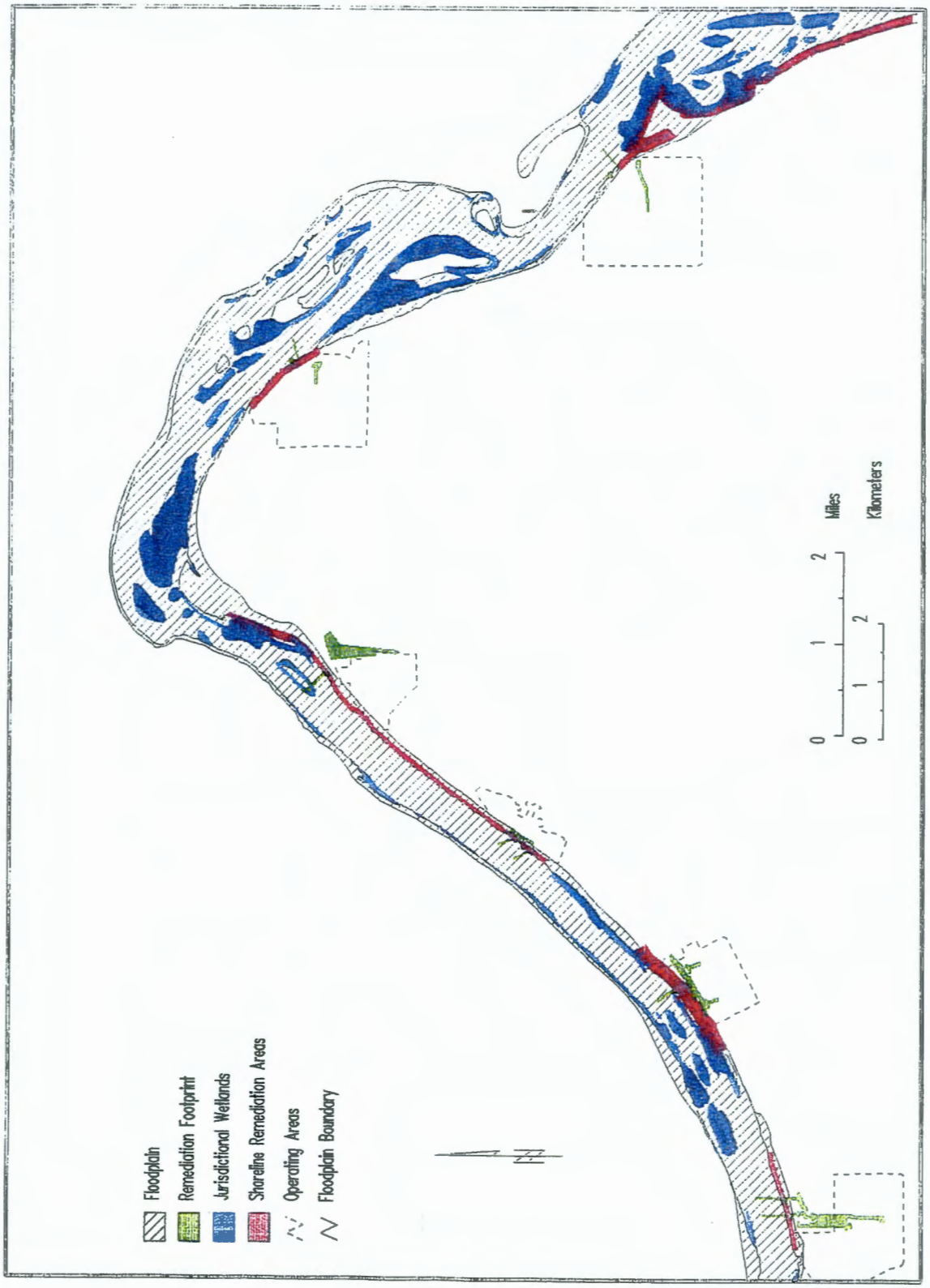
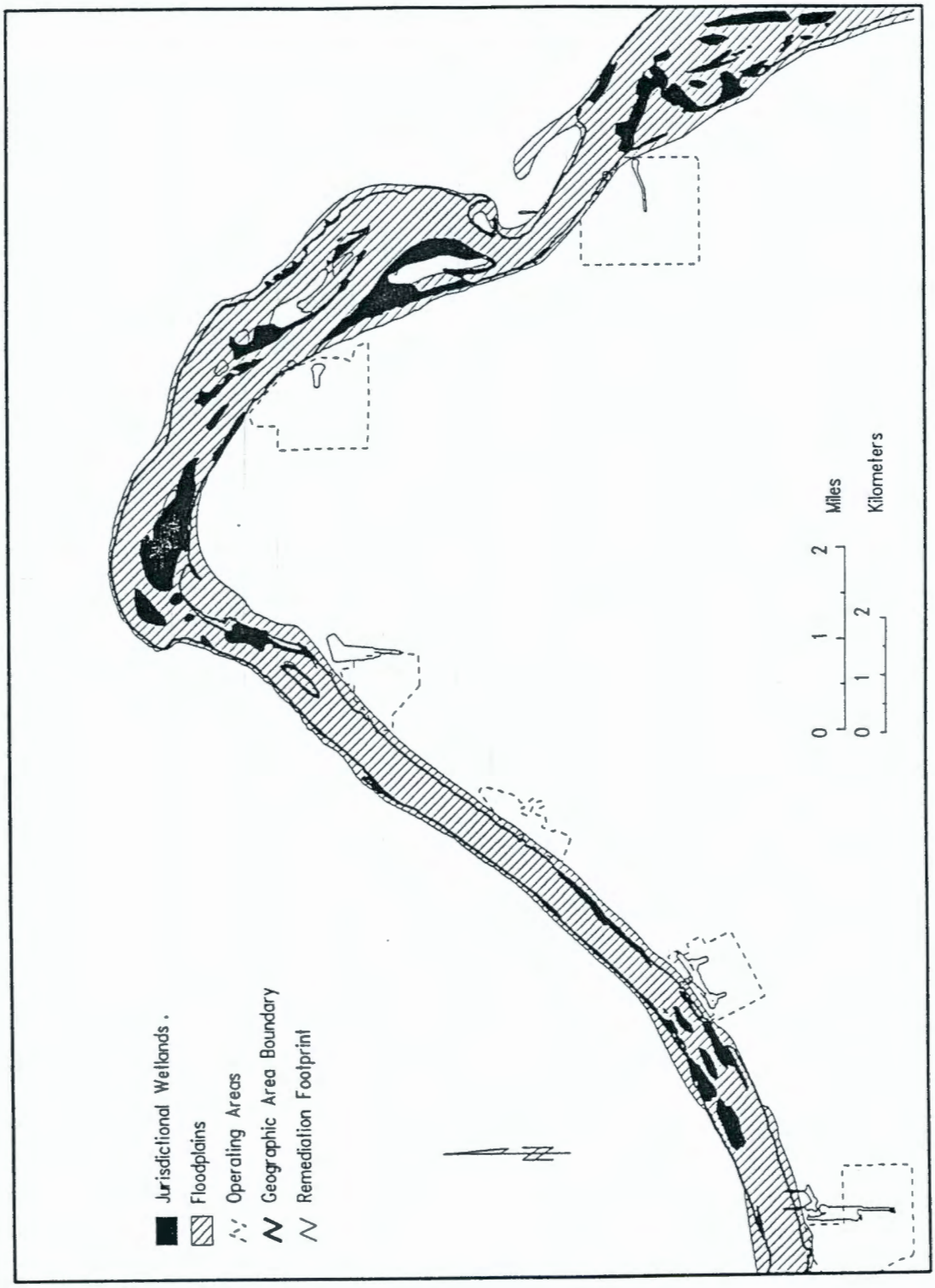


Figure 5-4. 100-Year Floodplain and Wetland Areas Impacted under the Columbia River Restricted Future Land-Use Alternative.



5.2.4 Ecology

The levels of habitat disturbance associated with each alternative are summarized in Table 5-3.

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	11 locations	1 location

[a]Areal impact information was generated from the GIS, and includes potential disturbance associated with excavation, outfall capping, trample zones, and discharge pipeline disposition.

[b]National Wetlands Inventory Data.

[c]Includes bald eagle habitat (roosts and perching locations) within the zone of disturbance.

GIS = geographic information system.

5.2.4.1 Impacts on Ecological Resources from the No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, and the continuation of current environmental monitoring and maintenance activities.

5.2.4.1.1 Aquatic Habitat. The activities conducted under the No-Action Alternative are not expected to significantly impact aquatic habitat in the Columbia River geographic area.

5.2.4.1.2 Wetlands. The activities conducted under the No-Action Alternative would involve minimal disturbance of wetlands.

5.2.4.1.3 Shrub-Steppe Habitat. The No-Action Alternative is not expected to significantly impact shrub-steppe habitat in the Columbia River geographic area.

5.2.4.1.4 Species of Concern. The activities conducted under the No-Action Alternative would be designed to avoid any disturbance of sensitive species.

5.2.4.1.5 Ecological Risk. The No-Action Alternative is not expected to pose unacceptable risks to species or their habitats in the short term. One exception to this is the potential risk to salmon eggs and fry from the presence of hexavalent chromium. In addition, recent environmental monitoring data indicate that Hanford Site operations have resulted in small accumulations of some radionuclides in fish and wildlife. These concentrations, however, do not pose a hazard to the organisms themselves or to humans who might consume them (PNL 1993).

> Bechtel Hanford, Inc. recently attempted to quantify the degree to which fall chinook salmon eggs and other benthic aquatic species are exposed to hexavalent chromium. Studies of the river gravels near the 100-H Area indicate that approximately 10 to 20% of the salmon redds in this region would be exposed to levels of chromium greater than ambient water quality criteria (BHI 1996).

Potential long-term radiological risks to ecological receptors from the No-Action Alternative were evaluated in the ecological risk assessment (Appendix C). Radiation doses caused by potential exposure to radionuclides in the surface water of 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 5.2.3.1.2, with appropriate monitoring and mitigation, the No-Action Alternative is not expected to have an adverse impact on Columbia River water quality or ecological receptors (e.g., aquatic organisms and associated predator species).

5.2.4.1.6 Biodiversity. The No-Action Alternative is not expected to have significant short- or long-term impacts on biodiversity. The existing riverine ecosystem of the Hanford Reach is expected to remain intact and relatively undisturbed. The distribution and proportions of aquatic, wetland, and shrub-steppe habitats associated with the Columbia River, species diversity within those communities, and the abundance and genetic diversity of individual species probably would not be affected.

5.2.4.2 Impacts on Ecological Resources from the Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve the complete excavation and removal of river discharge pipelines, and contaminated riverbank, riverbottom, and island sediments.

5.2.4.2.1 Aquatic Habitat. Removal of river discharge pipelines and associated contaminated sediments would involve disturbance of the riverbottom, and would result in the loss of aquatic plants, riverbottom invertebrate species, and other aquatic lifeforms. Remediation activities could 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 main stem of the Columbia River (NPS 1994). Loss of spawning habitat from 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, which could compromise these fish populations and their ability to reproduce. Additional population losses could result in these species being listed as threatened or endangered under the *Endangered Species Act of 1973*.

5.2.4.2.1.1 Potential Mitigation Measures. Potential mitigation measures for aquatic habitats include:

- limiting activities below the high-water mark to periods of lowest river flow and periods when anadromous fish are not spawning or migrating, and when fish eggs are not present in redds

- consulting with the National Marine Fisheries Service and the Washington State Department of Fish and Wildlife to identify uncontaminated spawning areas to be avoided

- limiting areas of disturbance to minimize resuspension of sediments

- using riprap, biodegradable geotextiles, and other suitable materials to stabilize disturbed areas

- 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.

5.2.4.2.2 Wetlands. 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 5-3). This loss could be significant because of the value of sensitive species and unique wetland plant communities identified in the Hanford Reach (NPS 1994).

5.2.4.2.2.1 Potential Mitigation Measures. Potential mitigation measures for wetlands include:

- identifying uncontaminated wetlands to be avoided

- minimizing disturbance of uncontaminated wetland soils to preserve seed sources for revegetation

- requiring contractor equipment to be cleaned before entering work zones to prevent establishment or spread of undesirable species in remaining wetlands

- replacing damaged wetlands through purchase, construction, or restoration of wetlands.

Wetland mitigation plans would be developed in consultation with the State of Washington, the U.S. Army Corps of Engineers (Corps), and the U.S. Fish and Wildlife Service (USFWS)[2].

5.2.4.2.3 Shrub-Steppe Habitat. 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 5-5). This level of disturbance, representing less than 1% of the shrub-steppe habitat on the Hanford Site, is not expected to be significant. The areas disturbed also could include trees used as perching and roosting sites by bald eagles (see Section 5.2.4.2.4). The disturbed areas could be revegetated with native species.

5.2.4.2.4 Species of Concern. The Unrestricted Future Land-Use Alternative would involve the removal of river discharge pipelines and contaminated sediments. This alternative could adversely affect several species of concern including:

- the bald eagle
- the white pelican
- two mollusk species – the short-face lanx and Columbia pebble snail
- four fish species – the mountain sucker, sand roller, Paiute sculpin, and reticulate sculpin
- the Columbia River tiger beetle
- two plant species – the Columbia yellowcress and northern wormwood.

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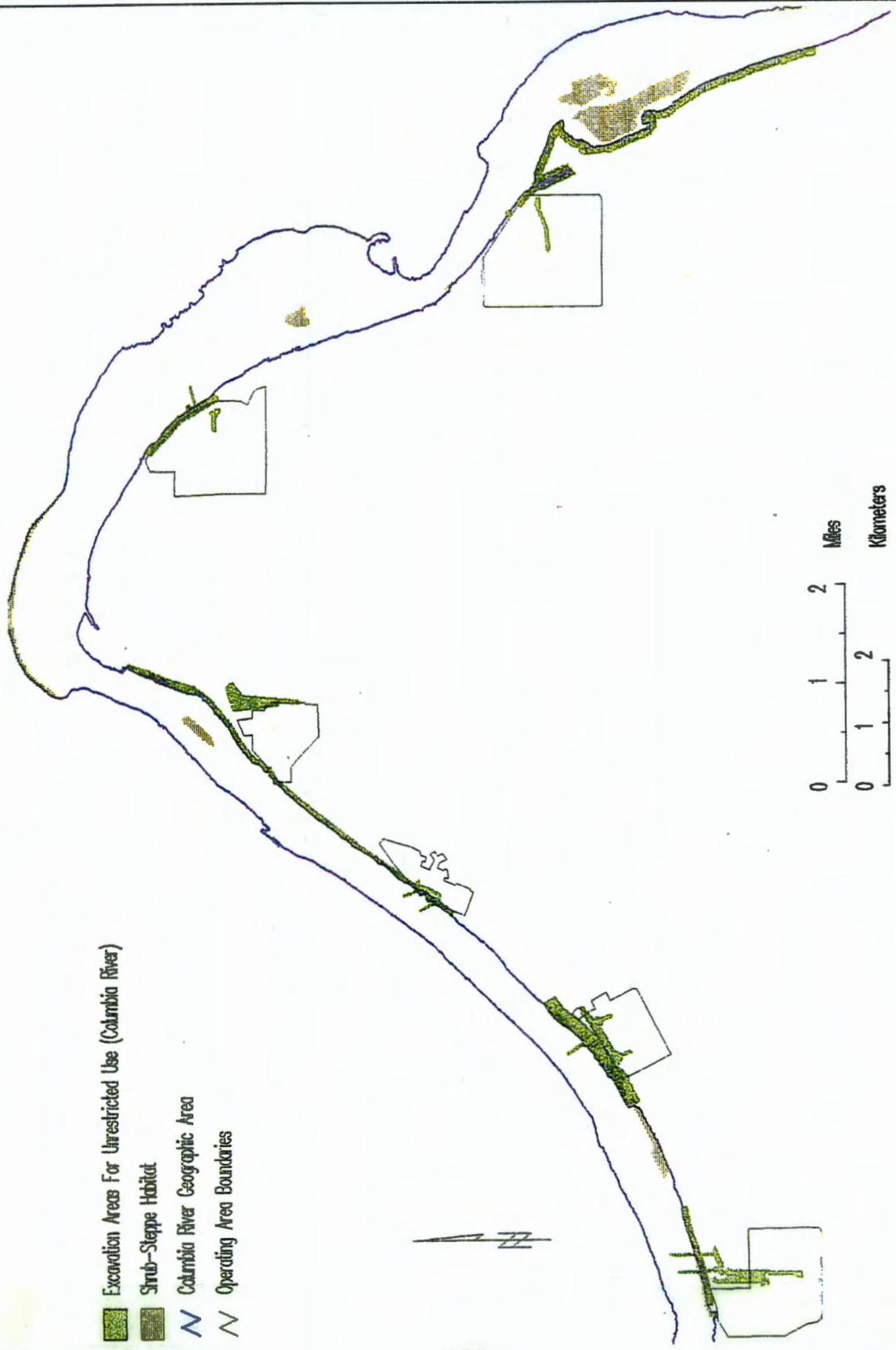
[2]Excavating or filling wetlands as part of a CERCLA remedial action would not require a permit, but would require meeting the substantive requirements of Section 404 of the *Clean Water Act of 1977*. More specific or additional mitigation measures would be negotiated through the CERCLA process.

Figure 5-5. Unrestricted Future Land-Use Alternative Impact on Shrub-Steppe Habitat, Columbia River Geographic Area.



Remediation activities could disrupt bald eagle use along the Hanford Reach, if remediation 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. Species adapted to shrub-steppe habitat (e.g., loggerhead shrikes and sage sparrows) also might be adversely affected. 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. Impacts to these species could result in population losses, which in turn could result in listing as threatened or endangered under the *Endangered Species Act of 1973*.

5.2.4.2.4.1 Potential Mitigation Measures. The potential mitigation measures previously described in Section 5.2.4.2.1.1 for aquatic habitats and in Section 5.2.4.2.2.1 for wetlands would help reduce impacts to species of concern. Additional potential mitigation measures include:

- excluding all disturbance (within the line of sight) within an 800-m (0.5-mi) buffer around winter roosts for bald eagles from November 15 to March 15
- avoiding any habitat alteration (out of the line of sight) 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.

5.2.4.2.5 Ecological Risk. The Unrestricted Future Land-Use Alternative could result in increased short-term risk to ecological receptors as a result of resuspension and transport of contaminated sediments. Remediation would reduce or eliminate long-term ecological risks. 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:

- installing runoff barriers to prevent contaminated sediments from entering the river when remediation activities that disturb soil or sediment along the Columbia River are being conducted
- limiting areas of disturbance below the high-water mark to minimize resuspension of disturbed materials
- using riprap, biodegradable geotextiles, and other suitable materials to stabilize disturbed areas
- supplying alternate municipal water if radiological and chemical concentrations downstream of the remediation activities indicate substantial water quality degradation.

5.2.4.2.6 Biodiversity. 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 could be significant in the short term; long-term impacts to biodiversity could be avoided or reduced through implementation of the mitigation measures previously discussed.

5.2.4.3 Impacts on Ecological Resources from the Restricted Future Land-Use Alternative.

5.2.4.3.1 Aquatic Habitat. The Restricted Future Land-Use Alternative would involve in-place stabilization of the river discharge pipelines. 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 briefly during decommissioning of the river discharge pipelines. Therefore, this alternative is not expected to have substantial impacts on aquatic habitats.

5.2.4.3.1.1 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.

5.2.4.3.2 Wetlands. The Restricted Future Land-Use Alternative would affect less than 0.4 ha (less than 1 ac) of wetlands (see Figure 5-4).

5.2.4.3.3 Shrub-Steppe Habitat. Activities in upland areas under the Restricted Future Land-Use Alternative would be limited to previously disturbed areas, and are not expected to impact the existing shrub-steppe habitat.

5.2.4.3.4 Species of Concern. These activities could impact several species of concern, as discussed under the Unrestricted Future Land-Use Alternative; however, remediation activities 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.

5.2.4.3.4.1 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.

5.2.4.3.5 Ecological Risk. The Restricted Future Land-Use Alternative would involve in-place stabilization of the river discharge pipelines. The activities conducted under the Restricted Future Land-Use Alternative could result in short-term releases of small amounts of contaminants to the Columbia River. Such releases are not expected to significantly increase ecological risks.

5.2.4.3.6 Biodiversity. Under this alternative, disturbance would be limited to areas adjacent to river discharge pipelines. The limited remediation 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 could disrupt ecosystem functions in the short term, no long-term impacts are expected.

5.2.5 Air Quality

5.2.5.1 Impacts on Air Quality from the No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, and the continuation of current environmental monitoring and maintenance activities. Generation of airborne pollutants under the No-Action Alternative would not exceed the amounts currently generated by Hanford Site operations, which meet air quality standards (PNL 1995).

Comparison to Air Quality Standards

Several of the calculated air pollutant concentrations that could be generated during remediation appear to exceed the air quality standards provided for comparison. These concentrations were calculated using SCREEN2, which is a simple EPA model commonly used to determine if a permit can be issued for an emission source without performing complex modeling. The SCREEN2 model has been used to estimate maximum air concentrations of pollutants at downwind locations from an emission sources. More complex models are capable of accounting for factors such as variable wind speeds and directions; however, these were judged unnecessary at this stage, considering the lack of specificity in defining the action.

The calculated air pollutant concentrations are the result of conservative modeling and source-term assumptions with one or more remediation sites contributing to the dispersion plume. The analysis assumed that wind speed and direction would not change over the course of the eight hour day and that no mitigation measures would be implemented. Calculated concentrations represent the maximum concentrations that could be expected during normal daily working hours. Air quality standards are often average levels for longer periods of time (such as average standards for 24 hours/day, 365 days/year). When comparing concentration values and standards, the averaging times need to be considered as follows: a calculated maximum concentration could occur during 2,080 hours of the year [8 hrs/day, 5 days/week]) and comparison to the standard (365 days = 8,760 hours) must consider that the estimated concentration should be multiplied by a factor of 2,080/8,760, or 24%, based solely on averaging time. In addition to accounting for work hours, comparison to annual standards also must consider that excavation of any particular site is not expected to require a full year to complete. When multiple sites were included in the analysis comparison between calculated concentrations and standards, the fire sites were assumed to be linearly aligned with the direction of the wind. Spatial separation of waste sites out of wind alignment would lead to air concentrations at a given location that were less than modeled.

In addition, as stated above, comparing the estimated concentration to the standard assumes that atmospheric conditions, such as wind direction and speed, never change. These parameters effect the concentration of a pollutant at a receptor location, but are not considered in estimating maximum air concentrations. When all of these conservative factors are taken into account, it can be determined that exceeding long-term standards at any particular location is unlikely. These conservative scenarios were used in the analysis in order to bound potential impacts of remediation activities.

Mitigation measures would be implemented during excavation activities. These measures would serve to substantially reduce the air concentrations of pollutants associated with fugitive dust (i.e., PM_{10} and contaminants).

5.2.5.2 Impacts on Air Quality from the Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve the complete excavation and removal of river discharge pipelines, and contaminated riverbank, riverbottom, and island sediments. 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. To ensure that the analysis conservatively estimated the impacts, 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 of this EIS, and concentrations of pollutants downwind from the Hanford Site were projected. The estimated concentrations workers could be exposed to would not exceed applicable standards and guidelines (Table 5-4). The same is true for concentrations the general public could be exposed to.

The concentrations presented in Table 5-4 are consequences of remediation activities at one remediation site. Simultaneous activities at several sites could result in higher concentrations, particularly if the sites were in line and parallel to the wind direction. To account for this possibility, 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 to do not exceed applicable standards or guidelines (Table 5-5). The pollutant concentrations in Table 5-5 represent short-term impacts that would cease when remediation activities are 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 micrometers in size (PM_{10}) were projected by a line source dispersion model, with an assumed 5-m/s (11 mi/hr) wind blowing perpendicular to the direction of the roadway. Figure 5-6 shows the estimated concentrations of dust for traffic flow rates from 5 to 500 trucks/hr.

Substantial 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 round trips. 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.

Substantial air quality impacts are not expected to occur from the Unrestricted Future Land-Use Alternative, because the conservative 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 could be produced by quarrying and excavation of materials for backfilling or construction of caps (see Appendix E). 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, wetting storage piles and haul roads with water or dust suppressants, 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, could 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}[f]	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	150, 24-h average
	carbon monoxide	470	55,000 8-h average	75	9,000, 8-h average
	nitrogen dioxide	730	9,000, 8-h average	120[g]	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 of this EIS. The estimated concentrations of fugitive dust and fuel combustion products do not include background concentrations.

[b]Concentrations immediately downwind from the excavation site are the maximum predicted ground-level concentrations workers could be exposed to.

[c]Occupational standards for fugitive dust and combustion products are Permissible Exposure Limits 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 peak concentrations the general public could be exposed to.

[e]Air quality standards for fugitive dust, CO, and NO_2 are National Ambient Air Quality Standards (40 CFR 50-99). The standards for SO_2 and total suspended particulates are Washington State standards. Guidelines for airborne radionuclides are Derived Concentration Guides listed in DOE Order 5400.5 (DOE 1993a).

[f]PM_{10} = particulate matter less than 10 micrometers in size

[g]The concentration of NO_2 exceeds the air quality standard. All of the estimated concentrations, however, are levels that are expected during normal daily working hours, whereas the air quality standard is an average level during longer periods of time (e.g., during a 365-day year).

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}[f]	660	5,000, 8-h average	160[g]	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	150, 24-h average
	carbon monoxide	790	55,000 8-h average	190	9,000, 8-h average
	nitrogen dioxide	1,200	9,000, 8-h average	300[g]	50, annual average
	sulfur dioxide	170	13,000, 8-h average	40[g]	20, annual average

[a]Procedures and assumptions for estimating concentrations of airborne contaminants are discussed in Appendix G of this EIS. 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 the maximum predicted ground-level concentrations that workers could be exposed.

[c]Occupational standards for fugitive dust and combustion products are Permissible Exposure Limits 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 peak concentrations that the general public could be exposed.

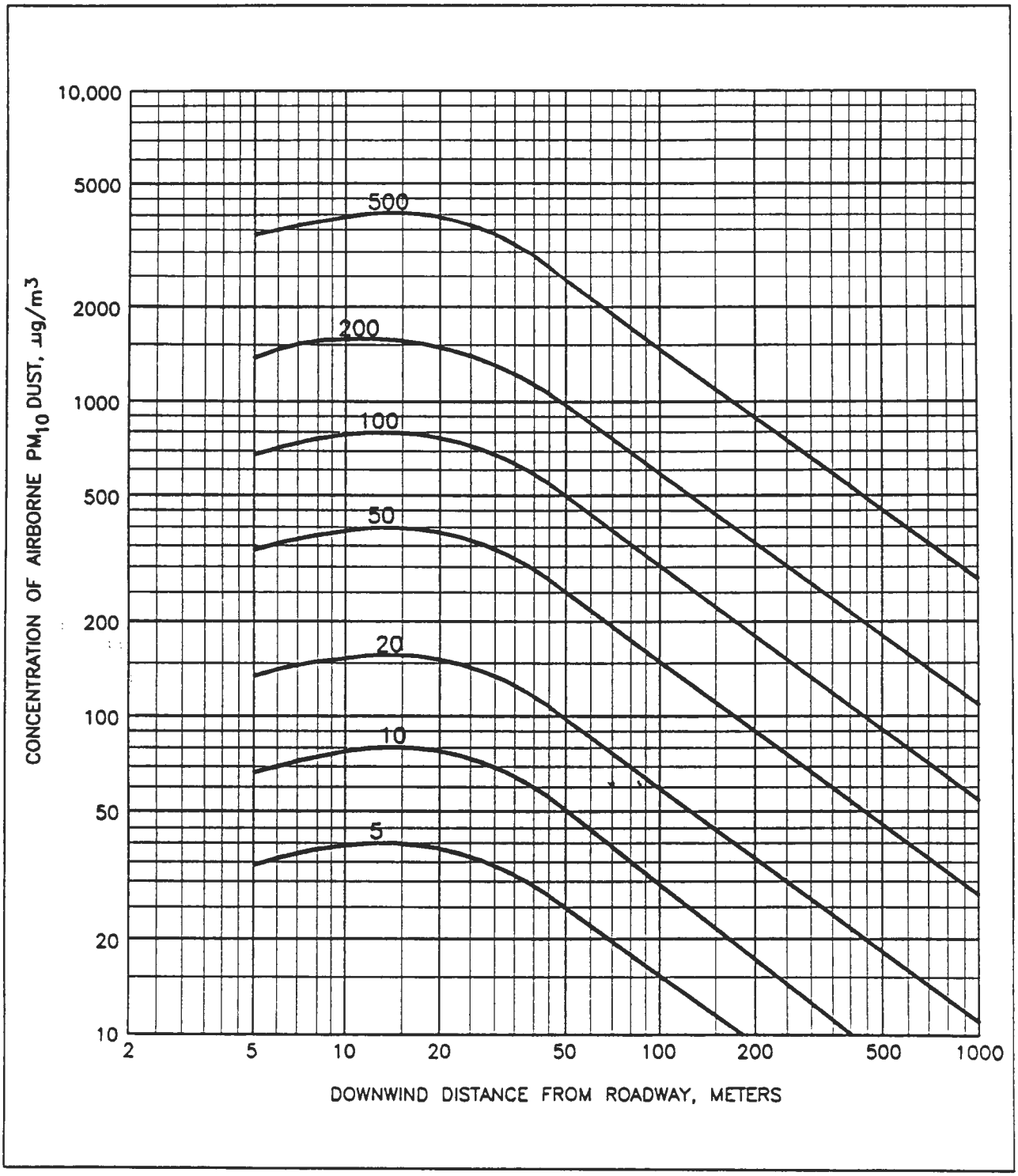
[e]Air quality standards for fugitive dust, CO, and NO_2 are National Ambient Air Quality Standards (40 CFR 50-99). The standards for SO_2 and total suspended particulates are Washington State standards. Guidelines for airborne radionuclides are Derived Concentration Guides listed in DOE Order 5400.5 (DOE 1993a).

[f]PM_{10} = particulate matter less than 10 micrometers in size.

[g]Concentrations of PM_{10}, NO_2 and SO_2 exceed air quality standards. All of the estimated concentrations, however, are levels that are 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).

9613159.2050

Figure 5-6. Concentration of Dust near Haul Roads, 5 to 500 Trucks per Hour.



5.2.5.3 Impacts on Air Quality from the Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would involve in-place stabilization of the river discharge pipelines, and the continuation of institutional controls. Concentrations of airborne pollutants from this alternative would be lower than those presented in Tables 5-4 and 5-5, because less contaminated sediment would be disturbed. The hauling of pipeline stabilization materials from quarry sites and borrow areas would generate similar fugitive dust concentrations as estimated for the Unrestricted Future Land-Use Alternative.

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 Impacts from the No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments and the continuation of current environmental monitoring and maintenance activities. Little or no change in noise impacts to the surrounding environment is expected to occur under this alternative. Sound levels in the ambient environment (which are minimal) are expected to remain the same.

5.2.6.2 Noise Impacts from the Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve the complete excavation and removal of river discharge pipelines, and contaminated riverbank, riverbottom, and island sediments. During removal of river discharge pipes and contaminated riverbank sediments, noisy construction equipment used in the operations could temporarily increase ambient noise levels. Noise levels generated by remediation 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.

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 Impacts from the Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative is not expected to result in 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 Impacts to Cultural Resources from the No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, and the continuation of current environmental monitoring and maintenance activities.

5.2.7.1.1 Archaeological and Historic Resources. 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 to archaeological or historic sites.

Environmental monitoring and maintenance activities would not have a significant impact on archaeological or historic sites in the Hanford Reach. Routine sampling and other activities could be planned to avoid disturbing identified sites. These resources would continue to be protected by public access restrictions.

5.2.7.1.2 Areas of Concern to Native Americans. The No-Action Alternative would involve stabilization of contaminated sediments, and the continuation of 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 adverse impacts on sacred or traditional use areas important to Native Americans. Access to these areas would continue to be restricted because of contamination.

5.2.7.2 Impacts to Cultural Resources from the Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve the complete excavation and removal of river discharge pipelines, and contaminated riverbank, riverbottom, and island sediments.

5.2.7.2.1 Archaeological and Historic Resources. The activities conducted under this alternative could adversely affect 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) (NPS 1988) 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 eligible for 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 multi-component 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 unidentified 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.

5.2.7.2.1.1 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 that have not been evaluated.

- Before any ground disturbance activities, consultations would be conducted with the U.S. Department of Energy, Richland Operations Office (RL) Cultural Resources Program Manager, the Washington State Historic Preservation Office (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 mapping and data recovery do not pose a potential health risk to field investigators.

- Whenever 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 remediation and maintenance activities to create greater awareness and sensitivity for the cultural resources in the area.

5.2.7.2.2 Areas of Concern to Native Americans. The activities conducted under the Unrestricted Future Land-Use Alternative could have adverse impacts on sacred or traditional use areas important to Native Americans. In addition to impacting the archaeological and historic values, as described in Section 5.2.7.2.1, the remediation 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.

Remediation activities temporarily would preclude access to areas where remediation is occurring. This alternative eventually could allow unrestricted access to sacred or traditional use areas important to Native Americans.

5.2.7.2.2.1 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 implementing project activities

- considering recommendations provided by Native American tribal governments and organizations in the development of project-specific cultural resource mitigation plans for proposed remediation activities

- considering recommendations provided by Native American tribal governments and organizations in revegetation plans for disturbed areas

- involving representatives of Native American tribal governments and organizations in archaeological monitoring during remediation activities.

5.2.7.3 Impacts to Cultural Resources from the Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would involve in-place stabilization of the river discharge pipelines, and the continuation of institutional controls.

5.2.7.3.1 Archaeological and Historic Resources. The Restricted Future Land-Use 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.

5.2.7.3.1.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternative are the same as for the Unrestricted Future Land-Use Alternative.

5.2.7.3.2 Areas of Concern to Native Americans. The Restricted Future Land-Use Alternative is not expected to substantially impact 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 substantial impacts on the salmon fishery or other natural resources important to Native Americans.

Because contaminated sediments would remain in place, restrictions on access to sacred or traditional use areas would continue.

5.2.7.3.2.1 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 Impacts on Visual and Aesthetic Resources from No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, and the continuation of current environmental monitoring and maintenance activities. These activities are expected to have minimal impact on visual and aesthetic resources.

5.2.8.2 Impacts on Visual and Aesthetic Resources from the Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve the complete excavation and removal of river discharge pipelines, and contaminated riverbank, riverbottom, and island sediments. Remediation activities could 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 could temporarily 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 remediation 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, could be significant. Once remediated, the riverbank could be restored as close as possible to its former condition, reducing 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 the extent possible
- controlling fugitive dust
- completing remediation in a timely manner
- restoring remediated areas by recontouring excavations to approximate original conditions and revegetating with native species
- conducting restoration activities immediately in remediated areas and contemporaneous with ongoing remediation activities in other areas.

5.2.8.3 Impacts on Visual and Aesthetic Resources from the Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would involve in-place stabilization of the river discharge pipelines, and the continuation of institutional controls. Under this alternative, disturbance would be limited to areas adjacent to river discharge pipelines. This alternative is not expected to have important 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 Impacts from the No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, and the continuation of current environmental monitoring and maintenance activities, and the continuation of institutional controls restricting public access. The No-Action Alternative would have only minimal 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.

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 Impacts from the Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve the complete excavation and removal of river discharge pipelines, and contaminated riverbank, riverbottom, and island sediments. Remediation activities 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 process. The use of good health physics and industrial hygiene practices should ensure that exposures to radioactive and hazardous chemicals, as a result of routine remediation activities, remain below applicable regulatory and administrative limits.

The potential effects of an accidental release of contaminants during remediation activities were evaluated. The accident scenario chosen, which is described in Appendix B of this EIS, involves the accidental release of contaminants in the sediments to the Columbia River. The sediment is transported downstream to offsite receptors and the water treatment facilities in the Tri-Cities. A dose to workers at other locations was not calculated because this scenario does not involve any releases to the atmosphere, and no worker exposure pathway exists. The radionuclide concentrations released are assumed to be the same as the maximum concentrations found in the waste sites in the Reactors on the River geographic area. This conservative assumption was used because data on shoreline contaminants, which are likely to have much 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 probability of this accident occurring ranges from 10^{-2} to 10^{-6} occurrences/year of operations, and would vary with the amount of remediation undertaken. The probability of an accident occurring during remediation to levels allowing unrestricted land use would be more likely than an accident occurring during remediation to restricted land use.

> ***Relating Radiological Dose to Cancer Effects***
>
> The factor used in this EIS to relate a dose to its potential health effect is 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 is assumed to 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).

The results of the accident analysis indicate that only minimal impacts to human health would occur. 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 of 1.5×10^{-3} latent cancer fatalities (LCF) in the exposed population. 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 eventual unrestricted human use.

5.2.9.2.1 Potential Mitigation Measures. Appropriate engineering and administrative measures would be applied during routine remediation 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
- using respiratory protection, when necessary
- limiting exposures to contaminants in accordance with as low as reasonably achievable (ALARA) guidelines and good health physics and industrial hygiene practices.

For protection of the general public, potential mitigation measures include 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 Impacts from the Restricted Future Land-Use Alternative. The accident analysis for the Unrestricted Future Land-Use Alternative is applicable to the Restricted Future Land-Use Alternative (see Section 5.2.9.2). 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 important consequences.

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.

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 Health and Safety

Potential impacts to the health and safety of remediation workers associated with implementing the future land-use alternatives in the Columbia River geographic area were estimated by comparing the field labor hours[3] identified in Appendix H of this EIS for each alternative with Bureau of Labor Statistics and DOE incident rates (DOE 1995k). The estimates assume that all remediation waste is transported by truck for onsite disposal, as truck transport requires more labor than rail transport. Complete documentation of this analysis is presented in Appendix I of this EIS.

5.2.10.1 Occupational Impacts from the 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 from the Unrestricted and Restricted Future Land-Use Alternatives. Table 5-6 presents the potential occupational impacts for the Unrestricted and Restricted Future Land-Use Alternatives for the Columbia River geographic area based on Bureau of Labor Statistics 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 5-7 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 Bureau of Labor Statistics incident rates because 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.

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[3]Labor hours associated with decommissioning and groundwater remediation activities were not included in this analysis.

Table 5-6. Summary of Occupational Impacts Using Bureau of Labor Statistics.

Future Land-Use Alternative (Labor hours)	Estimated Total Cases	Estimated Lost Workday Cases	Estimated Nonfatal Cases Without Lost Workdays	Estimated Lost Workdays
Unrestricted (10,233,386)	696	361	334	9,392
Restricted (213,396)	15	8	7	207

Table 5-7. Summary of Occupational Impacts Using U.S. Department of Energy Statistics for the Unrestricted and Restricted Future Land-Use Alternatives.

Remediation Alternative (Labor hours)	Estimated Total Cases	Estimated Total Fatalities	Estimated Lost Workday Cases	Estimated Lost Workdays
Unrestricted (10,233,385)	194	<1	92	2,640
Restricted (213,396)	4	<1	2	55

As expected, potential occupational impacts are greatest for remediation to unrestricted use because of the greater number of labor hours that would be required under this alternative.

5.2.10.2.1 Potential Mitigation Measures. Potential mitigation measures include continued emphasis on safety awareness and worker training.

5.2.11 Excavation Volumes, Material Requirements, and Costs

The assumptions and methodology used to develop cost estimates for each future land-use alternative are discussed in Appendix H of this EIS. The costs and excavation volumes presented in the following sections include only the remediation of the Columbia River areas adjacent to the reactors in the 100 Areas. The cost analysis is summarized in Table 5-8.

Table 5-8. Comparison of Excavation Volumes, Material Requirements, and Costs Associated with the 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[b] (ha)	0	177	4.1
Projected Cost in 1994 Dollars (millions)	2,424[c]	3,217 (truck haul) 3,404 (rail haul)	54 (truck haul) 59 (rail haul)

[a]Loose Cubic Meter (LCM) = 1.31 Loose Cubic Yard (LCY).
Bank Cubic Meter (BCM) = 1.31 Bank Cubic Yard (BCY).
[b]Totals include riverbed and river bank materials.
[c]Costs for 100 years of institutional control for the entire Hanford Site. The costs are not broken down by geographic area (see Table 5-25).

Costs for remediating contamination along the portion of the Columbia River adjacent to the 300 Area are not included, because investigations indicate that contaminants are not present at concentrations of potential concern. According to the *Remedial Investigation/Feasibility Study Report for the 300-FF-5 Operable Unit* (DOE-RL 1995b), sediments were sampled at several spring sites along the Columbia River. Samples were compared to background concentrations, and concentrations of contaminants detected above background levels were used during the risk-based and regulatory screening performed for the RI report. No compounds were identified in sediments at concentrations that exceeded risk-based or regulatory screening.

5.2.11.1 Excavation Volumes, Material Requirements, and Costs for the No-Action Alternative. The No-Action Alternative would involve stabilization of contaminated sediments, and the continuation of 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. Sitewide 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, for the purposes of this analysis, as much as 10% of the total costs were assumed to be incurred to control access and maintain institutional control in the Columbia River geographic area.

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 Excavation Volumes, Material Requirements, and Costs for the Unrestricted Future Land-Use Alternative. The Unrestricted Future Land-Use Alternative would involve the complete excavation and removal of river discharge pipelines, and contaminated riverbank, riverbottom, and island sediments. Removal of contaminated riverbank sediments could require the excavation of about 10.7 million bank cubic meters (BCM) (14 million bank cubic yards [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.

> ***Presentation of Costs in the National Environmental Policy Act Process.***
>
> The *National Environmental Policy Act of 1969* (NEPA) process evaluates potential impacts of agency actions on the quality of the human environment and, unlike the CERCLA process, cost of the action is not an element of the evaluation. However, NEPA documents frequently provide an estimate of the cost of implementing each alternative under consideration for information purposes.

The portions of the 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 LCM (9,800 LCY) of contaminated soil, equipment, and concrete and 160 LCM (210 LCY) of uncontaminated material could 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 $3.2 billion to $3.4 billion, depending on whether rail or truck hauling is assumed (see Table 5-8). These costs were estimated using the models described in Appendix H of this EIS. Costs include excavation of unsaturated sediments; however, they do not include dewatering saturated sediments or excavating island shorelines or shorelines 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).

Table 5-9. Breakdown of Potential Costs for the Unrestricted Future Land-Use Alternative.

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	1,792	0.7	--	--	--
Surface Water Collection and Control	--	--	--	--	--
Decommissioning	--	--	36	--	--
Solids Collection and Disposal	666	0.2*	0.2	--	--
Site Restoration	346	0.2	--	--	--
Demobilization	--	--	0.1	--	--
Total Costs	2,804	1.2	36.7	376	563
Fuel Use (millions) L	100	0.08	2.2	91	30
(gal)	(27)	. (0.02)	(0.6)	(24)	(8)
Labor Hours (millions)	9.5	0.006	0.035	4.0	2.2

*Includes ERDF disposal costs.
D&D = decommissioning.
ERDF = Environmental Restoration Disposal Facility.

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 Columbia River geographic area. These new technologies may include *in-situ* treatments, which could significantly reduce the volumes of contaminated soils requiring excavation and disposal.

5.2.11.3 Excavation Volumes, Material Requirements, and Costs for the Restricted Future Land-Use Alternative. The Restricted Future Land-Use Alternative would involve in-place stabilization of the river discharge pipelines, and the continuation of institutional controls. The land-based portions of the river discharge pipeline would be capped. The total volume of pipeline capping materials required for the Restricted Future Land-Use Alternative of the Columbia River geographic area is summarized in Table 5-10.

Required capping volumes are based on the reference cap design (Appendix E). The estimated cost for remediating the Columbia River geographic area under the Restricted Future Land-Use Alternative is $54 million with truck transport or $59 million with rail transport (Table 5-11).

5.2.11.3.1 Potential Mitigation Measures. Mitigation measures to reduce the volumes of capping materials required for the land-based portion of the 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 instead of the reference cap design. 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 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).

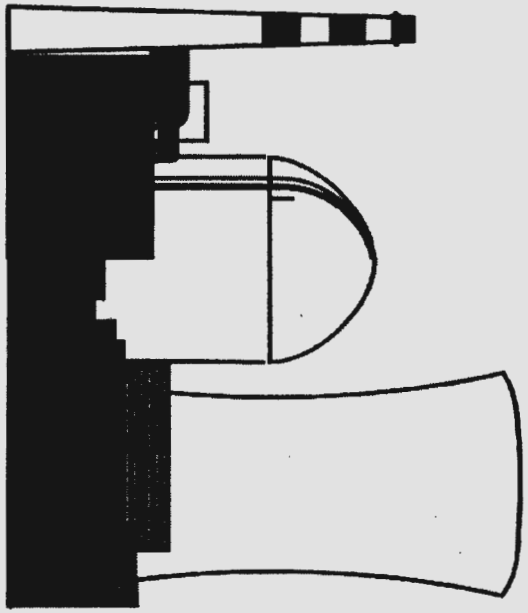
Table 5-10. Volumes of Capping Materials Required for the Restricted Future Land-Use Alternative.

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.

Resource	Project Cost in 1994 Dollars (millions)			
	Pipelines	Waste Sites	Transportation	
			Truck	Rail
Mobilization and Preparatory Work	0.8	0.2	--	--
Monitoring, Sampling, and Analysis	2.4	0.6	--	--
Surface Water Collection and Control	0.03	0.01	--	--
Solids Collection and Control	13.8	3.4	--	--
Site Restoration	18.3	4.1	--	--
Demobilization	0.2	0.04	--	--
Total Costs	35.5	8.3	10.1	15.2
Fuel Use (millions) L (gal)	1.2 (0.3)	0.3 (0.08)	2.4 (0.6)	0.8 (0.2)
Labor Hours (millions)	0.1	0.03	0.1	0.06



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Reactors on the River

5.3 Reactors on the River Geographic Area

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

Extensive contamination exists in some portions of the Reactor on the River surface soils, subsurface soils, and groundwater. This contamination resulted from the operation of the plutonium production reactors located in this area. Groundwater contamination concentrations exceed EPA drinking water standards for some contaminants. Contamination has reached the Columbia River from the 100 Areas through groundwater seepage.

The scope of the proposed actions in the Reactors on the River geographic area includes the past-practice waste sites, TSD units, 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 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. The impacts and potential mitigation measures are summarized in Chapter 3.0, Table 3-13.

5.3.1 Geology

5.3.1.1 Impacts on Geological Resources from the No-Action Alternative. Under the No-Action Alternative, the past-practice waste sites, effluent lines, TSD units, and surplus 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 short- or long-term adverse impacts. Continued environmental monitoring and maintenance activities should not have significant impact on the geologic resources of the Reactors on the River geographic area.

5.3.1.2 Impacts on Geological Resources from the 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 BCY) 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 short- or long-term adverse impacts on development of geologic resources. Complete removal of contamination under this alternative could allow for the eventual relaxation of these access restrictions.

Geologic features relevant to the study of the regional 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 should 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.

5.3.1.3 Impacts on Geological Resources from the 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.

Estimated waste volumes to be excavated 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 geologic resources. As in the No-Action Alternative, such access restrictions are not expected to have adverse impacts. Disturbance of geologic features under this alternative would not be significant.

Restricted Future Land-use Alternative (R1): Excavation Assumptions

Under this alternative, the desired remediation levels for waste sites would be determined through the CERCLA process, using the applicable exposure scenario (i.e., recreational, residential, or industrial). Excavation and removal of contaminated past-practice waste sites and effluent lines would proceed until the contaminant concentrations remaining in the soils meet the desired remediation levels.

Because the extent of excavation remains to be determined, it was necessary to make assumptions to estimate excavation volumes for this analysis. The maximum excavation depth was assumed to be 4.6 m (15 ft) below the ground surface. This value, which is based on the State of Washington's *Model Toxics Control Act of 1989*, was combined with Waste Information Data System data to calculate volumes to be excavated under this alternative. The models used to calculate volumes are described in greater detail in Appendix H.

5.3.1.4 Impacts on Geological Resources from the 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 units, 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 could result in depletion of the geologic resources of quarry and borrow sites. The depletion of geologic resources for quarry and borrow sites is discussed in Section 5.11 as an irreversible and irretrievable commitment of resources.

This alternative would involve the long-term continuation of existing restrictions on public access to geologic resources, because contamination would be left in place. As in the No-Action Alternative, such access restrictions are not expected to have adverse 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.

5.3.1.4.1 Potential Mitigation Measures. If excavation activities are expected to adversely affect geologic features, such as bergmounds or ripple marks, researchers could be invited to make observations before and during excavation so that the scientific value of the features would not be lost.

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.

Table 5-12. Soils Disturbed under Reactors on the River Geographic Area Future Land-Use Alternatives.*

Soil Types	No Action ha (ac)	Unrestricted ha (ac)	Restricted	
			R1 ha (ac)	R2 ha (ac)
Quincy (Rupert) sand	16 (41)	63 (158)	58 (145)	48 (120)
Burbank loamy sand	15 (38)	66 (166)	63 (157)	66 (165)
Ephrata sandy loam	21 (53)	74 (184)	53 (132)	68 (171)
Ephrata stony loam	29 (73)	149 (373)	135 (336)	125 (312)
Pasco silt loam	<1 (2.5)	0.8 (2)	0.8 (2)	1 (3)
Riverwash	3 (8)	8 (21)	7 (17)	8 (21)
Total	85 (213)	361 (903)	315 (788)	317 (791)

*Areal impact information generated from the GIS; includes area disturbed for excavation, trample zones, effluent lines, and haul roads.

GIS = geographic information system.

5.3.2.1 Impacts on Soils from the 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 could include some soil compaction and added potential for wind and water erosion. Long-term impacts should be minimal if appropriate mitigation measures were implemented. Continued environmental monitoring and facility maintenance activities are not expected to significantly impact the soils.

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 Impacts on Soils from the 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 units, decommissioning of surplus facilities, and groundwater remediation. This alternative could have adverse impacts on soils in the Reactors on the River geographic area. Approximately 361 ha (903 ac) could be disturbed. The use of heavy equipment (e.g., bulldozers, scrapers, and trucks) could compact soils at waste sites. Soil compaction could cause increased water runoff during storm events, resulting in less infiltration of water into the soil. Compaction also could 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 could increase soil erosion. The use of heavy equipment, particularly in undisturbed shrub-steppe habitat adjacent to waste sites, could 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 established 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 Impacts on Soils from the 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 units, decommissioning of surplus facilities, and groundwater remediation, combined with institutional controls. Remediation to restricted use (R1) could have adverse impacts on soils in the Reactors on the River geographic area. Remediation activities could disturb approximately 315 ha (788 ac), and could 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 Impacts on Soils from the 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 units, and groundwater remediation, combined with institutional controls. Remediation to restricted use (R2) could have adverse impacts on soils in the Reactors on the River geographic area.

Remediation activities would disturb approximately 317 ha (791 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 Impacts on Water Resources from the No-Action Alternative.

5.3.3.1.1 Groundwater. The No-Action Alternative would involve no treatment of existing groundwater contamination, and would not have short-term impacts on groundwater. Over the long term, groundwater contamination plumes could migrate to uncontaminated areas, and eventually 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 also have been detected. 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 to groundwater is not expected to be significant under existing conditions. Although natural groundwater recharge rates at the Hanford Site have not been definitively determined, the rates 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). Annual precipitation at the Hanford Site averages 16.1 cm (6.3 in.).

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, the contaminants would be diluted to low concentrations by mixing with the groundwater. In some locations, the presence of these contaminants could extend natural attenuation times for groundwater.

5.3.3.1.2 Surface Water. 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. These impacts could be reduced 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 (see Section 4.2.1.1). Natural shoreline erosion also could mobilize contaminated sediments. However, this process is very slow and is not expected to 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 1994 were tritium, strontium-90, iodine-129, plutonium and uranium (PNL 1995). However, current radionuclide concentrations in Columbia River water are below applicable drinking water standards (Table 5-13). Because water quality is not expected to deteriorate, downstream surface water supplies for municipal and other uses would not be affected.

Table 5-13. Annual Average Concentrations of Radionuclides in the Columbia River (PNL 1995).

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* (μg/L)
Tc-99	0.02	0.05	900
I-129	4.3×10^{-5}	7.7×10^{-5}	0.48

*Proposed.
EPA = U.S. Environmental Protection Agency.

Environmental monitoring and maintenance activities under the No-Action Alternative are not expected to adversely impact water quality in the Columbia River.

5.3.3.1.3 Floodplains. The No-Action Alternative is not expected to adversely affect 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 5-7). This area 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.

> Floodplains and wetlands impacts are discussed further in the Floodplain/Wetlands Assessment (Appendix J)

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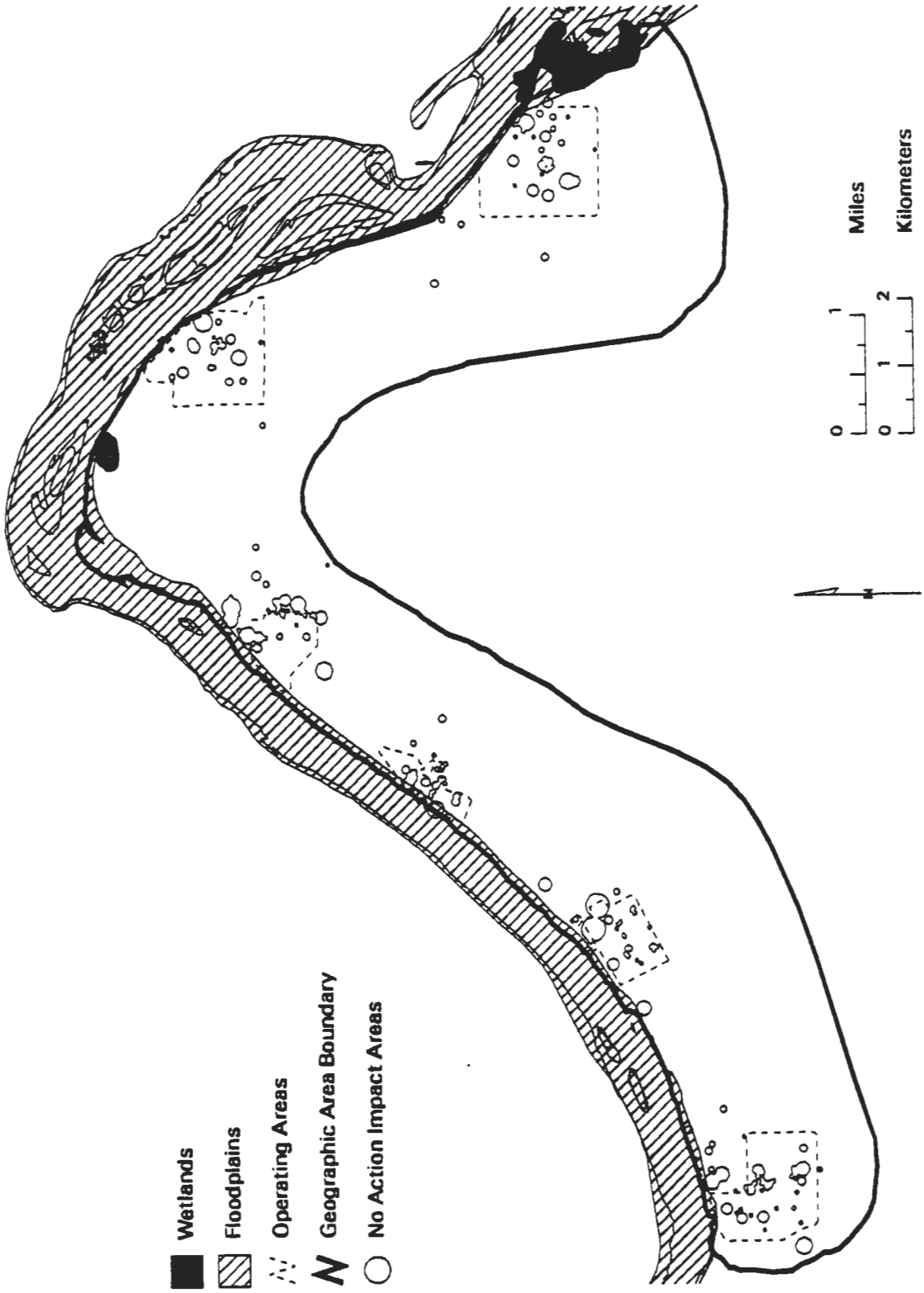
Figure 5-7. 100-Year Floodplain and Wetland Areas Impacted under the Reactors on the River No-Action Alternative.



5.3.3.2 Impacts on Water Resources from the Unrestricted Future Land-Use Alternative.

5.3.3.2.1 Groundwater. The Unrestricted Future Land-Use Alternative would involve groundwater remediation to reduce contamination to levels that would not preclude any human use. Groundwater remediation would include excavating contaminated soils to remove potential contaminant sources and pumping and treating groundwater plumes within the Reactors on the River geographic area to reduce contamination to acceptable levels under the agricultural exposure scenario.

Pumping and treating groundwater in the Reactors on the River geographic area could result in the localized drawdown of the water table and temporary changes in direction of groundwater flow. These effects would have only minimal impacts on groundwater, as groundwater use during remediation activities would continue to be restricted by contamination levels. Additionally, this alternative could require injecting treated groundwater back into the aquifer, resulting in groundwater mounds which could also potentially alter the directional flow of the groundwater. See Appendix D for additional information about disposal options for treated groundwater effluent. Groundwater remediation under the Unrestricted Future Land-Use Alternative is expected to have beneficial effects on groundwater, eventually allowing any human use.

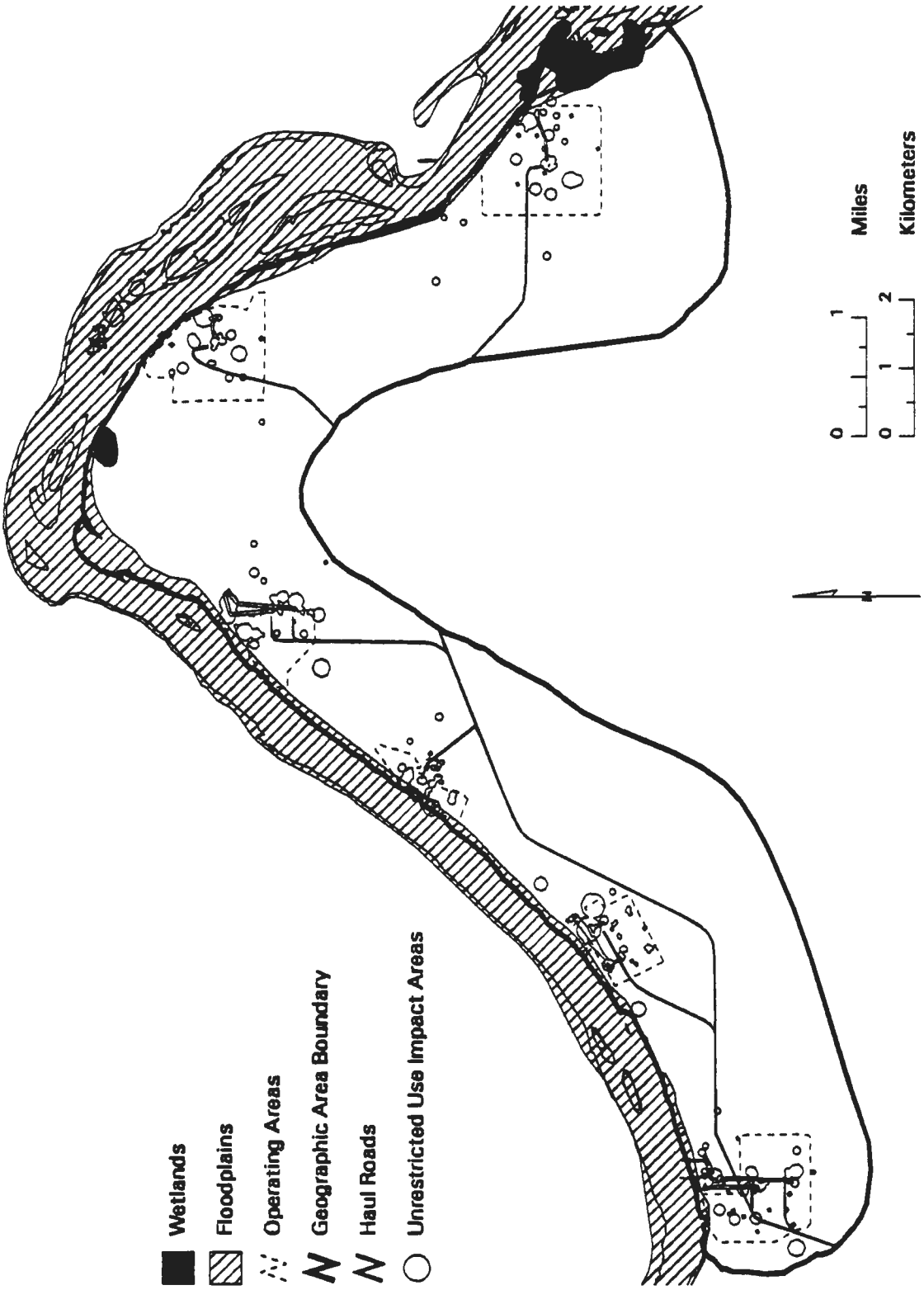
5.3.3.2.2 Surface Water. Groundwater remediation under the Unrestricted Future Land-Use Alternative should not adversely affect the water quality or flow characteristics of the Columbia River. Because protection of the Columbia River and its associated ecosystems would be a primary goal of groundwater 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 desired remediation levels 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.

Groundwater remediation could require discharge of treated effluent to the river. See Appendix D for details on options for the discharge of treated groundwater. The effluent may not have the same composition as normal groundwater because of the chemical effects of the treatment. Calculations presented in Appendix D indicate that no significant impacts to aquatic ecosystems or downstream users are anticipated.

5.3.3.2.3 Floodplains. Remediation to unrestricted use would involve disturbance of 14 ha (35 ac) of the Columbia River 100-year floodplain (Figure 5-8). This area 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 affect floodplain functions.

Figure 5-8. 100-Year Floodplain and Wetland Areas Impacted under the Reactors on the River Unrestricted Future Land-Use Alternative.



5.3.3.3 Impacts on Water Resources from the Restricted Future Land-Use Alternative (R1).

5.3.3.3.1 Groundwater. Remediation to restricted use (R1) would involve groundwater remediation, as described under the Unrestricted Future Land-Use Alternative. This alternative is not expected to have 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 could remain in place at waste sites. The removal of vegetation cover during remediation activities could temporarily increase the rate of contaminant migration to the groundwater. Some of the more mobile contaminants could reach groundwater under these conditions. These contaminants are likely to reach groundwater during the pump-and-treat phase and could be removed.

5.3.3.3.2 Surface Water. 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, the contaminants that reach groundwater probably would be removed by the groundwater remediation system and would not affect water quality in the Columbia River. As with the Unrestricted Future Land-Use Alternative, groundwater remediation could require (discharge of treated effluent to the river). See Appendix D for details on options for the discharge of treated groundwater.

5.3.3.3.3 Floodplains. Remediation to restricted use (R1) would involve disturbance of 15 ha (36 ac) of the Columbia River 100-year floodplain (Figure 5-9). This area 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 affect floodplain functions.

5.3.3.4 Impacts on Water Resources from the Restricted Future Land-Use Alternative (R2).

5.3.3.4.1 Groundwater. Remediation to restricted use (R2) would involve groundwater remediation, as described under the Unrestricted Future Land-Use Alternative. Groundwater remediation under this alternative could 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 is not expected to have adverse impacts on groundwater, and would have beneficial impacts over the long term.

5.3.3.4.2 Surface Water. Remediation to restricted use (R2) would involve construction of caps over waste sites and groundwater remediation. Groundwater remediation would have impacts similar to those described for the Restricted Future Land-Use Alternative (R1). 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 cap construction.

5.3.3.4.3 Floodplains. Remediation to restricted use (R2) would involve disturbance of 9 ha (21 ac) of the Columbia River 100-year floodplain (Figure 5-10). 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 affect floodplain functions.

Figure 5-9. 100-Year Floodplain and Wetland Areas Impacted under the Reactors on the River Restricted Future Land-Use Alternative (R1).

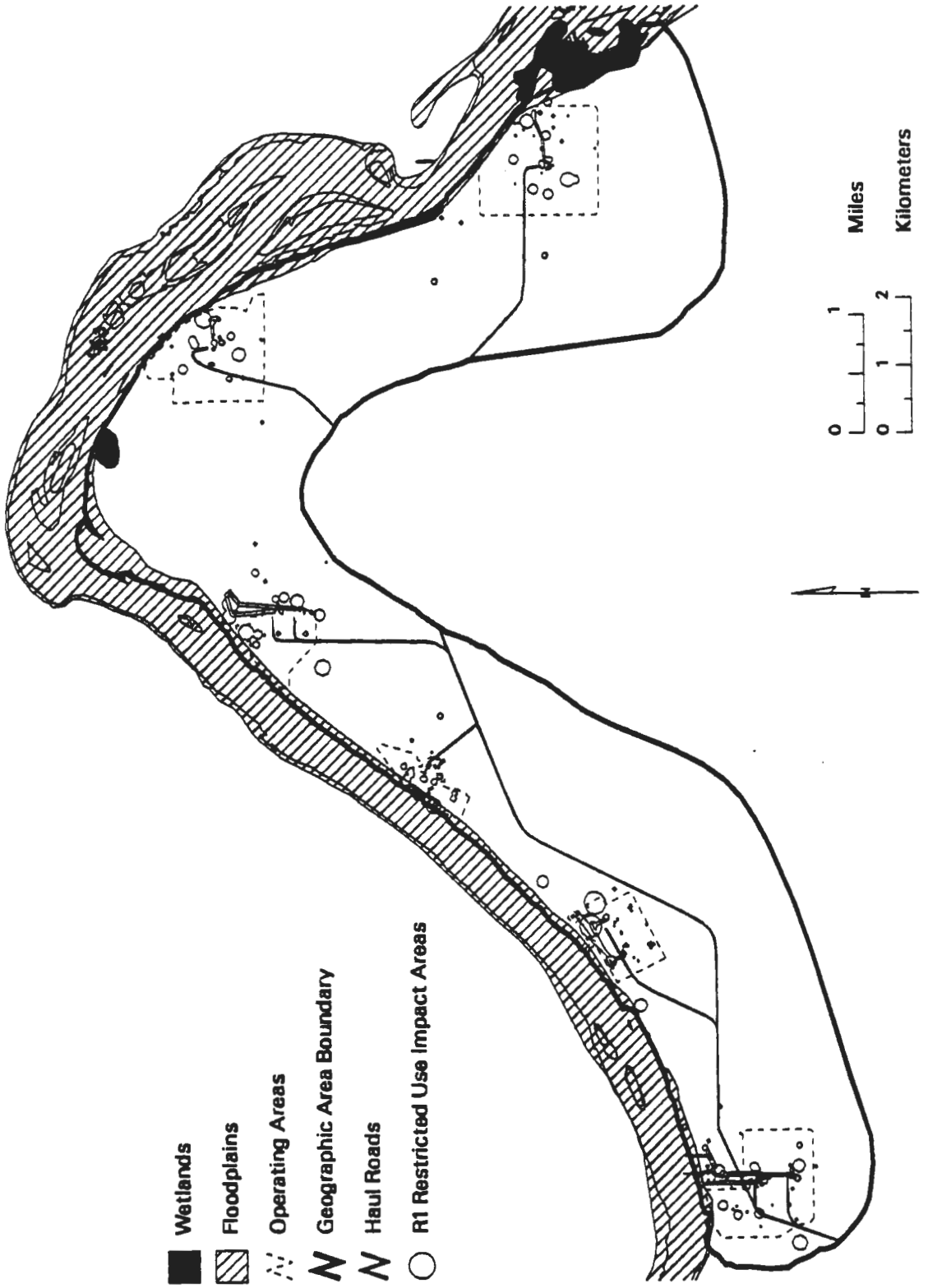
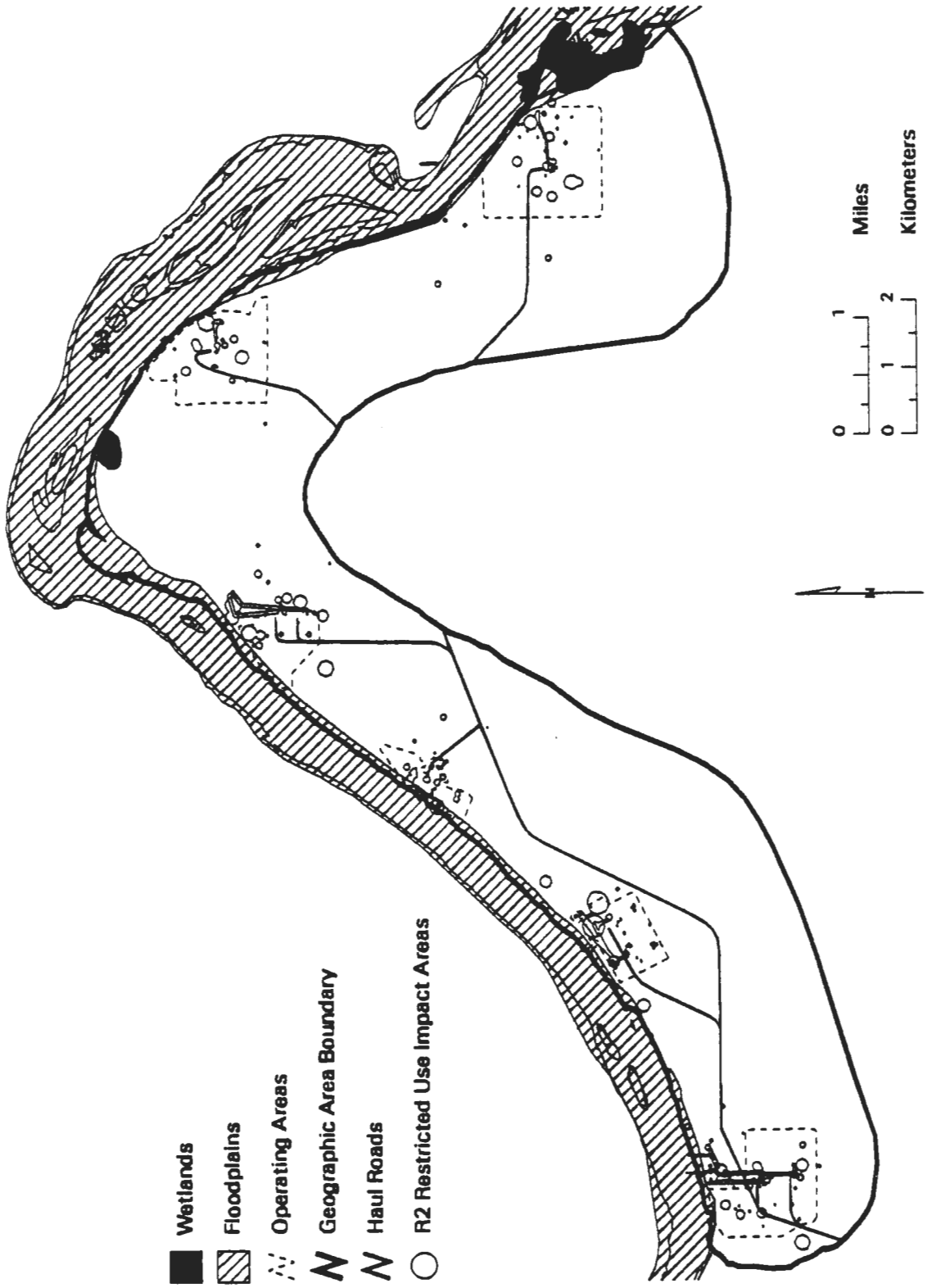


Figure 5-10. 100-Year Floodplain and Wetland Areas Impacted under the Reactors on the River Restricted Future Land-Use Alternative (R2).



5.3.4 Ecology

The levels of habitat disturbance associated with each alternative are summarized in Table 5-14.

Table 5-14. 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)	29 ha (71 ac)	27 ha (68 ac)	28 ha (70 ac)
Species of Concern[b]	1	5	5	2
Wetlands[c]	1 ha (4 ac)	5 ha (12 ac)	4 ha (11 ac)	3 ha (8 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.
GIS = geographic information system.

5.3.4.1 Impacts on Ecological Resources from the No-Action Alternative.

5.3.4.1.1 Wetlands. 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 1 ha (4 ac) of wetlands would be disturbed (see Figure 5-7). Environmental monitoring and maintenance activities would involve only minimal disturbance of wetlands.

5.3.4.1.2 Shrub-Steppe Habitat. The No-Action Alternative would involve surface decontamination and/or stabilization of waste sites (see Section 3.3.1) which 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 5-11). Environmental monitoring and maintenance activities would involve only minimal disturbance of shrub-steppe habitat.

5.3.4.1.3 Species of Concern. Surface decontamination and waste site stabilization activities under the No-Action Alternative could affect a ground perch site infrequently used by bald eagles. Disruption of winter roosting activity along the Columbia River might occur, but could be mitigated. No other species of concern are expected to be affected by the No-Action Alternative.

5.3.4.1.3.1 Potential Mitigation Measures. Potential mitigation measures for bald eagle habitat include: excluding all disturbance within an 800-m (0.5-mi) buffer around winter roosts for bald eagles from November 15 to March 15 and avoiding any habitat alteration within 400 m (0.25 mi) of bald eagle roosts (Fitzner et al. 1994).

5.3.4.1.4 Ecological Risk. 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 hazard

Figure 5-11. No-Action Alternative Impacts on Shrub-Steppe Habitat, Reactors on the River Geographic Area.

index for ecological receptors in the Reactors on the River geographic area ranged from 2.96 x 10^{-8} to 2.70 x 10^{4} (Table 5-15). All hazard index 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 5-16), the level below which radiation exposure is not considered harmful to terrestrial organisms (IAEA 1992). The distribution of these potential exposures for the entire Hanford Site is shown on Figures 5-12 through 5-19.

Table 5-15. Chemical 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 scientific notation for brevity. In scientific 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 a hazard index greater than 1.0.

Table 5-16. 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 scientific notation for brevity. In scientific 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 doses greater than 0.1 rad/d.

Figure 5-12. Distribution of Chemical Hazard Indices for a Generic Plant at the Hanford Site.

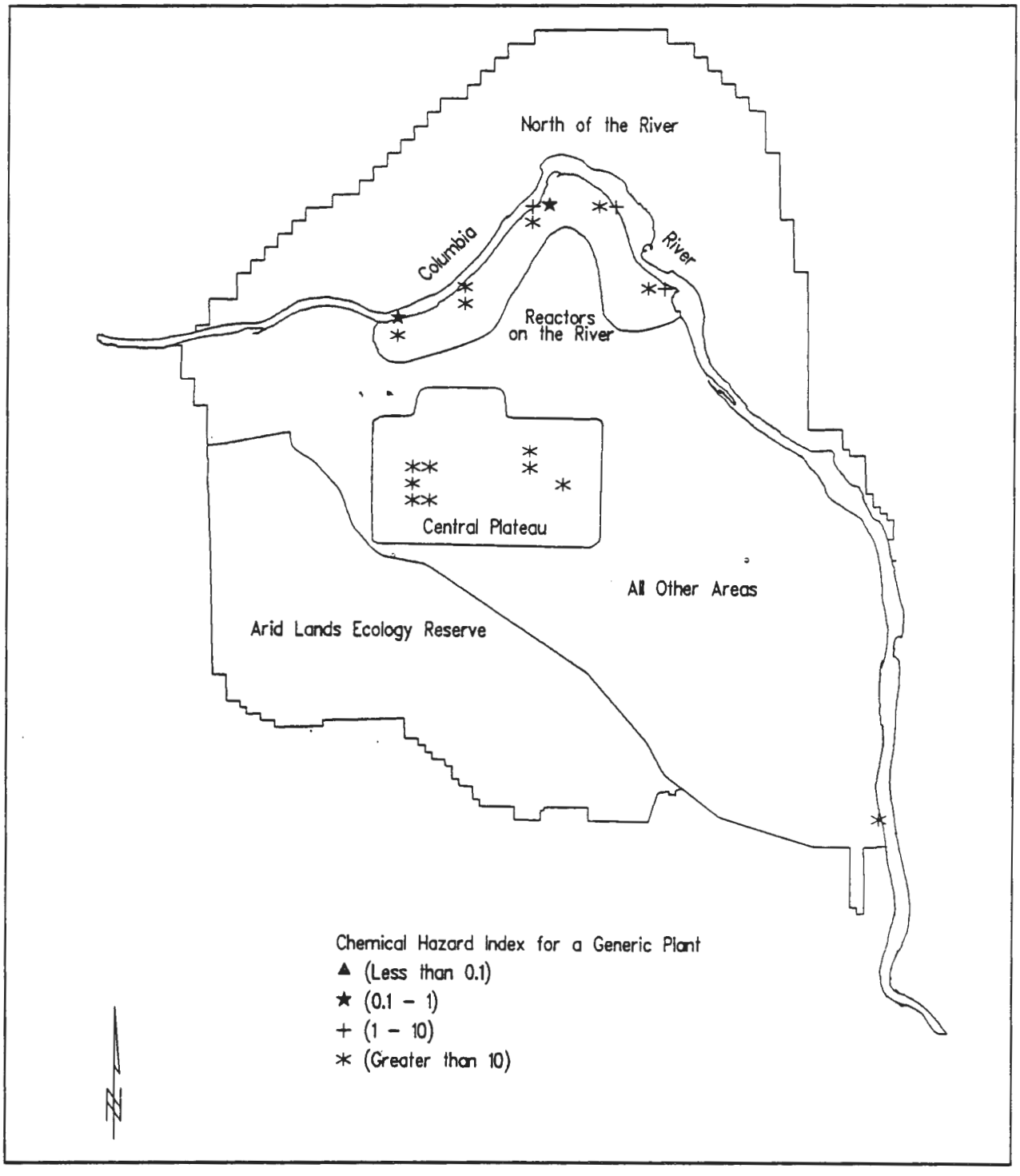


Figure 5-13. Distribution of Chemical Hazard Indices for a Great Basin Pocket Mouse at the Hanford Site.

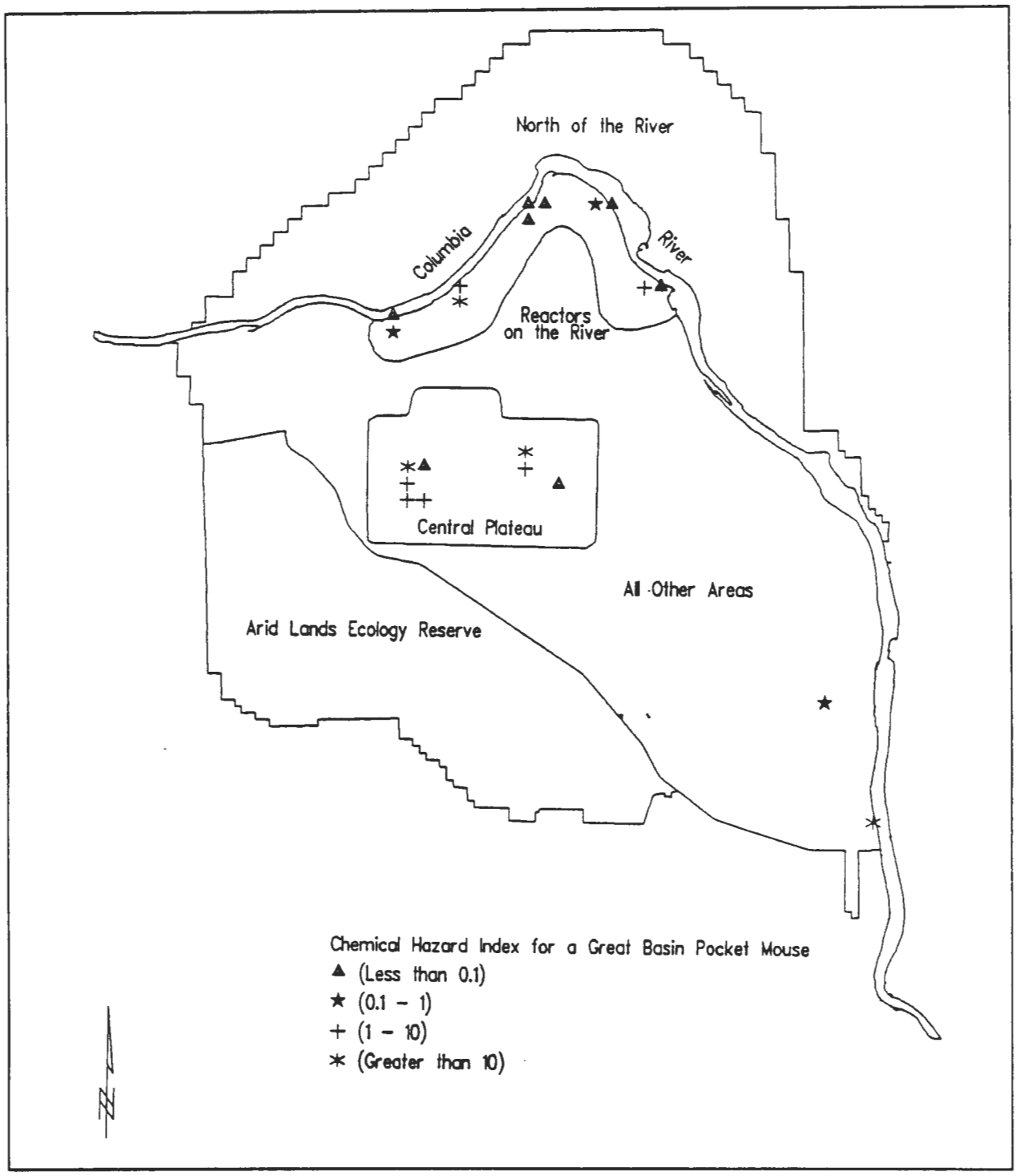


Figure 5-14. Distribution of Chemical Hazard Indices for a Coyote on the Hanford Site.

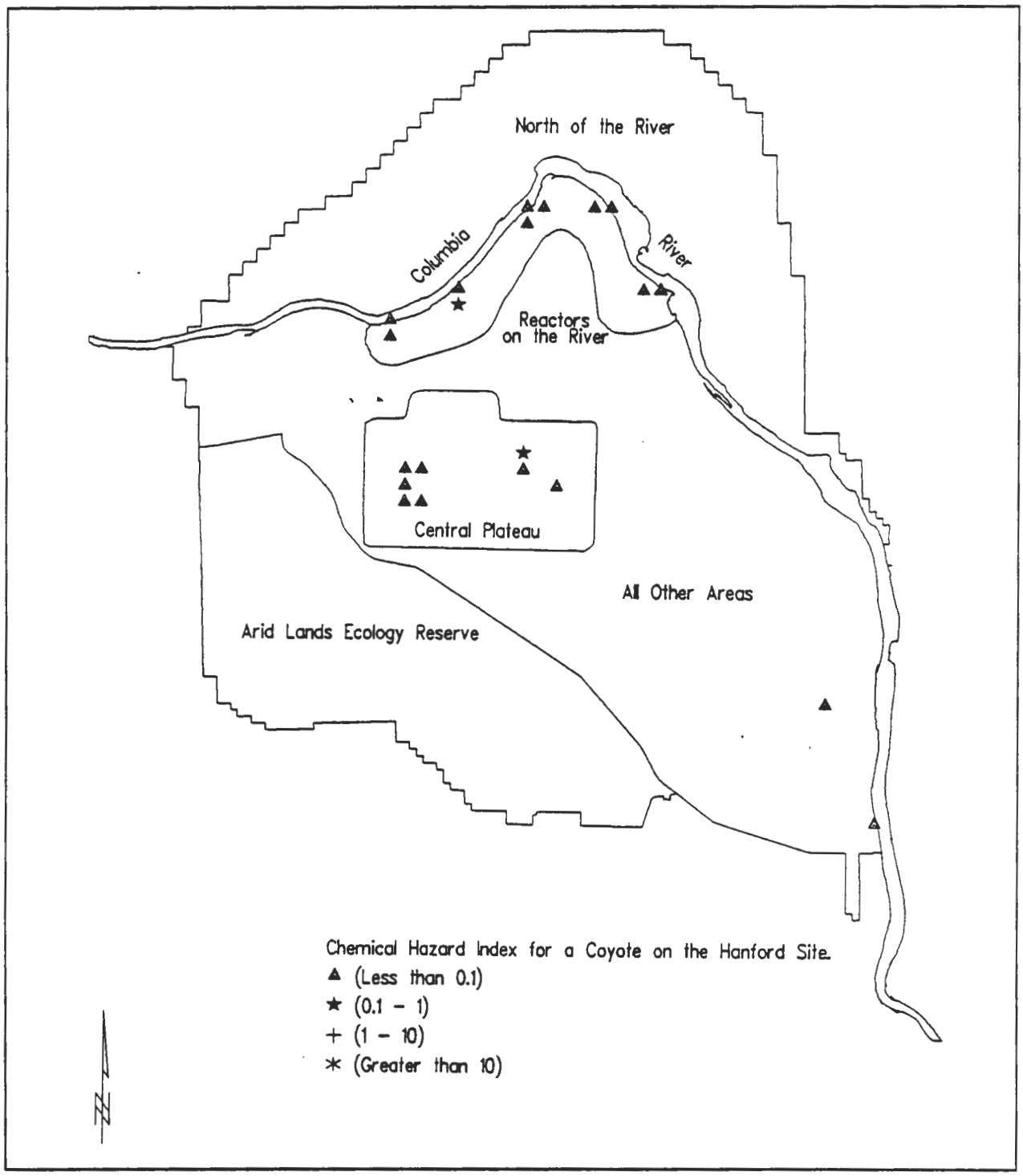


Figure 5-15. Distribution of Chemical Hazard Indices for a Red-Tailed Hawk on the Hanford Site.

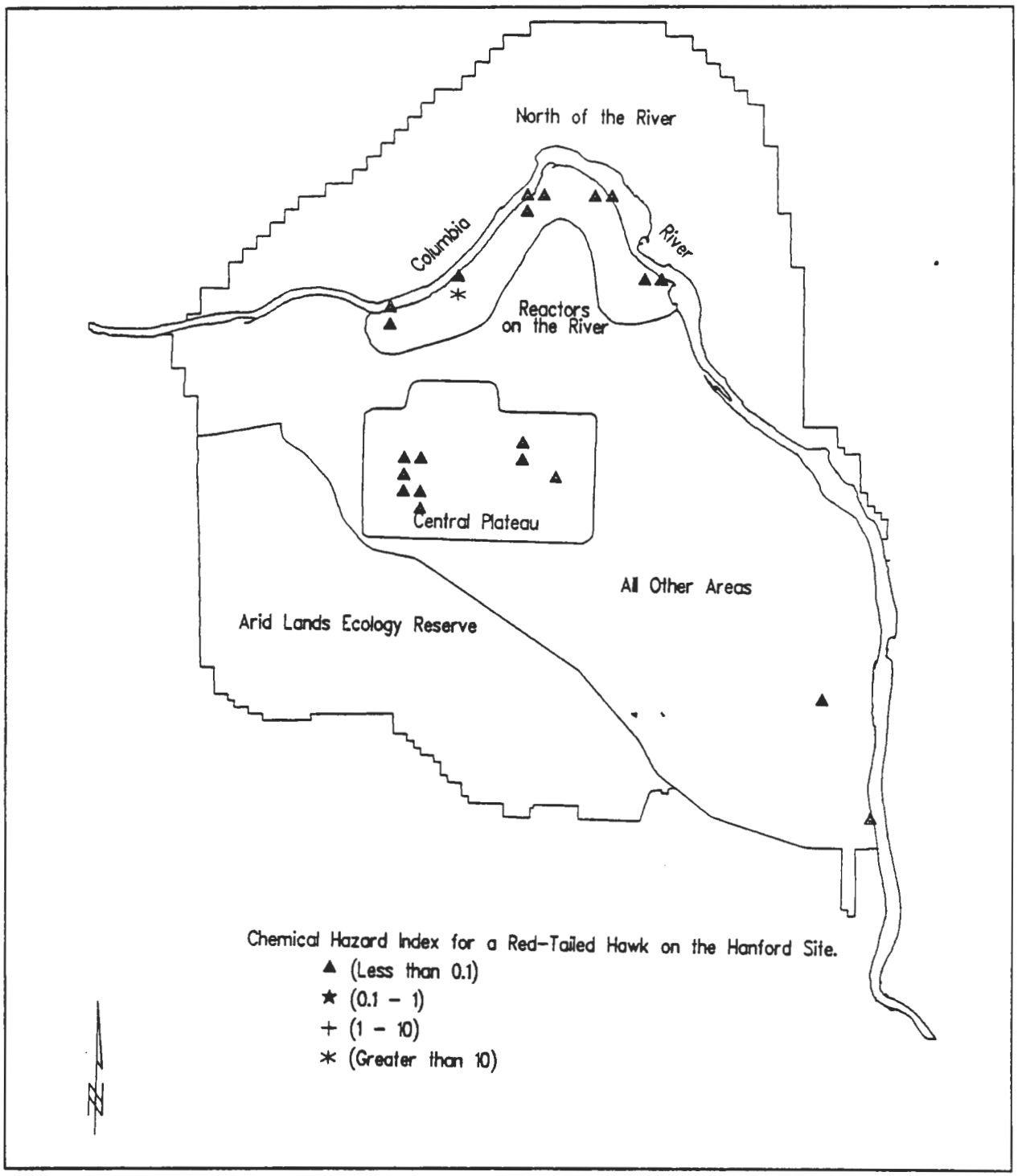


Figure 5-16. Distribution of Estimated Radiation Doses (Rads/day) for a Generic Plant at the Hanford Site.

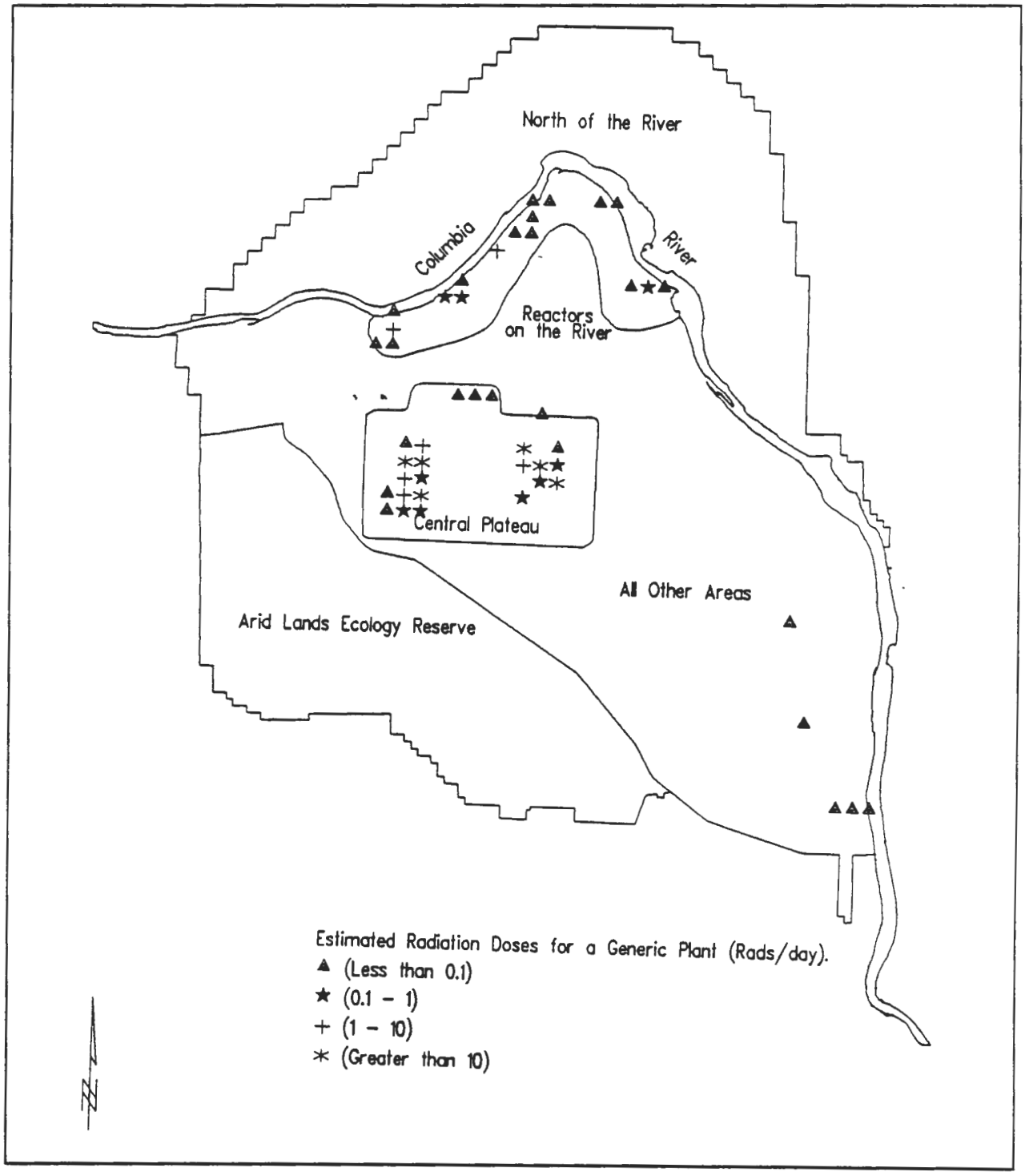


Figure 5-17. Distribution of Estimated Radiation Doses (Rads/day) for a Great Basin Pocket Mouse at the Hanford Site.

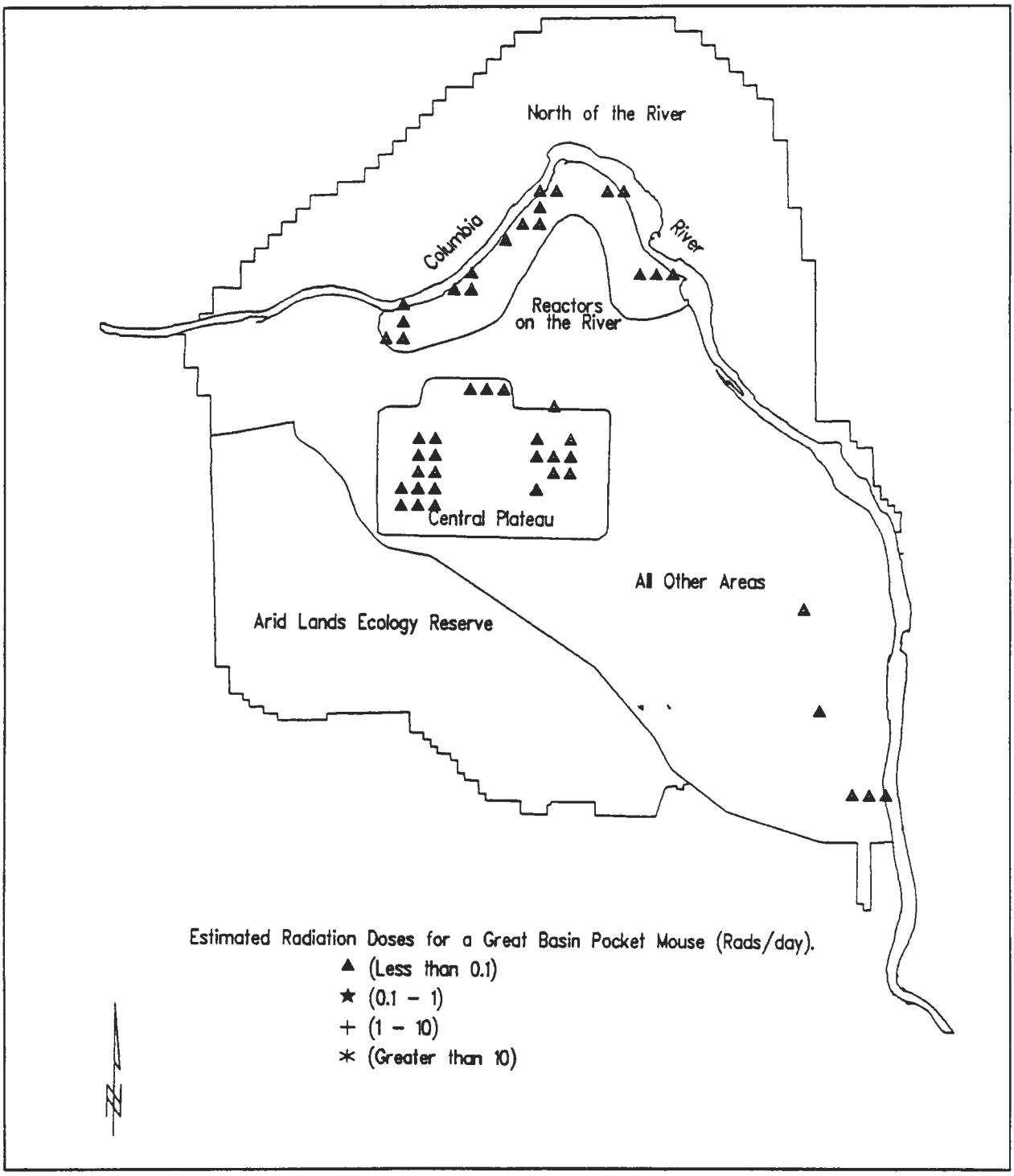


Figure 5-18. Distribution of Estimated Radiation Doses (Rads/day) for a Coyote on the Hanford Site.

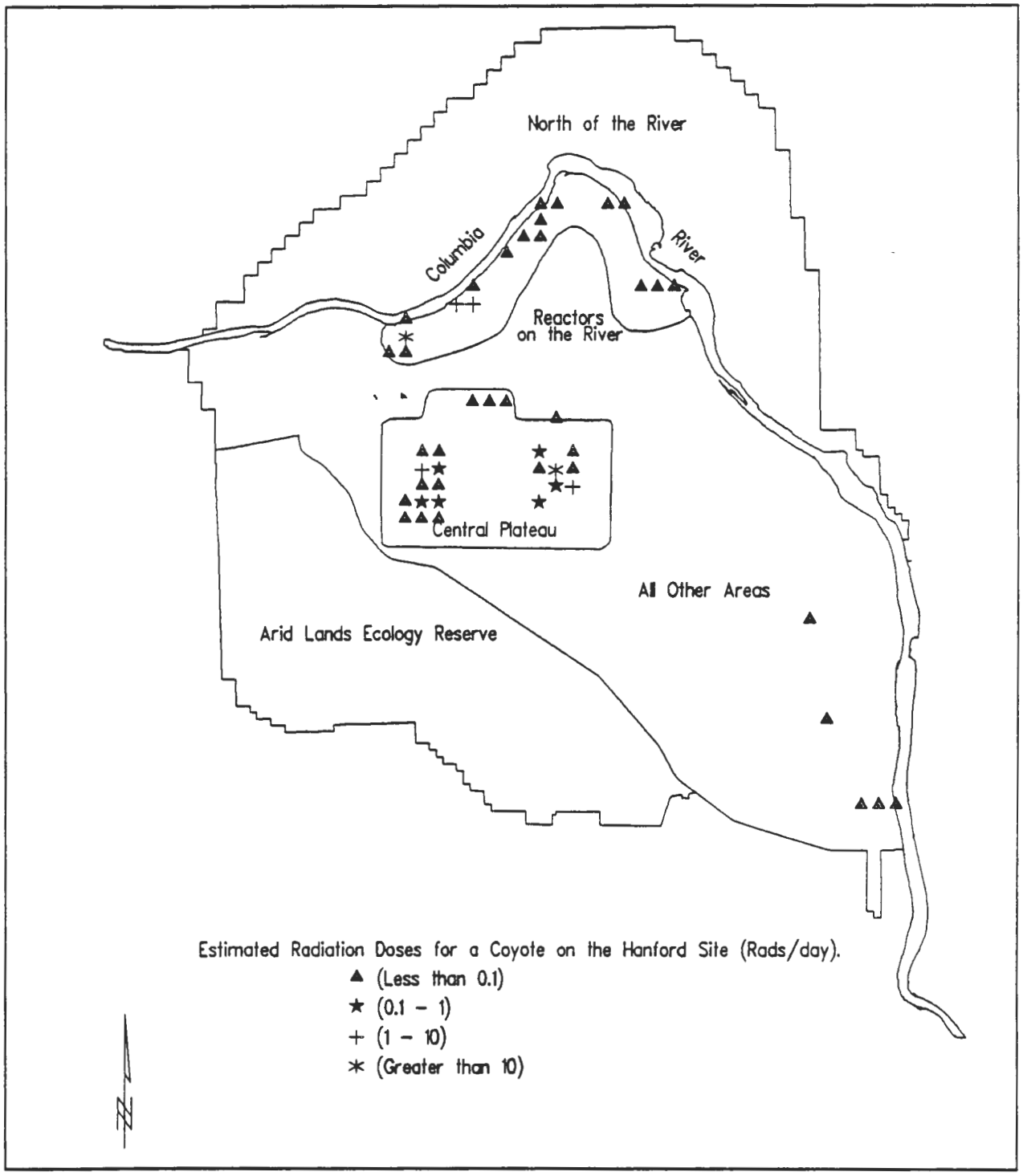
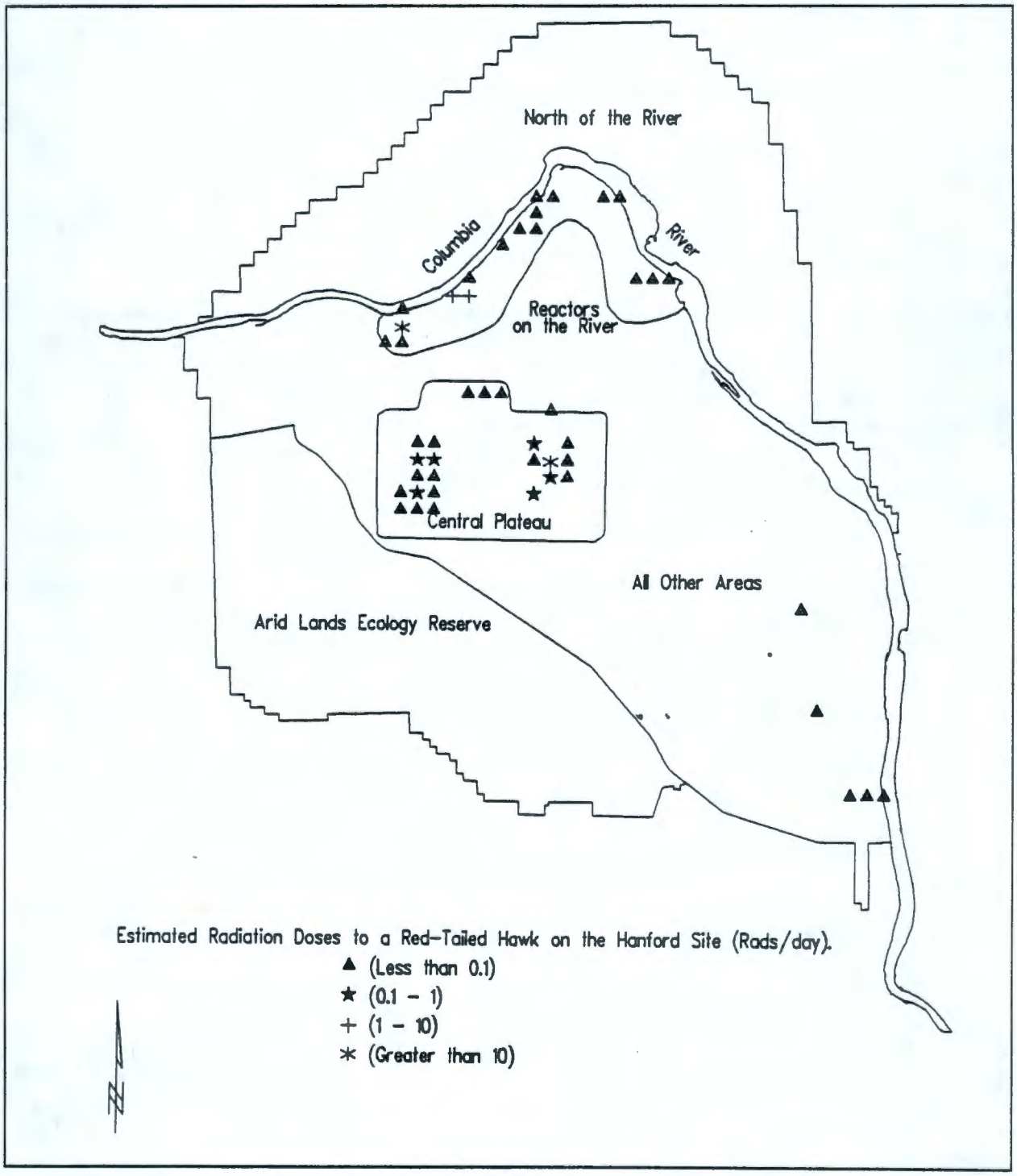


Figure 5-19. Distribution of Estimated Radiation Doses (Rads/day) for a Red-tailed Hawk on the Hanford Site.



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.

The potentially significant impacts identified in the ecological risk assessment could 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.

5.3.4.1.5 ***Biodiversity***. 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 or habitat fragmentation. These activities are not likely to affect species diversity in wetland and shrub-steppe plant communities, or affect the distribution of those communities.

The results of the ecological risk assessment indicate that potentially significant impacts could result 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 elevated levels of contamination. Continued monitoring would allow detection of potential adverse effects on ecological receptors so that additional corrective measures could be taken to minimize exposures.

5.3.4.2 ***Impacts on Ecological Resources from the Unrestricted Future Land-Use Alternative***.

5.3.4.2.1 ***Wetlands***. The Unrestricted Future Land-Use Alternative would involve complete excavation and removal of contaminated soils and effluent lines, closure of TSD units, 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.

5.3.4.2.1.1 Potential Mitigation Measures. Potential mitigation measures for wetlands include the following:

- Identifying uncontaminated wetlands to be avoided.
- Minimizing disturbance of uncontaminated wetland soils to preserve seed sources 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, Corps, and the USFWS[5].

[5]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.

5.3.4.2.2 Shrub-Steppe Habitat. The Unrestricted Future Land-Use Alternative would involve complete excavation and removal of contaminated soil and effluent lines, closure of TSD units, decommissioning of surplus facilities, and groundwater remediation. This alternative would affect approximately 29 ha (71 ac) of shrub-steppe habitat (Figure 5-20).

Disturbance of shrub-steppe areas could 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, could be subjected to habitat fragmentation and displacement, or mortality. Noise and increased vehicle use in these areas could disturb wildlife within hearing or visual distance of remediation 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 (see Section 5.3.4.1).

Potential long-term impacts could 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, could create conditions favorable to introduced species, such as noxious weeds that pioneer quickly on newly disturbed soil. These weed species could compete for available soil moisture and could make establishment of desirable native plants more difficult. Restoration efforts would reduce impacts on some habitats, but would not fully replace diverse plant communities that have developed over long time periods.

5.3.4.2.2.1 Potential Mitigation Measures. Potential mitigation measures for the Unrestricted Future Land-Use Alternative include the following:

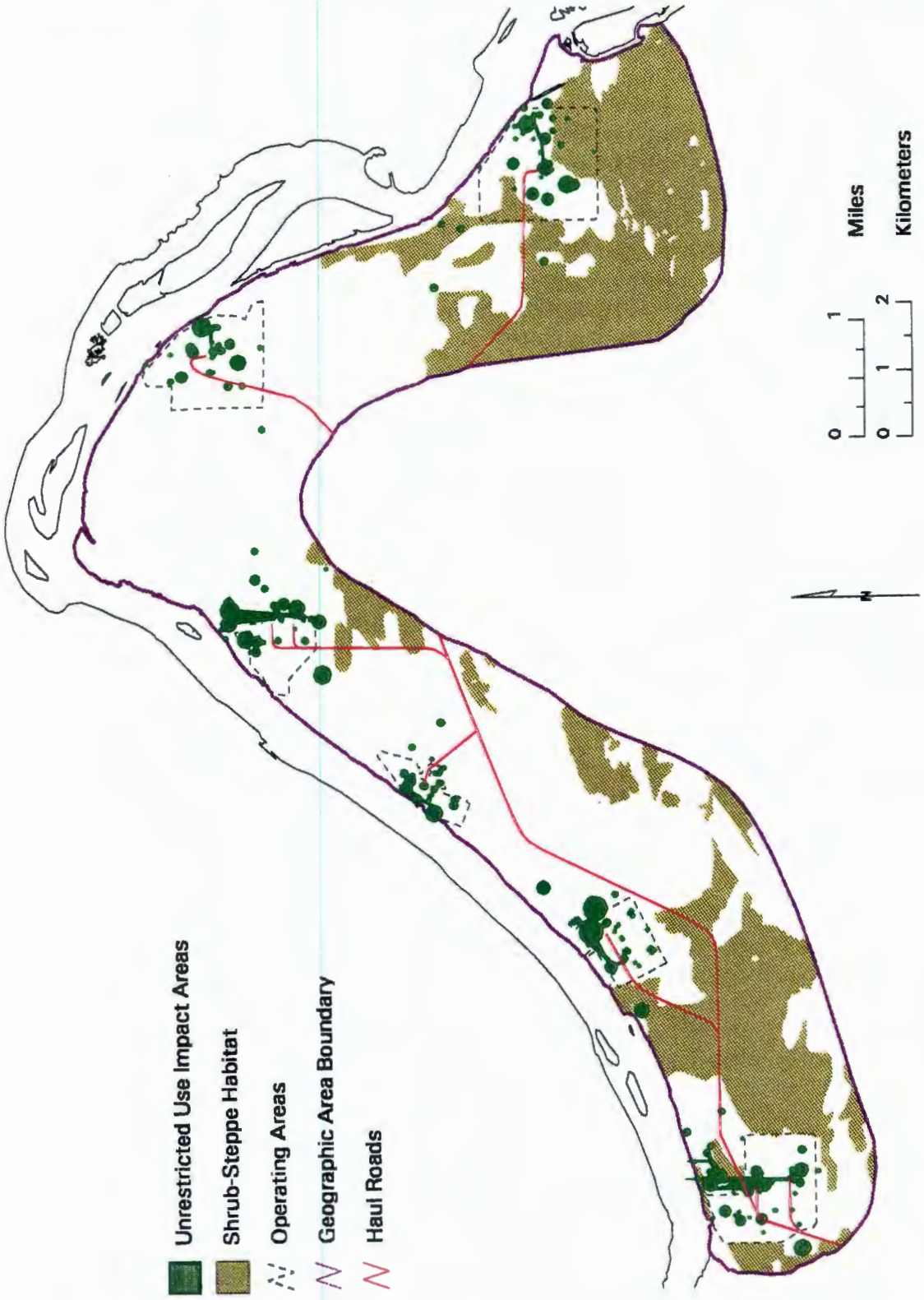
- Minimizing the amount of area disturbed during remediation by restricting disturbance to an area not exceeding the trample zone around each waste site

- Using established travel routes for transport of workers, and supplies, whenever possible, to concentrate traffic and associated noise in specific areas

- Initiating 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.

5.3.4.2.3 Species of Concern. The Unrestricted Future Land-Use Alternative would involve large-scale remediation activities that could affect bald eagle habitats, including five infrequently used tree roosts and perches, and infrequently used ground perches. Disruption of winter roosting activity along the Columbia River might occur, but could be mitigated. Plant species of concern potentially occurring in the Reactors on the River geographic area include the Columbia milk-vetch and northern wormwood. Remediation activities could potentially affect both of these plant species if implemented in their habitats. This alternative could result in permanent loss of habitat for species of concern, resulting in further population decline and possible listing of candidate species as federal threatened or endangered species under the *Endangered Species Act of 1973*.

Figure 5-20. Unrestricted Future Land-Use Alternative Impacts on Shrub-Steppe Habitat, Reactors on the River Geographic Area.



5.3.4.2.3.1 Potential Mitigation Measures. Potential mitigation measures for the Unrestricted Future Land-Use Alternative include the following:

- excluding all disturbance within an 800-m (0.5-mi) buffer around winter roosts of bald eagles from November 15 to March 15
- avoiding 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 the Columbia milk-vetch and northern wormwood
- rectifying or compensating, as necessary, for adverse impacts to biological resources to a degree that reflects the value of the resource and severity of impacts.

5.3.4.2.4 Ecological Risk. 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 short-term impacts, but could be reduced by the mitigation measures identified for soils (Section 5.3.2), water resources (Section 5.3.3), and air quality (Section 5.3.5). Long-term impacts would be beneficial, because potential exposures to radionuclides and hazardous chemicals would be eliminated by removing and disposing of the contaminated material.

5.3.4.2.5 Biodiversity. The Unrestricted Future Land-Use Alternative could have substantial 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 could fragment existing habitats and disrupt the connectivity among different habitats. These impacts could be important in the short term; long-term impacts to biodiversity could be avoided or reduced through implementation of the mitigation measures previously discussed.

5.3.4.3 Impacts on Ecological Resources from the Restricted Future Land-Use Alternative (R1).

5.3.4.3.1 Wetlands. The Restricted Future Land-Use Alternative (R1) would involve excavation and removal of past-practice waste sites and effluent lines, closure of TSD units, 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.

5.3.4.3.1.1 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.

5.3.4.3.2 ***Shrub-Steppe Habitat***. The Restricted Future Land-Use Alternative (R1) would involve similar activities as described for the Unrestricted Land-Use Alternative. Approximately 27 ha (68 ac) of shrub-steppe habitat would be disturbed in the Reactors on the River geographic area (Figure 5-21). The impacts of Restricted Future Land-Use Alternative (R1) would be similar to those discussed for the Unrestricted Future Land-Use Alternative, and could 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.

5.3.4.3.2.1 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.

5.3.4.3.3 ***Species of Concern***. The Restricted Future Land-Use Alternative (R1) would involve disturbances similar to those described for the Unrestricted Future Land-Use Alternative and would have similar impacts on species of concern.

5.3.4.3.3.1 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.

5.3.4.3.4 ***Ecological Risk***. 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 short-term impacts, but could be reduced by using appropriate mitigation measures. Remediation 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.

5.3.4.3.5 ***Biodiversity***. This alternative (R1) would involve levels of disturbance similar to the Unrestricted Future Land-Use Alternative, with similar impacts to biodiversity.

5.3.4.4 Impacts on Ecological Resources from the Restricted Future Land-Use Alternative (R2).

5.3.4.4.1 ***Wetlands***. The Restricted Future Land-Use Alternative (R2) would involve construction of caps over past-practice waste sites, effluent lines, and TSD units, 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.

5.3.4.4.1.1 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.

5.3.4.4.2 ***Shrub-Steppe Habitat***. This alternative (R2) would involve construction of caps over waste sites and construction of perimeter access roads around the caps, which would disturb approximately 28 ha (70 ac) of shrub-steppe habitat in the Reactors on the River geographic area (Figure 5-22). The impacts of Restricted Future Land-Use Alternative (R2) would be similar to those discussed for the Unrestricted Future Land-Use Alternative.

Figure 5-21. Restricted Future Land-Use Alternative (R1) Impacts on Shrub-Steppe Habitat, Reactors on the River Geographic Area.

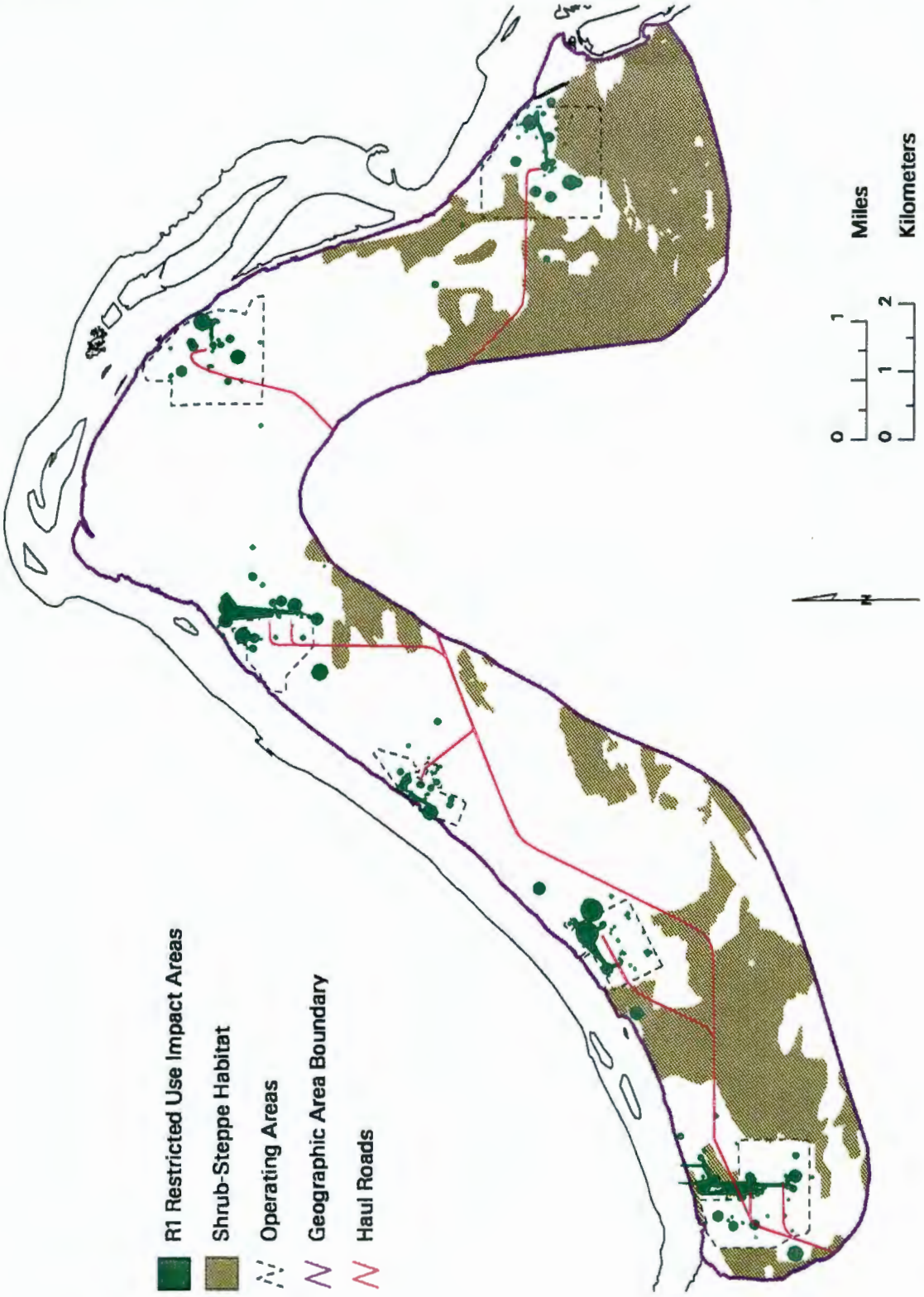
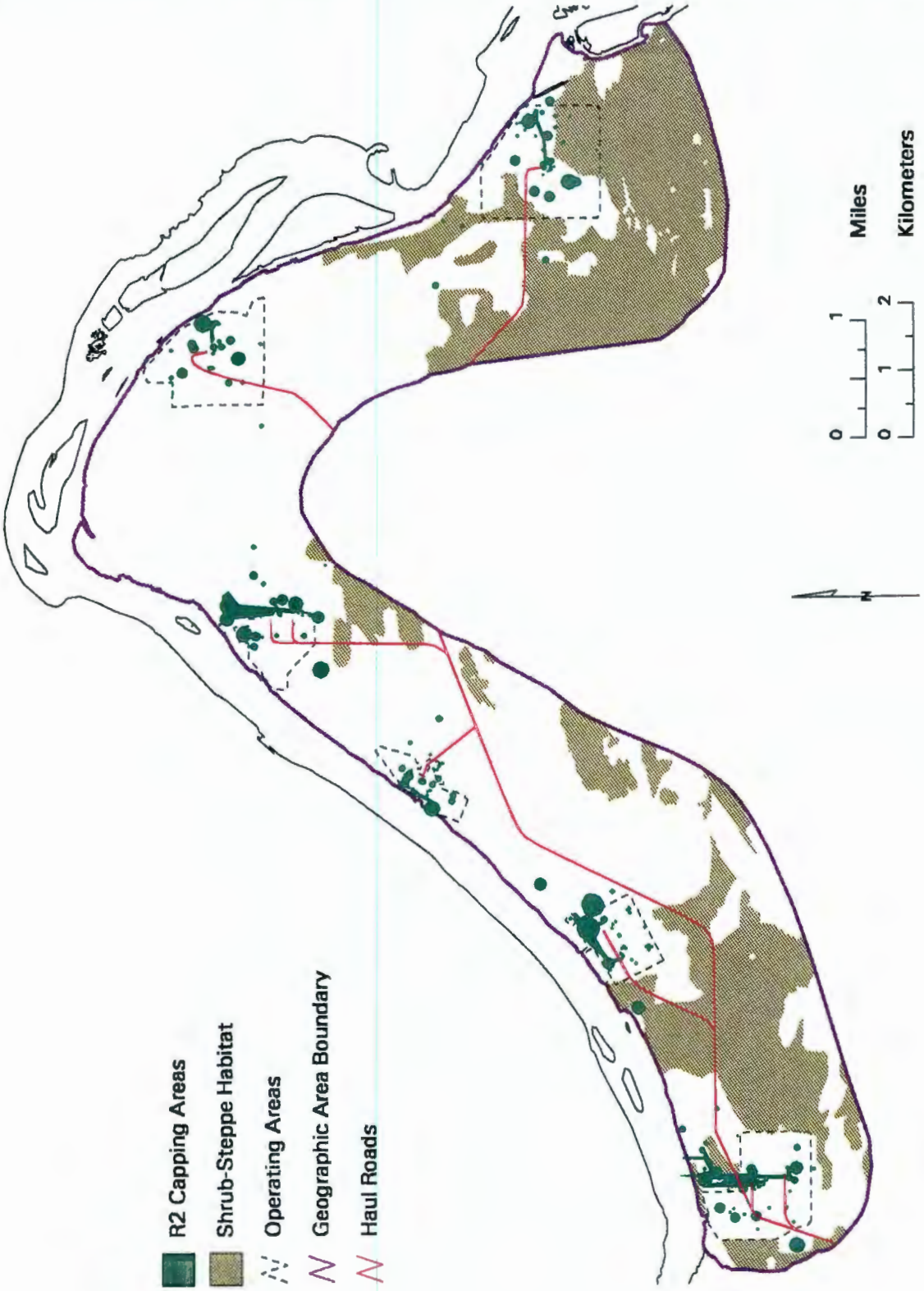


Figure 5-22. Restricted Future Land-Use Alternative (R2) Impacts on Shrub-Steppe Habitat, Reactors on the River Geographic Area.



5.3.4.4.2.1 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.

5.3.4.4.3 Species of Concern. The Restricted Future Land-Use Alternative (R2) would affect fewer bald eagle tree roosts and perches than the Unrestricted and Restricted Future Land-Use (R1) Alternatives. Effects on other species of concern would be similar to those described for the Unrestricted Future Land-Use Alternative.

5.3.4.4.3.1 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.

5.3.4.4.4 Ecological Risk. 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.

5.3.4.4.5 Biodiversity. This alternative (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 Impacts on Air Quality from the 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 expected to have only minimal air quality impacts.

5.3.5.2 Impacts on Air Quality from the 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 units, 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 to which workers could be exposed are within most applicable standards and guidelines (Table 5-17).

As shown in Table 5-17, the concentration of plutonium-239 and -240 to which the public could be exposed is estimated to exceed the DOE Derived Concentration Guide (DOE 1993a). This indicates the potential for short-term air quality impacts to members of the public located offsite. This potential impact would be addressed under the CERCLA process, could be reduced with the use of mitigation measures, and would cease when remediation activities are completed.

Table 5-17. Estimated Concentrations of Airborne Contaminants from Complete 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}[f]	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[g]	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	150, 24-h average
	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 the maximum predicted ground-level concentrations to which workers could be exposed.

[c]Occupational standards for fugitive dust and combustion products are Permissible Exposure Limits 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 peak concentrations to which 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 standards for SO_2 and total suspended particulates are Washington State standards. Guidelines for airborne radionuclides are Derived Concentration Guides listed in DOE Order 5400.5 (DOE 1993a).

[f]PM_{10} = particulate matter less than 10 micrometers in size.

[g]The concentration of Pu-239,-240 appears to exceed the air quality standard. The estimated concentration, however, is a level 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).

The concentrations presented in Table 5-17 are consequences of remediation activities at one site. Simultaneous activities at several sites could result in higher concentrations, particularly if the sites were in line and parallel to the wind direction. To account for this possibility, potential 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 to which workers could be exposed under this arrangement are below applicable standards and guidelines (Table 5-18).

Table 5-18. 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}[f]	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	0.35	400, annual average
	Pu-239, -240	0.7	3, annual average	0.35[g]	0.02, annual average
	U-238	0.3	300, annual average	0.001	0.10, annual average
Products of Fuel Combustion ($\mu g/m^3$)	total suspended particulates	120	15,000, 8-h average	0.6	150, 24-h average
	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 the maximum predicted ground-level concentrations to which workers could be exposed.

[c]Occupational standards for fugitive dust and combustion products are Permissible Exposure Limits 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 peak concentrations to which 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 standards for SO_2 and total suspended particulates are Washington State standards. Guidelines for airborne radionuclides are Derived Concentration Guides listed in DOE Order 5400.5 (DOE 1993a).

[f]PM_{10} = particulate matter less than 10 micrometers in size.

[g]The concentration of Pu-239,-240 appears to exceed the air quality standard. The estimated concentration, however, is a level 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).

As with Table 5-17, the results in Table 5-18 indicate a potential for short-term impacts to members of the public. These predicted impacts were derived using conservative assumptions, including the use of the highest contaminant concentrations and comparison to guideline concentrations that are annual averages. Conservative factors that must be considered when comparing calculated concentrations to standards are discussed in Section 5.2.5.2. Although the results presented in Tables 5-17 and 5-18 are based on a conservative analysis, they indicate that mitigation measures may be required to reduce potential air quality impacts.

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 round trips. 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 5-6), compared to the 5,000 $\mu g/m^3$ occupational standard.

5.3.5.2.1 Potential Mitigation Measures. Mitigation measures for air quality could include covering trucks, wetting storage piles and haul roads with water or dust suppressants, 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, could be used to protect workers.

5.3.5.3 Impacts on Air Quality from the 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 units, 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.

5.3.5.3.1 Potential Mitigation Measures. Mitigation measures for air quality under the Restricted Future Land-Use Alternative (R1) are the same as those for the Unrestricted Future Land-Use Alternative.

5.3.5.4 Impacts on Air Quality from the 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 units, and groundwater remediation, combined with institutional controls. Air quality impacts of remediation to restricted use (R2) would be lower than the estimates in Tables 5-17 and 5-18, 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. Only minimal impacts are expected.

5.3.6 Noise

5.3.6.1 Noise Impacts from the 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.

5.3.6.2 Noise Impacts from the Unrestricted Future Land-Use Alternative. Remediation to unrestricted use would generate increased noise from heavy truck traffic, and transport and operation of heavy equipment. Representative noise levels from remediation 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 remediation 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 5-23. The 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 5-23).

Table 5-19 lists the equivalent noise levels emanating from the 100-H Area predicted by the STAMINA noise model with respect to distance from the work site. The noise levels shown in Table 5-19 are cumulative 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 for industrial zones (Class C in Table 5-20), indicate that remediation activities are not expected to generate unacceptable noise levels.

Table 5-19. Noise Impacts of Full Excavation in the 100-H Area.

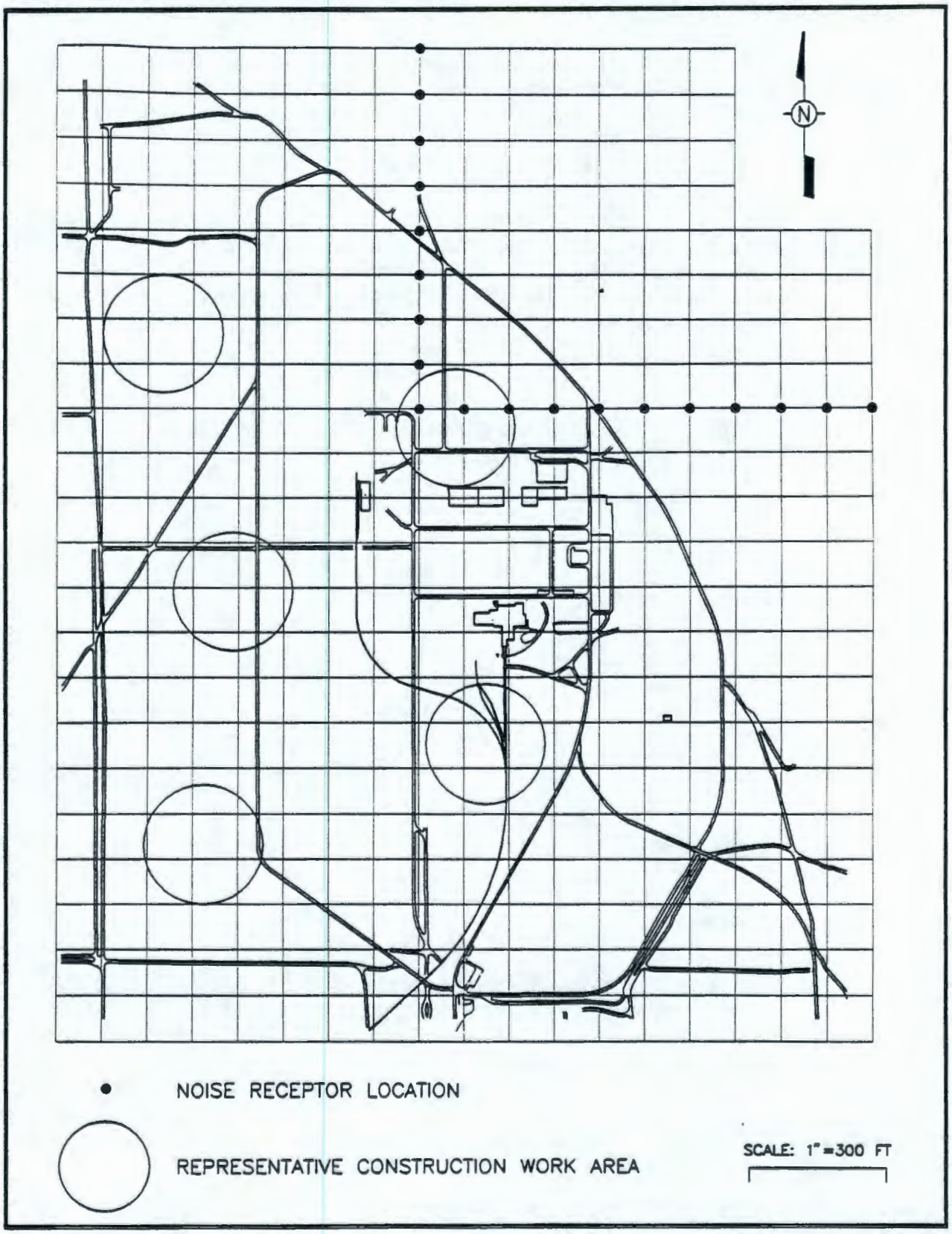
Receptor Direction	Distance from 100-H Area m (ft)	Decibels (dBA)
North	At Work Site	59
North	30 (100)	60
North	60 (200)	59
North	90 (300)	58
North	122 (400)	53
North	152 (500)	49
North	183 (600)	47
North	213 (700)	44
North	245 (800)	43
East	At Work Site	59
East	At Work Site	53
East	30 (100)	50
East	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 5-20. 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.

Figure 5-23. Representative Noise Sources Across the 100-H Area.



The construction-related noise could disturb wildlife within hearing or visual distance of remediation 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 remediation 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
- Excluding 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 Impacts from the 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.

5.3.7 Cultural Resources

5.3.7.1 Impacts to Cultural Resources from the No-Action Alternative.

5.3.7.1.1 Prehistoric Archaeological Resources. The No-Action Alternative could have substantial 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.

5.3.7.1.1.1 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 RL Cultural Resources Program Manager, the 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 if there is no potential health risk to field investigators.

- Whenever 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 if it does not pose a health risk to the archaeological monitor.

- An interpretive program outlining the history of the Hanford Site would be presented to personnel involved in the remediation and maintenance activities to foster greater awareness and sensitivity for the cultural resources in the area.

5.3.7.1.2 Historic Resources. 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 reflect the historic settlement and economic development of the area. Materials and structures related to the Manhattan Project and the World War II effort, as well as items and structures that are representative of the Cold War period are considered to be of historical significance. In essence, all construction related to the Hanford Site's defense mission from 1943 to 1989 must be considered for historical significance. This would include all the reactor areas and their ancillary support structures. It is unlikely, but possible, that facility maintenance activities under the No-Action Alternative could adversely affect a small number of potentially historic structures.

5.3.7.1.2.1 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 the structures are not unduly subjected to weathering and age. Mitigation measures that are currently being implemented include:

- Preparing building construction evaluations

- Documenting all historic structures determined to be eligible for the National Register in accordance with the Secretary of the Interior's Guidelines for Historic Architectural and Engineering Documentation

- Documenting all decommissioning work

- Monitoring of potentially historic structures for essential repair and maintenance work

- Restricting access to historic sites to authorized personnel.

5.3.7.1.3 Areas of Concern to Native Americans. The potential direct and indirect impacts to archaeological resources described in Section 5.3.7.1.1 would be of concern to Native Americans. In addition, the No-Action 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.

5.3.7.2 Impacts to Cultural Resources from the Unrestricted Future Land-Use Alternative.

5.3.7.2.1 Prehistoric Archaeological Resources. The Unrestricted Future Land-Use Alternative could 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 upstream of the 100-N Area also could be affected. These sites represent contributing elements to the Ryegrass Archaeological District, which is listed on the National Register.

5.3.7.2.1.1 Potential Mitigation Measures. Potential mitigation measures for this alternative would be the same as for the No-Action Alternative.

5.3.7.2.2 Historic Resources. The Unrestricted Future Land-Use Alternative could have impacts on historic resources in the Reactors on the River geographic area. At least four recorded historic sites could be affected, including cement foundations and domestic debris. In addition to the identified sites that would be directly affected, numerous historic sites within the immediate vicinity of areas could be disturbed.

5.3.7.2.2.1 Potential Mitigation Measures. Potential mitigation measures for this alternative would be the same as for the No-Action Alternative.

5.3.7.2.3 Areas of Concern to Native Americans. The potential direct and indirect impacts to archaeological resources described in Section 5.3.7.2.1 would be of concern to Native Americans. As was discussed in Section 4.5.4, 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 could 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 the future exercise of treaty rights.

Remediation activities under the Unrestricted Future Land-Use Alternative temporarily would preclude access to areas where remediation is occurring. This alternative could eventually allow unrestricted access to sacred or traditional areas important to Native Americans.

5.3.7.2.3.1 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

- Considering recommendations provided by Native American tribal governments and organizations in the development of project-specific cultural resource mitigation plans for proposed remediation activities

- Incorporating recommendations provided by Native American tribal governments and organizations in revegetation plans for proposed remediation activities

- Involving representatives of Native American tribal governments and organizations in archaeological monitoring during remediation activities.

5.3.7.3 Impacts to Cultural Resources from the Restricted Future Land-Use Alternatives (R1 and R2).

5.3.7.3.1 Prehistoric Archaeological Resources. 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.

5.3.7.3.1.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternatives would be the same as for the No-Action Alternative.

5.3.7.3.2 Historic Resources. 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.

5.3.7.3.2.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternatives would be the same as for No-Action Alternative.

5.3.7.3.3 Areas of Concern to Native Americans. Areas of concern to Native Americans would be similar to those discussed for the Unrestricted Future Land-Use Alternative, with the exception that these alternatives might continue to require access restrictions to traditional use and religious use areas important to Native Americans.

5.3.7.3.3.1 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 Impacts on Visual and Aesthetic Resources from the 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. Placement of caps over waste sites, revegetation of sites, and/or weed control may alter the landscape and viewsheds. These activities probably will have minimal impact on the visual and aesthetic resources of the area. Monitoring activities would not adversely affect visual and aesthetic resources.

5.3.8.2 Impacts on Visual and Aesthetic Resources from the 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 units, decommissioning of surplus facilities, and groundwater remediation. Full excavation of all waste sites in the Reactors on the River geographic area could 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 recontouring 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 remediation activities in other areas
- Restoring remediated areas by recontouring excavations to approximate original conditions and revegetating with native species.

5.3.8.3 Impacts on Visual and Aesthetic Resources from the 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 units, decommissioning of surplus facilities, and groundwater remediation, combined with institutional controls. Excavation under this alternative would not be as extensive as for the Unrestricted Future Land-Use Alternative 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 Impacts on Visual and Aesthetic Resources from the 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 units, 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, because the rigid geometric design and large size of the caps would 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 would be visible from certain points along State Routes 24 and 240.

Use of the modified RCRA caps instead of the reference cap design would reduce visual impacts. The modified RCRA caps would not be as large or as thick as the reference caps and would blend with the existing 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.

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 Impacts from the 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 expected to have only minimal 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 human health 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 5.8.3.

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 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 remediation activity (Appendix B5), with a probability of occuring on the Hanford Site approximately every 10 years.

The airborne pathway was the only exposure pathway considered for estimating the impacts of the range fire. 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, and for offsite

populations. The nearest public access location 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 5-21 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 5-21. 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** at 8,510 m (27,900 ft) 5.0 E-08[a]	**0.055** 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]	**0.006** at 8,510 m (27,900 ft) 3.0 E-09[a]	**0.0034** 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 latent cancer fatalities in this population.
MEI = maximally exposed individual.
NPAL = nearest public access location.

5.3.9.2 Human Health Impacts from the 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 units, decommissioning of surplus facilities, and groundwater remediation. Site-specific evaluations of potential risk to workers and the public would be performed as part of the CERCLA process. 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. Remediation activities are not expected to result in substantial adverse health effects to workers (Section 5.7) or the general public. 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 **health effects** of radiation exposure are discussed further in Section 5.8.

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 or not remediation took place, 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 groundwater, and the resultant release of contaminants to the atmosphere. The probability of these accidents occurring ranges from 10^{-2} to 10^{-6} occurrences/year of operations, and would vary with the amount of remediation undertaken. The probability of an accident occurring during remediation to levels allowing unrestricted land use would be more likely than an accident occurring during remediation to restricted land use.

The **excavation accident scenario** involves the inadvertent ignition of 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 to expose workers and the nearby population. The estimated radiation dose to remediation workers is less than 0.1% of the regulatory limit for radiation workers of 5,000 mrem/yr (see Table 5-21). The estimated radiation doses to a member of the public at the nearest public access location 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 5-21).

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 ion exchange treatment of groundwater (Appendix B5). Contaminants accumulated on the resin bed 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. 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 5-21). The estimated dose to an individual at the nearest public access location is much higher than the allowable annual dose of 10 mrem to members of the public, and therefore, is considered potentially significant. The 0.8-mrem Hanford Site boundary dose is small compared to the 10-mrem allowable annual dose.

5.3.9.2.1 Potential Mitigation Measures. Potential mitigation measures for the Unrestricted Future Land-Use Alternative are those designed to prevent accidents from occurring during remediation activities or to reduce the severity of the accident impacts. Appropriate engineering and administrative measures would be applied during routine remediation 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, the use of containment structures, and limiting the size of excavations exposed to the atmosphere.

5.3.9.3 Human Health Impacts from the 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 units, decommissioning of surplus facilities, and groundwater remediation, combined with institutional controls. Site-specific evaluations of potential

risk to workers and the public would be performed as part of the CERCLA process. 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. Remediation activities are not expected to result in significant adverse health effects to workers (see Section 5.7) 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 risks to levels at or below the target risk range of 10^{-4} to 10^{-6}. 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. The groundwater treatment accident scenario would have the same impacts under the Restricted Future Land-Use Alternative (R1) as for the Unrestricted Future Land-Use 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 risk of the excavation accident, when the probability of occurrence is factored in, would be lower than for the Unrestricted Future Land-Use Alternative.

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 Impacts from the 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 units, 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 groundwater use. The combination of caps and use restrictions would reduce risks to levels at or below the target risk range of 10^{-4} to 10^{-6}. If activity restrictions are violated, 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.

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 Health and Safety

Potential impacts to the health and safety of remediation workers associated with implementing the future land-use alternatives in the Reactors on the River geographic area were estimated by comparing the field labor hours[6] identified in Appendix H for each alternative with Bureau of Labor Statistics and DOE incident rates (DOE 1995k). The estimates were made assuming that all remediation waste is transported by truck for onsite disposal, because truck transport requires the most labor. Complete documentation of this analysis is presented in Appendix I.

5.3.10.1 Occupational Impacts from the 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 from the Unrestricted Future Land-Use and Restricted Future Land-Use Alternatives (R1 and R2). Table 5-22 presents the potential occupational impacts for the Unrestricted Future Land-Use and Restricted Future Land-Use Alternatives (R1 and R2) for the Reactors on the River geographic area based on Bureau of Labor Statistics 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 (subject to rounding error). 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 5-22. Summary of Occupational Injury Impacts Using Bureau of Labor Statistics.

Future Land-Use Alternative	Labor Hours	Estimated Total Cases	Estimated Lost Workday Cases	Estimated Nonfatal Cases Without Lost Workdays	Estimated Lost Workdays
Unrestricted	8,886,850	587	299	290	7,783
Restricted (R1)	6,414,602	427	215	212	5,564
Restricted (R2)	12,054,899	832	443	389	11,597

Table 5-23 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 Bureau of Labor Statistics 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.

[6]Labor hours associated with decommissioning and groundwater remediation activities were not included in this analysis.

Table 5-23. Summary of Occupational Injury Impacts per DOE Statistics.

Future Land-Use Alternative	Labor Hours	Estimated Total Cases	Estimated Lost Workday Cases	Estimated Lost Workdays
Unrestricted	8,886,850	587	299	7,783
Restricted (R1)	6,414,602	427	215	5,564
Restricted (R2)	12,054,899	832	443	11,597

Potential occupational impacts are greatest for remediation to restricted use (R2), which is achieved by construction of caps over past-practice waste sites, effluent lines, and TSD units. This is expected, as cap construction would require a substantial increase in labor hours for 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 Excavation Volumes, Material Requirements, and Costs

The assumptions and methodology used to estimate costs for each future land-use alternative are discussed in Appendix H. Volume and cost estimates for each future land-use alternative are summarized Table 5-24.

Table 5-24. 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[b]	5,666	0
Contaminated Soil	0	6,663[b]	4,585	0
Groundwater Remediation Costs in 1994 Dollars (millions)				
River Discharge	0	604	250	250
Aquifer Reinjection	0	606	251	251
Areas of Disturbance (ha)	87	420	390	373
Project Costs in 1994 Dollars (millions)	2,424[c]	$3,568 (truck haul) $3,685 (rail haul)	$2,375 (truck haul) $2,456 (rail haul)	$2,477 (truck haul) $2,758 (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]Includes volumes for effluent line excavation.

[c]Costs for 100 years of institutional control for the entire Hanford Site. The costs are not broken down by geographic area (see Table 5-25).

5.3.11.1 Excavation Volumes, Material Requirements, and Costs for the No-Action Alternative. The cost of the No-Action Alternative is more than $2.4 billion for 100 years of institutional control (Table 5-25). 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.

Table 5-25. Cost Summary for the No-Action Alternative.

Activity	Cost ($ millions)	
	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 1994a).
[1]Fiscal Year 1994 Target Costs.
[2]Fiscal Year 1993 Actual Costs.

5.3.11.1.1 Potential Mitigation Measures. Potential mitigation measures include efforts to reduce the costs of institutional controls.

5.3.11.2 Excavation Volumes, Material Requirements, and Costs for the 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-D and 100-K (Table 5-26). The total area disturbed by remedial actions is 420 ha (1,038 ac). Excavation 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 (see Table 5-27).

Table 5-26. Waste Volume Breakdown for Waste Sites and Pipelines in the Reactors on the River Geographic Area.

Reactor Area	Uncontaminated Soil (% of Total)	Contaminated Soil (% of Total)	Piping (% of Total)
100-B/C	16	18	11
100-D	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

The conceptual groundwater remediation system used for analysis in this EIS is described in Appendix D. For cost estimating purposes, it was assumed that groundwater remediation would occur for 30 years under the Unrestricted Future Land-Use Alternative in the Reactors on the River geographic area. The cost for remediating groundwater is $604 million, assuming that treated groundwater is discharged to the Columbia River. Groundwater remediation with disposal by aquifer reinjection would cost $606 million. The additional cost would be associated with installing additional piping from the treatment plants to upgradient reinjection locations.

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 the 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. The cost for decommissioning surplus facilities would be about $48 million.

Two transportation scenarios were analyzed for transporting waste to the ERDF: trucks and rail. The loose volumes to be transported were assumed to be 18% greater than bank (in-place) volumes. Costs for transportation of waste to the ERDF range from $235 million if wastes are hauled by truck to $353 million if wastes are hauled by rail (Table 5-27).

The total costs of remedial actions to restore the Reactors on the River geographic area to allow unrestricted uses are approximately $3.5 billion if materials are hauled by truck and approximately $3.7 billion if materials are hauled by rail (see Table 5-24).

5.3.11.2.1 Potential Mitigation Measures. All remediation activities would be planned and implemented with the goal of minimizing 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 unnecessary excavation of uncontaminated soils. Excavation of waste in combination with technologies such as soil washing could result in reduced waste volumes requiring disposal.

Table 5-27. 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	Rail
Mobilization and Preparatory Work	17	0.4	--	6.7	--	--
Monitoring, Sampling, and Analysis	1,441	361	--	3.0	--	--
Surface Water Collection and Control	0.9	0	--	0	--	--
Solids Collection and Disposal	491*	85	--	34.5	--	--
Site Restoration	238	39	--	3.3	--	--
Demobilization	5.5	0.3	--	0.1	--	--
Total Costs	2,193.4	485.7	604	47.5	235	353
Fuel Use (millions) L (gal)	75 (20)	24 (6.3)		3.0 (0.8)	57 (15)	19 (5.0)
Labor Hours (millions)	7.9	2.3	1.4	0.4	2.5	1.4

*Includes ERDF disposal costs.
D&D = decommissioning.
ERDF = Environmental Restoration Disposal Facility.

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 Excavation Volumes, Material Requirements, and Costs for the 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 units, 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 would be about $1.8 billion (Table 5-28), or about 30% less than under the Unrestricted Future Land-Use Alternative. The excavation volumes and costs for decommissioning surplus facilities under this alternative would be the same as those for the Unrestricted Future Land-Use Alternative. For cost estimating purposes, it was assumed that groundwater remediation under the Restricted Future Land-Use Alternative (R1) and (R2) would occur for 10 years. The total groundwater remediation costs for both of these alternatives would be $250 million. Total costs of remedial actions are $2.4 billion if wastes are hauled to the ERDF by truck and $2.5 billion if wastes are hauled to the ERDF by rail (see Table 5-24).

Table 5-28. 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	Rail
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	--	--
Solids Collection and Containment	323*	85	--	34.5	--	--
Site Restoration	160	39	--	3.3	--	--
Demobilization	5.5	0.3	--	0.1	--	--
Total Costs	1,426.3	485.7	250	47.5	162	243
Fuel Use (millions) L (gal)	45.1 (11.9)	23.8 (6.3)	--	3.0 (0.8)	38 (10)	13 (3.5)
Labor Hours (millions)	5.2	2.3	0.5	.4	1.7	0.9

*Includes ERDF disposal costs.
D&D = decommissioning.
ERDF = Environmental Restoration Disposal Facility.

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 Excavation Volumes, Material Requirements, and Costs for the 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 units, and groundwater remediation, combined with institutional controls. The reference cap design used to estimate excavation 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 5-29. The costs for capping waste sites, concrete stacks, and pipelines (excluding transportation) would be about $1.6 billion (Table 5-30). Surplus facilities decommissioning volumes and costs, and groundwater remediation costs 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). This includes approximately 137 ha (339 ac) that would be capped, which represents an irretrievable commitment of resources.

The total costs of remedial actions (see Table 5-24) for the Restricted Future Land-Use Alternative (R2) are $2.5 billion if cap material is hauled to the 100 Areas by truck and $2.8 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.

Table 5-29. 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 5-30. 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	Rail
Mobilization and Preparatory Work	18	2	--	6.7	--	--
Monitoring, Sampling, and Analysis	170	9.2	--	3.0	--	--
Surface Water Collection and Control	1.1	0.1	--	0	--	--
Solids Collection and Containment	948	53	--	34.5	--	--
Site Restoration	369	43	--	3.3	--	--
Demobilization	3.6	0.4	--	0.1	--	--
Total Costs	1,509.7	107.7	250	47.5	563	844
Fuel Use (millions) L (gal)	132.0 (35.0)	26 (7)	--	3.0 (0.8)	135 (36)	45 (12)
Labor Hours (millions)	7.2	0.4	0.5	0.4	6.0	3.3

D&D = decommissioning.

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 costs for a RCRA Subtitle C cap or modified RCRA cap are \$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).

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Central Plateau

5.4 Central Plateau Geographic Area

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 operation of these facilities resulted in the storage, disposal, and unplanned release of radioactive and hazardous waste. Extensive contamination exists in the surface soils, subsurface soils, and groundwater of the Central Plateau. Groundwater contamination concentrations exceed EPA drinking water standards for some contaminants. 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.

The scope of the proposed actions in the Central Plateau geographic area includes the past-practice waste sites and TSD units 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. The impacts and potential mitigation measures are summarized in Chapter 3.0, Table 3-14.

5.4.1 Geology

5.4.1.1 Impacts on Geological Resources from the No-Action Alternative. Under the No-Action Alternative, stabilization of waste sites might require the use of borrow materials. 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 not been prepared. Continuing to exclude geologic resources in the Central Plateau geographic area from development would not be expected to result in important short- or long-term adverse impacts. Continued environmental monitoring and maintenance activities probably would have only minimal impacts on the geologic resources of the Central Plateau geographic area.

5.4.1.2 Impacts on Geological Resources from the Exclusive Future Land-Use Alternative. The Exclusive Future Land-Use Alternative would involve groundwater remediation, limited consolidation of waste materials, and the capping of waste sites. Capping would require approximately 17,500,000 LCM (22,900,000 LCY) of materials, based on installation of modified RCRA caps. Although current

> ***Alternative Cap Designs***
>
> Most of the analyses in this EIS of capping volumes and costs and areas of disturbance associated with capping were performed using the reference cap design described in Appendix E. However, for the Central Plateau geographic area, the modified RCRA cap design was used to analyze costs and capping volumes to provide more accurate and current estimates. The cost and volume data were obtained from Bechtel Hanford, Inc.'s draft baseline planning documents (BHI 1995b).
>
> The areas of disturbance estimated for capping in the Central Plateau geographic area are based on using the reference cap design, and conservatively bound the amounts of disturbance associated with using the smaller modified RCRA cap.

planning documents are based on the assumption that modified RCRA caps would be used in the Central Plateau, the reference cap design described in Appendix E would be used to cap certain waste sites, such as pre-1970 transuranic (TRU) waste sites. Regardless of the type of cap used, this alternative would have an impact on the geologic resources of the quarry and borrow sites (Appendix E). Section 5.11 discusses the use of quarry and borrow materials 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. A small number of features relevant to the study of the region's geologic evolution potentially could be destroyed during remediation, but this probably would result in minimal impacts, since such features occur elsewhere on the Hanford Site.

5.4.2 Soils

The potential effects of the alternatives on soils in the Central Plateau geographic area are summarized in Table 5-31.

Table 5-31. Soils Disturbed under Central Plateau Geographic Area Future Land-Use Alternatives.*

Soil Types	No Action ha (ac)	Exclusive ha (ac)
Quincy sand	124 (311)	861 (2,127)
Burbank loamy sand	132 (330)	604 (1,492)
Ephrata sandy loam	9 (22)	116 (287)
Esquatzel silt loam	7 (17)	33 (82)
Total	272 (680)	1,614 (3,987)

*Areal impact information generated from GIS. Includes area disturbed for capping, trample zones, and haul roads.
GIS = geographic information system.

5.4.2.1 Impacts on Soils from the No-Action Alternative. Approximately 1,164 ha (3,987 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 are expected to have only minimal impact on the soils in the Central Plateau geographic area.

5.4.2.2 Impacts on Soils from the Exclusive Future Land-Use Alternative. Approximately 1,192 ha (2,980 ac) of soils could be disturbed by remediation activities under this alternative. Potential short-term impacts on soils could include soil compaction and increased potential for erosion. Soil compaction (Table 5-32), particularly in Ephrata sandy loam soils, could cause increased runoff during storm events, resulting in less infiltration of water into the soil, and compaction could reduce

Table 5-32. Compaction and Erosion Potential for Affected Soils in the Central Plateau 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[c]	NA[c]

[a]Brincken (1994).
[b]Bolick (1994).
[c]Erosion class not available for Ephrata sandy loam.

the amount of loose soil that promotes plant growth. Wind erosion resulting from disturbance of existing vegetation during remediation could 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 established 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

5.4.3.1 Impacts on Water Resources from the No-Action Alternative.

5.4.3.1.1 Groundwater. The No-Action Alternative would involve no treatment of existing groundwater contamination, and would not have 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 originating in the Central Plateau geographic area would continue to adversely affect groundwater quality in the other geographic areas. 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 on groundwater quality 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).

Hanford Site Quick Facts: Central Plateau Groundwater Contaminant Plumes

- chromium
- nitrate
- trichloroethylene
- fluoride
- carbon tetrachloride
- chloroform
- technetium-99
- cyanide
- cobalt-60
- strontium-90
- tritium
- uranium
- cesium-137
- iodine-129
- plutonium

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 lower concentrations as they mix with the groundwater. In some locations, these contaminants could extend natural attenuation times for groundwater.

5.4.3.1.2 Surface Water. 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. However, concentrations of detected radionuclides remain well below applicable drinking water standards (see Table 5-13). Under the No-Action Alternative, it is likely that other contaminants such as technetium-99 also eventually would reach the river. At the present time, it is not known if the contaminants that reach the river in the future would be detectable at concentrations above the drinking water standards. Because of this uncertainty, the potential impacts of taking no action in the Central Plateau geographic area could be considered significant.

5.4.3.2 Impacts on Water Resources from the Exclusive Future Land-Use Alternative.

5.4.3.2.1 Groundwater. Under the Exclusive Future Land-Use Alternative, capping would eliminate natural infiltration at waste sites. The pump-and-treat system could temporarily draw down the water table and change groundwater flow patterns in the immediate vicinity of the pump-and-treat systems. Additionally, this alternative could require injecting treated groundwater back into the aquifer, resulting in groundwater mounds which could potentially alter the directional flow of groundwater.

Under this alternative, the use of caps would prevent the infiltration of vadose zone contaminants to the groundwater. Pumping and treating would minimize the movement of groundwater contaminants to downgradient areas. Implementation of the Exclusive Future Land-Use Alternative in the Central Plateau geographic area would enhance groundwater remediation efforts in the Reactors on the River and All Other Areas geographic areas, as well as in the Central Plateau geographic area.

5.4.3.2.2 Surface Water. Construction of caps over waste sites, limited consolidation of waste materials, and groundwater remediation are expected to have only minimal effects on surface water. Groundwater remediation could require discharge of treated effluent to the Columbia River. As demonstrated in Appendix D, impacts are expected to be minimal, if any, as a result of treated effluent discharge.

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).

5.4.4.1 Impacts on Ecological Resources from the No-Action Alternative.

5.4.4.1.1 Habitat Disturbance. Under the No-Action Alternative, 50 ha (125 ac), which represents 0.7% of the shrub-steppe habitat in the Central Plateau geographic area, would be disturbed by surface decontamination and stabilization actions. Environmental monitoring and maintenance activities under the No-Action Alternative are expected to have only minimal impacts on the shrub-steppe habitat.

5.4.4.1.2 Species of Concern. Under the No-Action Alternative, there might be some direct mortality to small mammals and reptiles inside the boundaries of waste sites that undergo stabilization. These impacts are not expected to be significant.

5.4.4.1.3 Ecological Risk. 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 red-tailed hawk. All values of the chemical hazard index for plants and most of these for the mouse were equal to or greater than 1.0 (Table 5-33), 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 5-34), the level below which radiation exposure is not considered harmful to terrestrial organisms (IAEA 1992). Figures 5-12 through 5-19 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 Central Plateau geographic area. The maximum estimated contaminant concentrations represents worst-case conditions. However, these risk estimates are supported by past monitoring data, which indicate numerous instances of radionuclide uptake by plants and animals in or near the 200 Area waste sites. About 1,000 samples of measured radionuclide concentration in vegetation since 1965 indicate levels in excess of 10 pCi/g. Since 1965, about 800 samples have shown radionuclide uptake by animals, nearly all in small mammals or small mammal feces that resulted in concentrations greater than 10 pCi/g (WHC 1994b).

Table 5-33. Chemical 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	--	--	--	--

NOTE: These values are presented in scientific notation for brevity. In scientific notation, a value of 3.83 E+03 corresponds to 3,830; a value of 5.91 E-01 corresponds to 0.591.

Range: 1.33 E-07 to 6.30 E+04.

Bold italics indicates a hazard index greater than 1.0; -- indicates no data (see Appendix C).

Table 5-34. 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 rad/day.

5.4.4.1.4 Biodiversity. 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 should not result in significant population losses of sensitive species or habitat fragmentation.

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 elevated 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.

5.4.4.2 Impacts on Ecological Resources from the Exclusive Future Land-Use Alternative.

5.4.4.2.1 Habitat Disturbance. Under the Exclusive Future Land-Use Alternative, capping of waste sites, limited consolidation of waste materials, and groundwater pump-and-treat operations would disturb approximately 437 ha (1,079 ac), which is 6% of the shrub-steppe habitat in the Central Plateau geographic area (Figure 5-24).

Disturbance of shrub-steppe areas could 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 could be subjected to habitat fragmentation and displacement, or mortality. Noise and increased vehicle use in these areas could disturb wildlife within hearing or visual distance of remediation activities. This could result in startle behavior by some species and abandonment of nest or den sites.

Potential long-term impacts could include the permanent loss of habitat for species dependent on dense sagebrush. Disturbance of large areas, even if revegetated, could 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. Restoration efforts would reduce impacts on some habitats, but would not fully replace diverse plant communities that have developed over long time periods.

5.4.4.2.2 Species of Concern. No federally listed threatened or endangered species occur in the Central Plateau geographic area. Species of concern that might occur in this area include the ferruginous hawk, golden eagle, Swainson's hawk, sage sparrow, sage thrasher, loggerhead shrike, striped whipsnake, and possibly the Columbia milk-vetch. Potential short-term impacts under the Exclusive Future Land-Use Alternative could include the loss of habitat and prey-base for some species. This alternative could cause permanent loss of habitat for species of concern, resulting in further population losses and possible listing of candidate species as threatened or endangered under the *Endangered Species Act of 1973*.

5.4.4.2.3 Ecological Risk. The Exclusive Future Land-Use Alternative 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.

Figure 5-24. Exclusive Future Land-Use Alternative Impact on Shrub-Steppe Habitat, Central Plateau.

*5.4.4.2.4 **Biodiversity***. The Exclusive Future Land-Use Alternative could adversely impact 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 could fragment existing habitats and disrupt the connectivity among different habitats. These impacts could be significant in the short term, but long-term effects on biodiversity could be avoided or reduced through implementation of mitigation measures.

*5.4.4.3 **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 areas
- 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 restore the native plant community and 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
- rectifying or compensating, as necessary, for adverse impacts to biological resources to a degree that reflects the value of the resource and the severity of impact.

5.4.5 Air Quality

*5.4.5.1 **Impacts on Air Quality from the No-Action Alternative***. Generation of airborne pollutants under the No-Action Alternative would not exceed the quantities presently generated under Hanford operations. Present Hanford operations meet air quality standards (PNL 1995). No substantial impacts are expected from implementation of the No-Action Alternative.

*5.4.5.2 **Impacts on Air Quality from the Exclusive Future Land-Use Alternative***. Capping of waste sites and limited consolidation of waste materials would generate fugitive dust, possibly contaminated with radioactive particles. Cap construction on some waste sites in the Central Plateau could result in short-term airborne releases of some contaminants in concentrations exceeding guidelines. Stringent engineering practices and mitigation measures such as dust suppression are expected to maintain airborne particulates at levels similar to quantities presently generated under Hanford operations. Airborne pollutants also would be released in exhaust from equipment used for cap construction but are expected to remain below applicable standards. No significant impacts are expected from implementation of the Exclusive Future Land-Use Alternative in the Central Plateau geographic area.

Transportation of capping materials would generate fugitive dust along haul roads. The amounts of fugitive dust generated are not expected to exceed the amounts estimated for transporting wastes from other geographic areas (see Sections 5.2.5.2 and 5.3.5.2) or standards for fugitive dust. The dust generated from hauling capping materials to the Central Plateau geographic area is not expected to result in substantial adverse air quality impacts.

5.4.5.2.1 Potential Mitigation Measures. Potential mitigation measures to reduce air quality impacts include the use of dust suppression measures and covering haul trucks.

5.4.6 Noise

5.4.6.1 Noise Impacts from the No-Action Alternative. The No-Action Alternative for the Central Plateau geographic area would involve little or no change in noise impacts to the surrounding environment.

5.4.6.2 Noise Impacts from the Exclusive Future Land-Use Alternative. The Exclusive Future Land-Use Alternative involves the capping of waste sites, limited consolidation of waste materials, and groundwater remediation in the Central Plateau geographic area. Noisy construction equipment used in the operations could temporarily increase ambient noise levels. Noise levels generated by remediation 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 adversely affect humans or the environment.

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 Impacts to Cultural Resources from the No-Action Alternative.

5.4.7.1.1 Prehistoric and Historic Resources. Surface decontamination and waste site stabilization activities could disturb prehistoric and historic resources located within waste site boundaries. 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 that have been recorded in the Central Plateau geographic area could be affected.

5.4.7.1.1.1 Potential Mitigation Measures. Potential mitigation measures for the No-Action Alternative include the following:

- Avoiding cultural resource areas identified during project planning, whenever possible
- Conducting a survey of the affected areas, whenever practicable

- Before any ground disturbance activities, conducting consultations with the RL Cultural Resources Program Manager, 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)

- 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 remediation activities.

5.4.7.1.2 Areas of Concern to Native Americans. Potential direct and indirect impacts on Native American prehistoric sites described in Section 5.4.7.1.1 would be an issue of concern to Native Americans. In addition, this alternative would require continued access restrictions on traditional use areas and sacred sites important to Native Americans.

5.4.7.1.2.1 Potential Mitigation Measures. Mitigation measures to address issues of concern to Native Americans include:

- Consulting with Native American tribal governments/groups with regard to the potential impacts on areas that might concern them before implementation of project activities

- Considering recommendations provided by Native American tribal governments/groups in the development of project-specific cultural resource mitigation plans for proposed remediation activities

- Considering recommendations provided by Native American tribal governments and organizations in revegetation plans for proposed remediation activities

- Involving representatives of Native American tribal governments and organizations in archaeological monitoring during remediation activities.

5.4.7.2 Impacts to Cultural Resources from the Exclusive Future Land-Use Alternative.

5.4.7.2.1 Prehistoric and Historic Resources. This alternative would include capping of waste sites, limited consolidation of waste materials, and groundwater pump-and-treat operations, which could affect the same prehistoric and historic resources described under the No-Action Alternative. Because of the greater area of disturbance under this alternative, additional unrecorded sites could be affected. These impacts would be potentially significant, but could be mitigated.

5.4.7.2.1.1 Potential Mitigation Measures. Potential mitigation measures for the Exclusive Future Land-Use Alternative include the measures identified for the No-Action Alternative presented in Section 5.4.7.1.1.1.

5.4.7.2.2 Areas of Concern to Native Americans. 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 use areas or areas of religious use) are affected. This alternative would require continued restrictions on the use of traditional use areas and sacred sites important to Native Americans.

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 and could be used for Native American and other uses.

5.4.7.2.2.1 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 Impacts on Visual and Aesthetic Resources from the No-Action Alternative. Continued environmental monitoring and maintenance activities and stabilization of waste sites are not expected to have significant impacts on visual and aesthetic resources.

5.4.8.2 Impacts on Visual and Aesthetic Resources from the Exclusive Future Land-Use Alternative. Under the Exclusive Future Land-Use Alternative, capping of waste sites, limited consolidation of waste materials, and groundwater pump-and-treat operations could have short-term impacts on visual and aesthetic resources. Construction activities would generate fugitive dust, which could reduce visual clarity and obscure viewsheds. In addition, the capping of waste sites could result in long-term impacts on visual and aesthetic resources in the Central Plateau geographic area. The construction of caps on waste sites in the Central Plateau geographic area would permanently alter the landscape. 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 Impacts from the 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 result in short-term 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 human health 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 5.8.3.

The risk assessment performed for the No-Action Alternative also included evaluation of an accident scenario. The scenario involves a range fire that burns a 2.6-km^2 (1-mi^2) area, releasing 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 (see 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 (Table 5-35). 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).

Table 5-35. 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.

5.4.9.2 Human Health Impacts from the Exclusive Future Land-Use Alternative. The Exclusive Future Land-Use Alternative would be achieved through a combination of institutional controls, capping of contaminated areas, limited consolidation of waste materials, 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 preventing exposure to contamination. The combination of capping wastes, groundwater remediation, and groundwater use restrictions would reduce risks to levels at or below the target risk range of 10^{-4} to 10^{-6}. Risks could be higher if activity restrictions are violated.

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 of 5,000 mrem/yr for radiation workers (see Table 5-35). The estimated doses at the nearest public access location and the site boundary are less than 10% of the 10 mrem limit. Therefore, the adverse impacts of accidents under the Exclusive Future Land-Use Alternative on human health are not considered substantial.

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 remediation activities or to reduce the severity of accident impacts. Appropriate engineering and administrative measures would be applied during routine remediation 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 Health and Safety

This section estimates potential impacts to occupational health and safety 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[7] identified in Appendix H for each future land-use alternative with Bureau of Labor Statistics and DOE incident rates (DOE 1995k).

5.4.10.1 Occupational Impacts from the 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 from the Exclusive Future Land-Use Alternatives. Table 5-36 presents the potential occupational impacts for the Exclusive Future Land-Use Alternative for the Central Plateau geographic area based on Bureau of Labor Statistics incident rates. Total cases include all work-related deaths and illnesses, and those work-related injuries that result in loss of

[7]Labor hours associated with decommissioning and groundwater remediation activities were not included in this analysis.

Table 5-36. Summary of Occupational Impacts per Bureau of Labor Statistics.

Future Land-Use Alternative (labor hours)	Estimated Total Cases	Estimated Lost Workday Cases	Estimated Nonfatal Cases Without Lost Workdays	Estimated Lost Workdays
Exclusive (6,339,920)	439	242	197	6,427

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 (subject to rounding error). 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 5-37 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 Bureau of Labor Statistics 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.

Table 5-37. Summary of Occupational Impacts per DOE Statistics.

Future Land-Use Alternative (labor hours)	Estimated Total Cases	Estimated Total Fatalities	Estimated Lost Workday Cases	Estimated Lost Workdays
Exclusive (6,339,920)	439	<1	242	6,427

5.4.10.2.1 Potential Mitigation Measures. Potential mitigation measures include continued emphasis on safety awareness and worker training.

5.4.11 Excavation Volumes, Material Requirements, and Costs

The assumptions and methodology used to estimate excavation volumes, material requirements, and costs are described in Appendix H. Excavation volumes and cost estimates for each alternative are summarized in Table 5-38. Capping material volumes in Table 5-38 were estimated assuming that a modified RCRA cap would be implemented at nearly all waste sites in the Central Plateau. Appendix E and Section 5.11 discuss material volumes that would be required for implementation of the reference cap design, which provides for a more conservative estimate of cumulative impacts to quarry and borrow sites.

5.4.11.1 Excavation Volumes, Material Requirements, and Costs for the 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).

Table 5-38. Comparison of Excavation Volumes, Material Requirements, and Costs Associated with the Central Plateau Geographic Area Future Land-Use Alternatives.

Resources	Alternatives	
	No Action	Exclusive
Capping Materials (LCM[a]) (x 10^6)	0	17.5[b]
Groundwater Treatment Costs in 1994 Dollars (millions)	0	172
Areas of Disturbance (ha)	280	1,240
Project Cost in 1995 Dollars (millions)	2,424[c]	1,275[b]

[a]Loose Cubic Meter (LCM) = 1.31 Loose Cubic Yard (LCY), ha = 2.47 ac.
[b]Value represents installation of Modified RCRA caps.
[c]Cost for 100 years of institutional control for the entire Hanford Site (see Table 5-25). The costs are not broken down by geographic area.

The costs of implementing the No-Action Alternative are estimated to be more than $2.4 billion for 100-years of institutional controls. These costs, which are summarized in Table 5-25, 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.

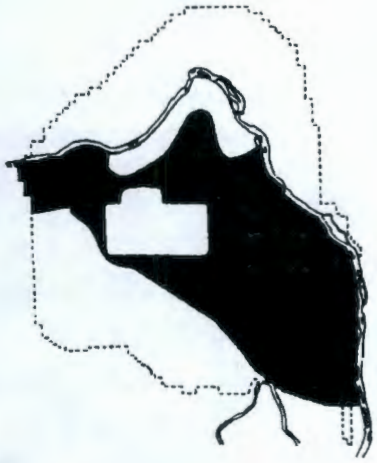
5.4.11.2 Excavation Volumes, Material Requirements, and Costs for the Exclusive Future Land-Use Alternative. The total area disturbed by remedial actions is 1,240 ha (3,063 ac). The costs of remedial actions are approximately $1.3 billion. This includes approximately 1,138 ha (2,812 ac) that would be capped, and represents an irretrievable commitment of resources.

5.4.11.2.1 Potential Mitigation Measures. Additional 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.

All Other Areas

96134592.2092

5.5 All Other Areas Geographic Area



The All Other Areas geographic area comprises approximately 624 km^2 (241 mi^2) in the 300, 400, 600, 1100, and 3000 Areas of the Hanford Site.

The 300 Area is located north of the City of Richland and covers 1.5 km^2 (0.6 mi^2). Wastes in this area have resulted from the fuel fabrication process and various research and development (R&D) projects.

The 400 Area, located southeast of the 200 East Area, is the site of the Fast Flux Test Facility (FFTF). The DOE has announced plans to close the FFTF and its support facilities. Recently, however, a consortium of private companies have expressed an interest in purchasing and operating the facility. Much of the 400 Area overlies groundwater contaminant plumes.

The 600 Area includes all of the lands within the Hanford Site not occupied by the 100, 200, 300, 400, 1100, and 3000 Areas. Land uses in the 600 Area include a 41-ha (100-ac) tract leased by the DOE to the State of Washington and subleased to US Ecology, Inc. for the disposal of commercial low-level waste (LLW); the Laser Interferometer Gravitational-Wave Observatory (LIGO) which, when completed, will detect gravitational waves for research purposes; and a Reference Repository Site once used as the principal borehole and exploratory shaft for a candidate Basalt Waste Isolation Program, which was terminated in 1987. The 1100 Area serves as the central warehousing, vehicle maintenance, and transportation operations center for the Hanford Site. Waste sites in the 1100 Area have been remediated, and are not within the scope of this EIS.

The 3000 Area, located northeast of the 1100 Area, accommodates engineering and construction support facilities. The 3000 Area is relatively uncontaminated, and has been declared excess by the DOE and turned over to the General Services Administration for disposition.

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, technetium-99, and 1,2-dichloroethylene. Potential impacts of the No-Action and future land-use alternatives for this area are discussed in the following sections. The impacts and potential mitigation measures are summarized in Chapter 3.0, Table 3-15.

5.5.1 Geology

5.5.1.1 Impacts on Geological Resources from the No-Action Alternative. Under the No-Action Alternative, past-practice waste sites and TSD units 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 minimal impacts on the geologic resources of this area.

5.5.1.2 Impacts on Geological Resources from the Restricted Future Land-Use Alternative (R1). This alternative would involve partial excavation and removal of contaminated soils at past-practice waste sites, closure of TSD units, groundwater remediation, 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.

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 require the long-term continuation of existing restrictions on public access to geologic resources. As in the No-Action Alternative, such access restrictions are expected to have minimal adverse effects on the commercial development of geologic resources.

Features relevant to the study of regional glacial flood events are found in the All Other Areas geographic area. A small number of these features could be destroyed during remediation. This would cause minimal adverse impact because similar features would remain available for study elsewhere within the Hanford Site.

Restricted Future Land-use Alternative (R1): Excavation Assumptions

Under this alternative, the desired remediation levels for waste sites would be determined through the CERCLA process, using the applicable exposure scenario (i.e., recreational, residential, or industrial). Excavation and removal of contaminated materials in waste sites would proceed until the contaminant concentrations remaining in the soils meet the desired remediation levels.

Because the extent of excavation remains to be determined, it was necessary to make assumptions to estimate excavation volumes for this analysis. The maximum excavation depth was assumed to be 4.6 m (15 ft) below the ground surface. This value, which is based on the State of Washington's *Model Toxics Control Act of 1989*, was combined with Waste Information Data System data to calculate the volume of material to be excavated under this alternative. The models used to calculate volumes are described in greater detail in Appendix H of this EIS.

5.5.1.3 Impacts on Geological Resources from the Restricted Future Land-Use Alternative (R2). The Restricted Future Land-Use Alternative (R2) would involve constructing caps over past-practice waste sites and TSD units, and groundwater remediation. Estimated volumes of capping materials used for this alternative are presented in Section 5.5.11. This alternative could result in significant depletion of the geologic resources in quarry and borrow sites. The locations of these sites and the reference cap design are described in Appendix E of this EIS. The impacts on geologic resources are discussed in Section 5.11 as irreversible and irretrievable commitments of resources.

Because contamination would be left in place, this alternative would require 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 are not expected to significantly affects the commercial development of geologic resources. This alternative would have minimal impacts on natural geologic features.

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 design.

5.5.2 Soils

The potential impacts of the alternatives on soils in the All Other Areas geographic area are summarized in Table 5-39.

Table 5-39. 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)	50 (124)	94 (234)
Burbank loamy sand	10 (26)	36 (91)	54 (136)
Ephrata sandy loam	14 (36)	43 (107)	52 (130)
Kiona silt loam	4 (10)	2 (4)	3 (9)
Esquatzel silt loam	<0.4 (<1)	1 (3)	2 (6)
Warden silt loam	0	74 (186)	74 (186)
Total	45 (114)	206 (515)	280 (700)

*Areal impact information generated from the GIS; includes area disturbed for partial excavation, cap construction, trample zones, effluent lines and haul roads.
GIS = geographic information system.

5.5.2.1 Impacts on Soils from the No-Action Alternative. Under the No-Action Alternative, surface decontamination and/or stabilization of past-practice waste sites and TSD units would disturb approximately 45 ha (114 ac) of soils (see Table 5-39). Potential short-term impacts on soils under this alternative could include some soil compaction and an added potential for wind erosion. If appropriate mitigation measures are implemented, long-term impacts would be minimal. 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:

- 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.

5.5.2.2 Impacts on Soils from the Restricted Future Land-Use Alternative (R1). Remediation to restricted use (R1) could significantly impact soils in the All Other Areas geographic area. Remediation activities would include excavating, loading, and hauling contaminated soil from past-practice waste sites and TSD units; constructing groundwater remediation systems; restoring sites; and the use of institutional controls. The Restricted Future Land-Use Alternative (R1) would disturb approximately 206 ha (515 ac) of soils in this areas (see Table 5-39).

The use of heavy equipment, such as scrapers and trucks, could compact soils at waste sites. 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 5-40).

Table 5-40. 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
Esquatzel silt loam	Severe	Not 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.

Soil disturbance during remediation activities also could 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 and Burbank loamy sand (see Table 5-40). 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 erosion.

5.5.2.3 ***Impacts on Soils from the 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 units, constructing groundwater remediation systems, and restoring sites. Remediation activities would disturb approximately 280 ha (700 ac) of soils (see Table 5-39), and

could 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 the Restricted Future Land-Use Alternative (R1).

5.5.3 Water Resources

5.5.3.1 Impacts on Water Resources from the 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 no groundwater remediation would occur under 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.

5.5.3.1.1 Groundwater. The No-Action Alternative would involve no treatment of existing groundwater contamination, and would result in minimal 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 drinking water standards, requiring long-term restrictions on withdrawal and use of groundwater.

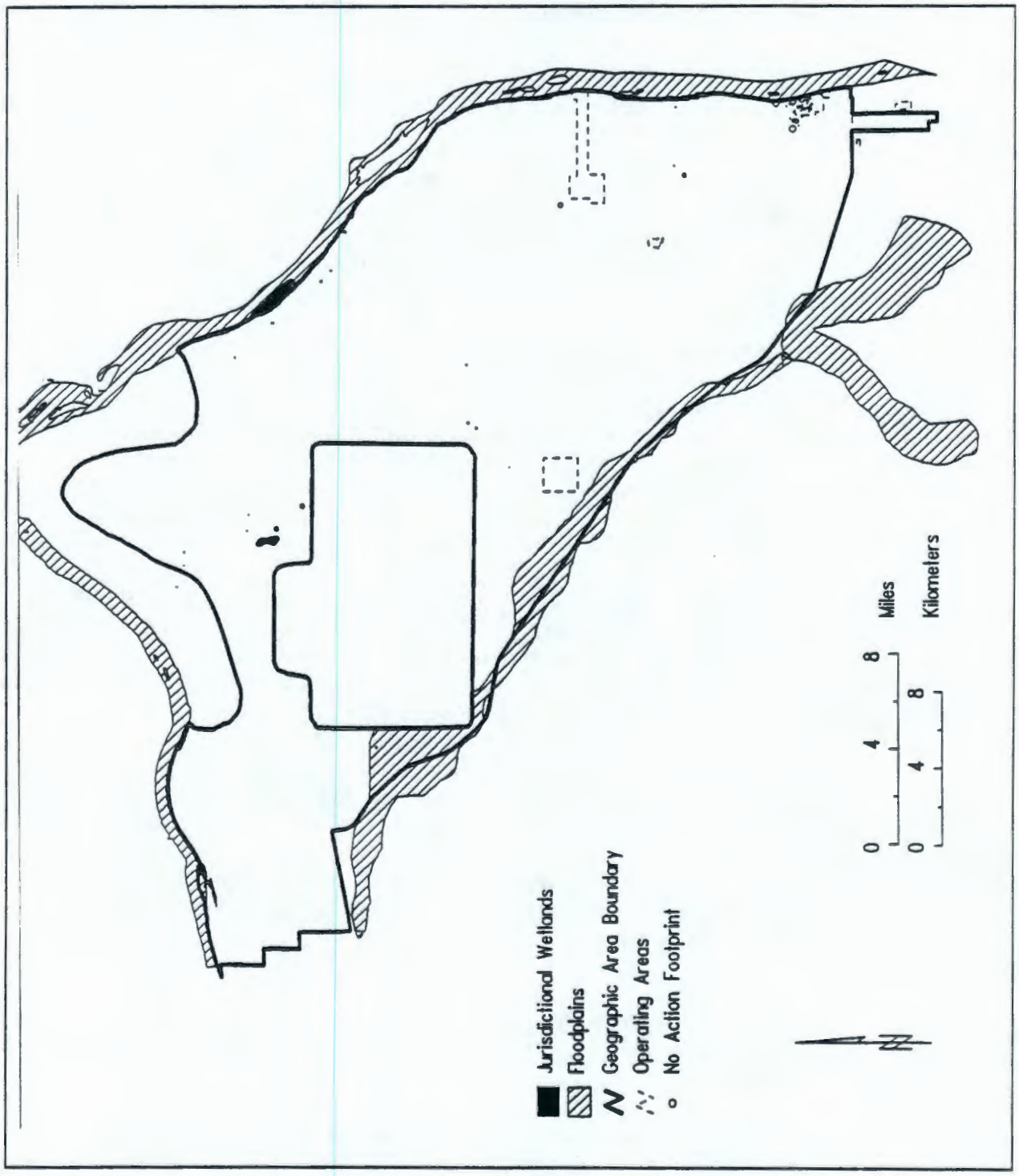
5.5.3.1.2 Surface Water. The No-Action Alternative is not expected to degrade Columbia River water quality in the short or long term. Surface decontamination and stabilization of past-practice waste sites and TSD units could result in increased runoff and soil erosion, as described in Section 5.5.2.1. The mitigation measures described in that section for soils could 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 drinking water standards and are not expected to increase. Because surface water quality is not expected to deteriorate, downstream surface water supplies for municipal and other uses should not be affected.

5.5.3.1.2.1 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.

5.5.3.1.3 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 5-25), which represents less than 0.1% of the total Columbia River floodplain on the Hanford Site.

Figure 5-25. 100-Year Floodplain and Wetland Areas Impacted under the All Other Areas No-Action Alternative.



5.5.3.2 Impacts on Water Resources from the 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 are not expected to adversely affect the use of groundwater because groundwater use during remediation activities would continue to be restricted. Additionally, this alternative could require injecting treated groundwater back into the aquifer, resulting in groundwater mounds which could potentially alter the directional flow of the groundwater.

Groundwater remediation under the Restricted Future Land-Use Alternative (R1) would reduce radionuclide and hazardous chemical concentrations in the groundwater. Groundwater remediation is not expected to have 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 migration from the vadose zone to groundwater.

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 alter groundwater flow patterns, treated groundwater could be reinjected or discharged to the river. See Appendix D for additional details on options for discharging treated groundwater. The potential effects on Columbia River flows are expected to be minimal, given the high flow rates in the river.

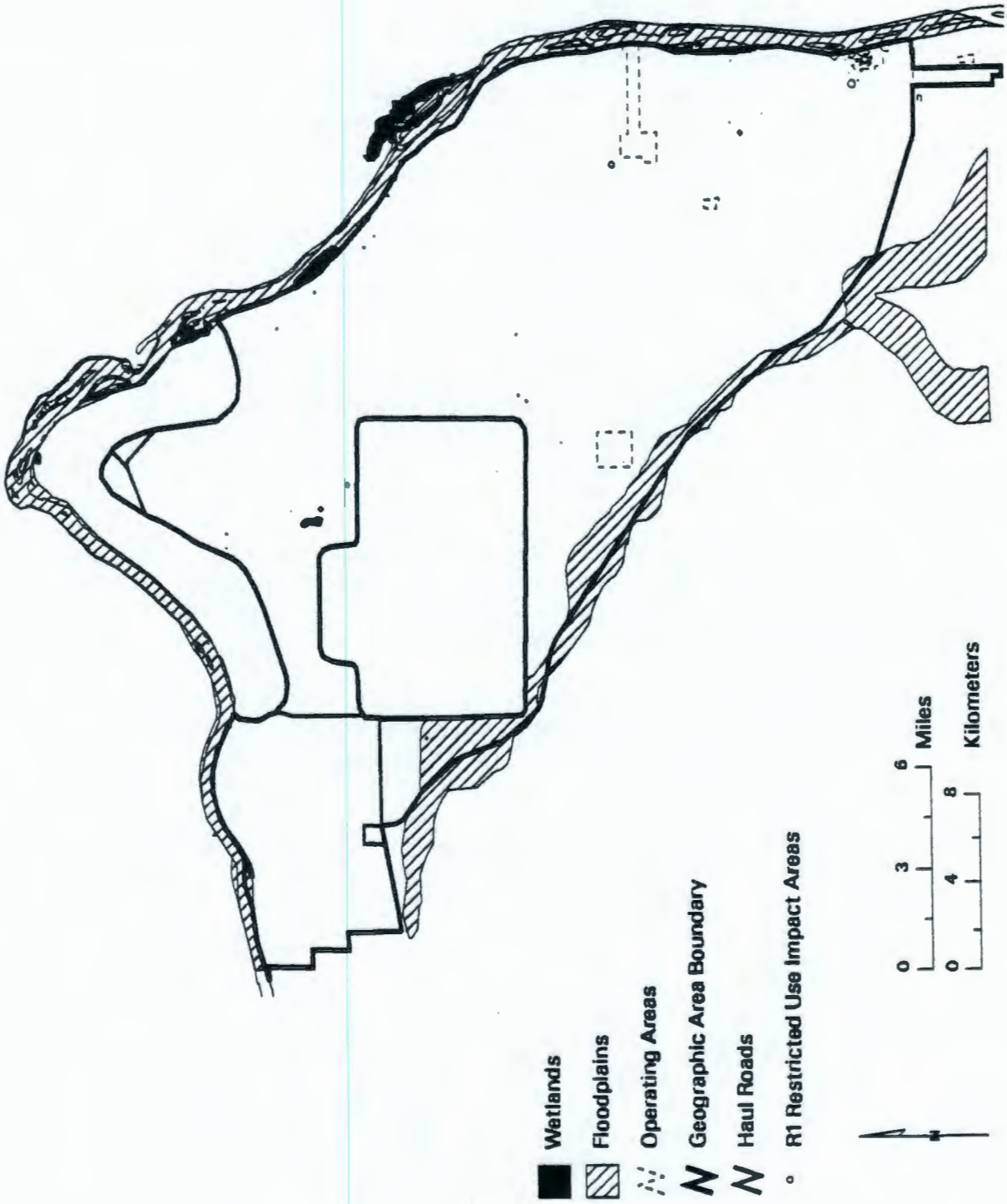
Groundwater remediation could reduce the rate of groundwater movement toward the Columbia River because pumping wells would reduce the hydraulic head gradient toward the river. Eventually, the groundwater contaminant concentrations would be reduced below desired remediation levels, so the pumping could be discontinued and groundwater allowed to discharge freely to the river.

Groundwater remediation could require discharge of treated effluent 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 (*Clean Water Act of 1977*), and are not expected to adversely affect water quality in the Columbia River. Calculations presented in Appendix D indicate that there would be little, if any, impacts to the Columbia River and its ecosystems as a result of treated effluent discharge to the 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.

5.5.3.2.3 Floodplains. Excavation of contaminated soils under the Restricted Future Land-Use Alternative (R1) is not expected to adversely impact the 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 5-26). 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 discussed further in the Floodplain/Wetlands Assessment (Appendix J).

Figure 5-26. 100-Year Floodplain and Wetland Areas Impacted under the All Other Areas Restricted Future Land-Use Alternative (R1).



5.5.3.3 Impacts on Water Resources from the 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 substantial impact, as infiltration is not considered a significant source of groundwater recharge under natural conditions (DOE-RL 1993b).

5.5.3.3.1 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 installed over waste sites would prevent precipitation from percolating into the vadose zone and transporting contaminants to groundwater. Groundwater remediation is not expected to have significant adverse impacts on groundwater quality, and would have beneficial impacts over the long term.

5.5.3.3.2 Surface Water. Remediation to restricted use (R2) should not have adverse impacts on the water quality of the Columbia River. Over the long term, caps over waste sites and groundwater remediation would reduce contamination entering the Columbia River. Groundwater remediation could require discharge of treated effluent directly to the Columbia River. Impacts resulting from this discharge are expected to be similar to those discussed for the Restricted Future Land-Use (R1) (Section 5.5.3.2.2). 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.

5.5.3.3.3 Floodplains. Construction of caps over past-practice waste sites and TSD units under the Restricted Future Land-Use Alternative (R2) are not expected to adversely impact the 100-year 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 5-27). These acreages represent less than 2% of the Columbia River floodplain and less than 0.1% 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.

5.5.4 Ecology

The levels of habitat disturbance associated with each alternative are summarized in Table 5-41.

Table 5-41. 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)	91 ha (229 ac)	134 ha (329 ac)
Species of Concern[b]	0	2	1
Wetlands[c]	0	0	0

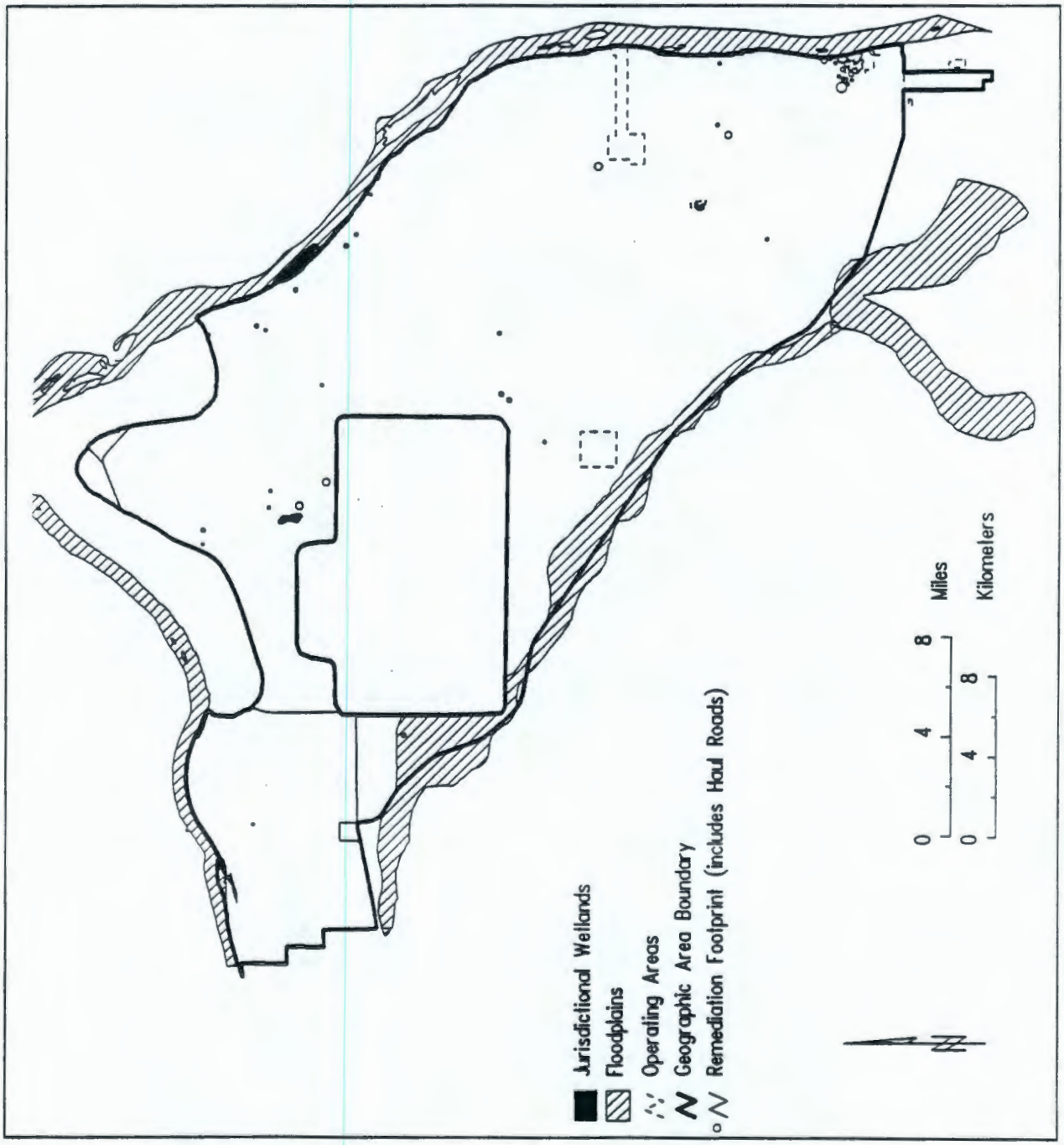
[a]Areal impact information generated from the GIS; includes potential disturbance associated with excavation, cap construction, trample zones, and haul roads.

[b]Includes Swainson's hawk and loggerhead shrike habitat within zone of disturbance.

[c]National Wetlands Inventory Data.

GIS = geographic information system.

Figure 5-27. 100-Year Floodplain and Wetland Areas Impacted under the All Other Areas Restricted Future Land-Use Alternative (R2).



5.5.4.1 Impacts on Ecological Resources from the No-Action Alternative.

5.5.4.1.1 Habitat Disturbance. 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 5-41). Potential impacts of waste site stabilization could 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 in or near waste site boundaries. Surface decontamination and waste site stabilization should not affect wetlands in the All Other Areas geographic area. Environmental monitoring and maintenance activities are expected to result in only minimal impacts on habitats.

5.5.4.1.2 Species of Concern. The No-Action Alternative is not expected to have significant impacts on species of concern in the All Other Areas geographic area.

5.5.4.1.3 Ecological Risk. 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 (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 (Table 5-42), the level below which radiation exposure is not considered harmful to terrestrial organisms (IAEA 1992). The distribution of potential chemical and radionuclide exposures for the entire Hanford Site is illustrated in Figures 5-12 through 5-19.

Table 5-42. 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

NOTE: These values are presented in scientific notation for brevity. In scientific notation, a value of 3.83 E+03 corresponds to 3,830; a value of 5.91 E-01 corresponds to 0.591.
Range: 1.05 E-11 to 5.18 E-03.

The chemical hazard index for ecological receptors in the All Other Areas geographic area ranged from 1.87 x 10^{-7} to 1.55 x 10^{3} (Table 5-43). One value for plants and one value for the mouse were 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 allow only limited conclusions about potential chemical hazards to ecological receptors. Waste site stabilization under the No-Action Alternative could reduce the potential for adverse effects.

Table 5-43. Chemical 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 a hazard index greater than 1.0; -- indicates no data (see Appendix C).

5.5.4.1.4 Biodiversity. The No-Action Alternative is not expected to have significant impacts on biodiversity in the short term. With adequate mitigation, 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.

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.

5.5.4.1.4.1 Potential Mitigation Measures. Potential mitigation measures for the No-Action Alternative include the following:

- restricting waste site stabilization activities to the immediate waste site area and avoid disturbing shrub-steppe habitat, whenever possible
- revegetating decontaminated and stabilized areas to provide habitat for small mammals and reptiles, and to reduce additional habitat loss from soil erosion
- continuing monitoring of wildlife and vegetation for potential adverse exposures to hazardous chemicals and radionuclides.

5.5.4.2 Impacts on Ecological Resources from the Restricted Future Land-Use Alternative (R1).

5.5.4.2.1 Habitat Disturbance. The Restricted Future Land-Use Alternative (R1) would involve excavating, loading, and hauling contaminated soil from past-practice waste sites and TSD units; constructing groundwater remediation systems; restoring sites; and the use of institutional controls. Implementation of the Restricted Future Land-Use Alternative (R1) would result in destruction of 91 ha (229 ac) of shrub-steppe habitat in All Other Areas (Figure 5-28 and Table 5-41). Disturbance of these areas could 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, could be subjected to habitat fragmentation, displacement, or mortality. Noise and increased vehicle use in these areas could disturb wildlife within hearing or visual distance of remediation activities. This could result in startle behavior by some species and abandonment of nest or den sites.

Disturbance of large areas, even if revegetated, could create conditions favorable to introduce noxious weed species 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.

5.5.4.2.2 Species of Concern. The Restricted Future Land-Use Alternative (R1) could have potentially significant impacts on species of concern in the All Other Areas geographic area. The remediation 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 small 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 Piper's daisy and northern wormwood. Remediation activities potentially could affect the potential habitats of both of these plant species. 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 habitats, but would not fully replace diverse plant communities that have developed over long periods of time.

5.5.4.2.3 Ecological Risk. 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 short-term impacts, but could be reduced by implementation of mitigation measures for soils (Section 5.5.2), water resources (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.

5.5.4.2.4 Biodiversity. The Restricted Future Land-Use Alternative (R1) could adversely impact 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

Figure 5-28. Restricted Future Land-Use Alternative (R1) Impact on Shrub-Steppe Habitat, All Other Areas Geographic Area.

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 could fragment existing habitats and disrupt the connectivity among different habitats. These impacts could be significant in the short term; long-term impacts to biodiversity could be avoided or reduced through implementation of mitigation measures.

5.5.4.2.4.1 Potential Mitigation Measures. Potential mitigation measures for ecological resources under the Restricted Future Land-Use Alternative (R1) include the following:

- Minimizing the amount of area disturbed during remediation by restricting disturbance to an area not exceeding the trample zone around each waste site
- Revegetating all disturbed areas with a mixture of native vegetation including shrubs, grasses, and forbs
- Performing site restoration contemporaneous with remediation activities to help offset habitat loss in the short term, limit the spread of noxious weeds, and reduce the time required to rehabilitate disturbed areas
- Limiting unnecessary off-road travel during remediation to avoid additional damage to shrub-steppe
- Using established travel routes whenever possible, to concentrate traffic and associated noise in specific areas
- Using silt fences to control erosion and spray water on dry areas during excavation
- Reestablishing shrub-steppe habitat in other suitable locations onsite in cases where shrub-steppe cannot be restored or developed in remediated waste sites
- Excluding human activity within a 250-m (807-ft) buffer around active Swainson's hawk nests from April to September
- Avoiding disturbance of habitat known to contain loggerhead shrike nests and foraging areas from March 1 to September 30
- Including plant species of concern in revegetation efforts
- rectifying or compensating, as necessary, for adverse impacts to biological resources to a degree that reflects the value of the resource and the severity of impact.

5.5.4.3 Impacts on Ecological Resources from the Restricted Future Land-Use Alternative (R2).

5.5.4.3.1 Habitat Disturbance. The Restricted Future Land-Use Alternative (R2) would involve constructing caps over past-practice waste sites and TSD units, 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 108 ha (270 ac) or 0.7% of the shrub-steppe habitat in the All Other Areas geographic area (Figure 5-29 and Table 5-41). This alternative would have impacts similar to those described for the Restricted Future Land-Use Alternative (R1).

*5.5.4.3.2 **Species of Concern**.* The Restricted Future Land-Use Alternative (R2) could adversely affect 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).

Remediation activities potentially could affect populations of Piper's daisy and northern wormwood, if the activities are implemented in their habitats. Over the long term, the additional habitat losses could result in further population decline and possible listing as threatened or endangered species under the *Endangered Species Act of 1973*.

*5.5.4.3.3 **Ecological Risk**.* 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.

*5.5.4.3.4 **Biodiversity**.* 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.

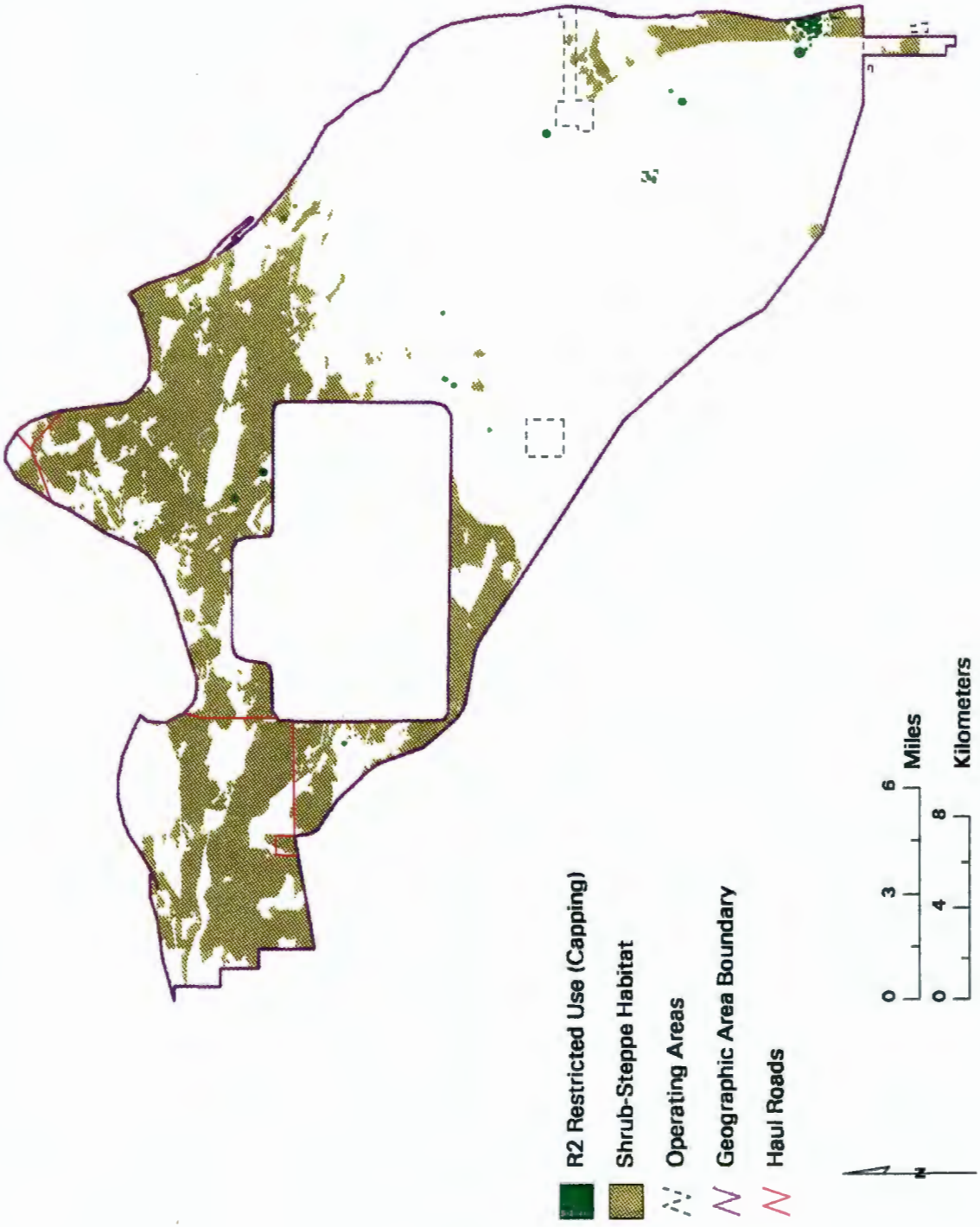
5.5.4.3.4.1 Potential Mitigation Measures. Potential mitigation measures for ecological resources for the Restricted Future Land-Use Alternative (R2) are the same as for the Restricted Future Land-Use Alternative (R1).

5.5.5 Air Quality

*5.5.5.1 **Impacts on Air Quality from the No-Action Alternative**.* The No-Action Alternative would involve surface decontamination and stabilization of past-practice waste sites and TSD units. 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 using other methods of dust suppression where soil is disturbed and revegetating exposed areas to minimize long-term dust generation.

Figure 5-29. Restricted Future Land-Use Alternative (R2) Impact on Shrub-Steppe Habitat, All Other Areas Geographic Area.



5.5.5.2 Impacts on Air Quality from the 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 units; constructing groundwater remediation systems; restoring sites; and the use of institutional controls. 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 to which workers could be exposed are within appropriate protective standards (Table 5-44).

The results presented in Table 5-44 indicate that remediation activities could have short-term air quality impacts to members of the public located immediately offsite. Estimated concentrations of airborne radionuclides to which the general public could be exposed are at or somewhat above guideline concentrations. These short-term impacts would cease when remediation was completed.

Several factors lend conservatism to this analysis. For example, the estimated downwind concentrations of uranium-238 in Table 5-44 were based on the highest known concentration of uranium-238 in any waste site in the 300 and 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. Conservative factors that must be considered when comparing calculated concentrations to standards are discussed in Section 5.2.5.2.

Concentrations in Table 5-44 are consequences of remediation 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. To account for this possibility, 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 5-45). The results presented in Tables 5-44 and 5-45, 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 the ERDF 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 and haul roads with water or other dust suppressants, 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 might 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 Impacts on Air Quality from the Restricted Future Land-Use Alternative (R2). The Restricted Future Land-Use Alternative (R2) would include placing caps over past-practice waste sites and TSD units, constructing groundwater remediation systems, and restoring sites. Airborne

Table 5-44. 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}[f]	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[g]	0.10, annual average
Products of Fuel Combustion ($\mu g/m^3$)	total suspended particulates	72	15,000, 8-hr average	3.9	150, 24-h average
	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 the maximum predicted ground-level concentrations that workers could be exposed.

[c]Occupational standards for fugitive dust and combustion products are Permissible Exposure Limits 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 peak 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 standards for SO_2 and total suspended particulates are Washington State standards. Guidelines for airborne radionuclides are Derived Concentration Guides listed in DOE Order 5400.5 (DOE 1993a).

[f]PM_{10} = particulate matter less than 10 micrometers in size.

[g]The concentration of U-238 appears to exceed the air quality standard. The estimated concentration, however, is a level that would be expected during normal daily working hours, whereas the air quality standards are average levels during a 365-day year. Using conservative background concentrations during nonworking periods, and with consideration of changes in wind direction, it can be shown that the averaged levels of U-238 would not exceed the air quality standard.

Table 5-45. 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}[f]	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[g]	0.02, annual average
	U-238	5.0	300, annual average	0.5[g]	0.10, annual average
Products of Fuel Combustion ($\mu g/m^3$)	total suspended particulates	120	15,000, 8-hr average	13	150, 24-h average
	carbon monoxide	790	55,000, 8-hr average	84	9,000, 8-hr average
	nitrogen dioxide	1,200	9,000, 8-hr average	130[g]	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 the maximum predicted ground-level concentrations that workers could be exposed.

[c]Occupational standards for fugitive dust and combustion products are Permissible Exposure Limits 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 peak 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 standards for SO_2 and total suspended particulates are Washington State standards. Guidelines for airborne radionuclides are Derived Concentration Guides listed in DOE Order 5400.5 (DOE 1993a).

[f]PM_{10} = particulate matter less than 10 micrometers in size.

[g]The concentrations of Pu-239, -240, U-238, and NO_2 appear 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 with consideration of changes in wind direction, it can be shown that averaged levels of Pu-239, -240, U-238, and NO_2 would not exceed the air quality standard.

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 5-44 and 5-45, because less contaminated materials would be disturbed.

The hauling of materials from borrow areas for construction of caps would generate fugitive dust emissions similar to those generated by hauling wastes to the ERDF (see Section 5.3.5.2). No substantial short or long-term impacts are 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 Impacts from the No-Action Alternative. The No-Action Alternative would result in little or no change in noise levels in the surrounding environment and is not expected to result in significant noise impacts.

5.5.6.2 Noise Impacts from the Restricted Future Land-Use Alternative (R1). This alternative involves excavating, loading, and hauling contaminated soil from past-practice waste sites and TSD units, constructing groundwater remediation systems, restoring sites; and the use of institutional controls. 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 more conservative scenario for unrestricted use, adverse noise impacts also are expected to be less. 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 are not expected to 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 and excavation personnel.

5.5.6.3 Noise Impacts from the Restricted Future Land-Use Alternative (R2). This alternative involves constructing caps over past-practice wastes and TSD units, constructing groundwater remediation systems, and restoring sites. Because associated remediation activities would be less intense than those associated with the Restricted Future Land-Use Alternative (R1) 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 and noise impacts of this alternative are not expected to be significant.

5.5.7 Cultural Resources

5.5.7.1 Impacts to Cultural Resources from the No-Action Alternative.

5.5.7.1.1 Prehistoric Resources. The No-Action Alternative could have significant impacts on prehistoric 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 units, 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.

5.5.7.1.1.1 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 RL Cultural Resources Program Manager, 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 if there is no potential health risk to field investigators.

- Whenever 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 if it does not pose a health risk to the archaeological monitor.

- An interpretive program outlining the history of the Hanford Site would be presented to personnel involved in the remediation and maintenance activities to foster greater awareness and sensitivity for the area's cultural resources.

5.5.7.1.2 Historic Resources. 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. These resources include materials and structures related to the Manhattan Project and the World War II effort as well as items and structures that are representative of the

Cold War period. Current surveillance and maintenance activities attempt to maintain and stabilize the existing structures within the area to ensure that the structures are not unduly subjected to weathering and age.

5.5.7.1.2.1 Potential Mitigation Measures. Potential mitigation measures for Historic Resources under the No-Action Alternative include the following:

- preparing building construction evaluations
- documenting all historic structures determined to be eligible for the National Register in accordance with the Secretary of the Interior's Guidelines for Historic Architectural and Engineering Documentation
- monitoring of potentially historic sites for essential repair and maintenance work
- restricting access to historic sites to authorized personnel.

5.5.7.1.3 Areas of Concern to Native Americans. As discussed in Section 5.5.7.1, the potential for adverse 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 ongoing traditional cultural uses are affected. This alternative would continue the existing restrictions on the use of some traditional use areas 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 use under the No-Action Alternative.

5.5.7.1.3.1 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
- considering recommendations provided by Native American tribal governments and organizations in the development of project-specific cultural resource mitigation plans for proposed remediation activities
- considering recommendations provided by Native American tribal governments and organizations in revegetation plans for proposed remediation activities
- involving representatives of Native American tribal governments and organizations in archaeological monitoring during remediation activities.

5.5.7.2 Impacts to Cultural Resources from the Restricted Future Land-Use Alternatives (R1 and R2).

5.5.7.2.1 Prehistoric Resources. The Restricted Future Land-Use Alternatives (R1 or R2) could have potentially 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.

5.5.7.2.1.1 Potential Mitigation Measures. Potential mitigation measures for the Restricted Future Land-Use Alternatives (R1 and R2) would be the same as those for the No-Action Alternative.

5.5.7.2.2 Historic Resources. A single historic resource, a livestock water cistern, was identified within the Restricted Future Land-Use Alternative (R2) impact areas. Other historic sites and structures that have not been recorded could also 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 during remediation activities.

5.5.7.2.2.1 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.

5.5.7.2.3 Areas of Concern to Native Americans. The potential for adverse 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. Remedial actions associated with these alternatives could encroach on the traditional use areas and cultural properties of the Native Americans. Major excavations of sites that contain artifacts or human remains, or are of spiritual importance to Native Americans, would be significant because the sites would be unavoidably altered.

Implementation of either of the Restricted Future Land-Use Alternatives would reduce potential exposures to contamination and would 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.

5.5.7.2.3.1 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 Impacts on Visual and Aesthetic Resources from the No-Action Alternative. The No-Action Alternative would involve surface decontamination and/or stabilization of past-practice waste sites and TSD units, and continuation of existing environmental monitoring activities. These activities are not expected to result in significant short- or long-term impacts on visual and aesthetic resources.

5.5.8.2 Impacts on Visual and Aesthetic Resources from the Restricted Future Land-Use Alternative (R1). Short-term impacts on visual resources could occur under the Restricted Future Land-Use Alternative (R1). Remediation activities would include excavating, loading, and hauling contaminated soil from past-practice waste sites and TSD units; constructing groundwater remediation systems, restoring sites; and the use of institutional controls. During the construction period, excavation activities would alter the natural terrain. Stockpiled soil would be located along open excavations while remediation activities were occurring. The sites 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. Groundwater treatment facilities are not likely to have a visual impact. 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 remediation activities in other areas
- restoring remediated areas by recontouring excavations to approximate original conditions and revegetating with native species.

5.5.8.3 Impacts on Visual and Aesthetic Resources from the Restricted Future Land-Use Alternative (R2). The Restricted Future Land-Use Alternative (R2) would involve placing caps over past-practice waste sites and TSD units, constructing groundwater remediation systems, and restoring sites. The caps could adversely affect visual and aesthetic resources, depending on the design used. If the reference cap design 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 the rigid geometric design and large size of the caps would 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 probably 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 using the following:

- surface markers designed to be compatible with the surrounding landscape
- natural materials and native vegetation in cap construction to minimize contrast with the surrounding landscape
- the RCRA Subtitle C cap or Modified RCRA cap instead of the reference cap design.

5.5.9 Human Health Risks

5.5.9.1 Human Health Impacts from the No-Action Alternative. Under the No-Action Alternative, activities would include surface decontamination and/or stabilization of past-practice waste sites and TSD units, 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 expected to have only minimal adverse 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 All Other Areas geographic area under the No-Action Alternative are discussed in Section 5.8.3.

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 remediation activity (Appendix B5).

The airborne pathway was the only exposure pathway considered for estimating the impacts of the range fire. 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, and for offsite populations. The nearest public access locations 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 5-46 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 the range fire 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 nearest public access location is below the DOE standard of 10 mrem for public exposure to routine airborne releases as established in DOE Order 5400.5 (DOE 1993a).

5.5.9.2 Human Health Impacts from the 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 units, constructing groundwater remediation systems, restoring sites; and the use of institutional controls. Remediation activities are not expected to result in 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.

Table 5-46. 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]

NOTE: These values are presented in scientific notation for brevity. In scientific notation, a value of 3.83 E+03 corresponds to 3,830; a value of 5.91 E-01 corresponds to 0.591.

[a]Increased probability of this individual contracting a fatal cancer.

[b]Increase in latent cancer fatalities in this population.

MEI = maximally exposed individual.

NPAL = nearest public access location.

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 groundwater 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 5.8 and Appendix B5. The probability of these accidents occurring ranges from 10^{-2} to 10^{-6} occurrences/year of operations, and would vary with the amount of remediation undertaken. The probability of an accident occurring during remediation to levels allowing unrestricted land use would be more likely than an accident occurring during remediation to restricted land use.

For the **excavation accident**, the maximum radiation dose to remediation workers, evaluated at 100 m (328 ft) from the accident location, is less than 0.1% of the regulatory limit for radiation workers of 5,000 mrem/yr (see Table 5-46). Estimated doses at the nearest public access location 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.

For the **groundwater treatment accident**, the estimated maximum radiation dose to workers would be 7% of the regulatory limit of 5,000 mrem/yr for radiation workers (see Table 5-46). The estimated dose at the nearest public access location is much higher than the 10-mrem limit and the estimated dose at the Hanford Site boundary approaches the limit. Therefore, human health impacts of a groundwater treatment accident under the Restricted Future Land-Use Alternative (R1) 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 remediation activities or to reduce the severity of accident impacts. Appropriate engineering and administrative measures would be applied during routine remediation 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. Protection of the general public 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 controll the spread of contaminants.

5.5.9.3 Human Health Impacts from the Restricted Future Land-Use Alternative (R2). The Restricted Future Land-Use Alternative (R2) would involve placing caps over past-practice waste sites and TSD units, constructing groundwater remediation systems, and restoring sites. As with the Restricted Future Land-Use Alternative (R1), remediation activities under this alternative are not expected to result in 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 through the 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, use restrictions, and groundwater remediation would reduce cancer risks to workers and the public 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 Restricted Future Land-Use Alternative (R1) 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 Restricted Future Land-Use Alternative (R1). Therefore, adverse impacts of this accident 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 the Restricted Future Land-Use Alternative (R1).

5.5.10 Occupational Health and Safety

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[8] identified in Appendix H for each alternative with the Bureau of Labor Statistics and DOE incident rates (DOE 1995k). 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. Complete documentation of this analysis is presented in Appendix I.

5.5.10.1 Occupational Impacts from the 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 Occupational Impacts from the Restricted Future Land-Use Alternatives (R1 and R2). Table 5-47 presents the potential occupational impacts for the Restricted Future Land-Use Alternatives (R1 and R2) for the All Other Areas geographic area based on Bureau of Labor Statistics 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 5-47. Summary of Occupational Impacts Using Bureau of Labor 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)	2,161,073	145	73	71	1,884
Restricted (R2)	5,487,262	369	200	169	5,346

Table 5-48 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 Bureau of Labor Statistics 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 requires substantial labor 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.

[8]Labor hours associated with decommissioning and groundwater remediation were not included in this analysis.

Table 5-48. Summary of Occupational Impacts Using DOE Statistics.

Future Land-Use Alternative	Labor Hours	Estimated Total Cases	Estimated Total Fatalities	Estimated Lost Workday Cases	Estimated Lost Workdays
Restricted (R1)	2,161,073	41	<1	19	558
Restricted (R2)	5,487,262	104	<1	49	1,416

5.5.11 Excavation Volumes, Material Requirements, and Costs

The assumptions and methodology used to estimate the volumes, disturbed areas and costs of each future land-use alternative are described in Appendix H. Impacts of each alternative are summarized in Table 5-49.

Table 5-49. Comparison of Excavation Volumes, Material Requirements, 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	513	513
Areas of Disturbance (ha)	43	309	384
Project Costs in 1994 Dollars (millions)	2,424[b]	$1,224 (truck haul) $1,252 (rail haul)	$1,443 (truck haul) $1,573 (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 entire Hanford Site (see Table 5-25). The costs are not broken down by geographic areas.

5.5.11.1 Excavation Volumes, Material Requirements, and Costs for the No-Action Alternative. The No-Action Alternative involves moving large quantities of surface soils to consolidate the contamination and stabilize the sites 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 are summarized for the Hanford Site in Table 5-25. 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 Excavation Volumes, Material Requirements, and Costs for the 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 units, constructing groundwater remediation systems, restoring sites; and the use of institutional controls. 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 5-49). 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 $1.22 billion if waste is hauled to the ERDF by truck or $1.25 billion if waste is hauled by rail (Tables 5-49 and 5-50).

Table 5-50. 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 Disposal	137*	--	--	--
Site Restoration	83	--	--	--
Demobilization	1.7	--	--	--
Total Costs	655.9	513	57	85
Fuel Use (millions) L (gal)	23 (6.1)	0 (0)	6 (3.6)	4.6 (1.2)
Labor Hours (millions)	2.4	0.9	0.6	0.3

*Includes Environmental Restoration Disposal Facility disposal costs.

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.

5.5.11.3 Excavation Volumes, Material Requirements, and Costs for the Restricted Future Land-Use Alternative (R2). The Restricted Future Land-Use Alternative (R2) would involve placing caps over past-practice waste sites and TSD units; 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 units are shown in Table 5-51. The total area disturbed by remedial actions is 384 ha (948 ac). This includes 73 ha (180 ac) that would be capped, which represents an irretrievable commitment of resources. Two haul options for cap material are analyzed: truck and rail. The costs of remedial actions for this alternative are approximately $1.4 billion if cap materials are hauled by truck and $1.6 billion if hauled by rail (Tables 5-49 and 5-52).

Table 5-51. 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 5-52. 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	462	--	--	--
Site Restoration	118	--	--	--
Demobilization	0.1	--	--	--
Total Costs	670.3	513	259	389
Fuel Use (millions) L (gal)	40 (10.3)	0 (0)	62 (16.4)	21 (5.5)
Labor Hours (millions)	3.5	0.9	2.8	0.4

5.5.11.3.1 Potential Mitigation Measures. Additional 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 would be 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).

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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 [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 5.13), 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, 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 remediation 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 15,200, which was the size of the workforce as of October 1995 (Hanford Reach 1996). This conservative estimate assumes that future remediation activities will require employment of additional workers. However, as the DOE continues to restructure the workforce at the Hanford Site to meet the changing mission, it is likely that the current workforce will continue to decrease. 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 remediation 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 (with the exception of certain continuing actions, such as groundwater remediation).

The total number of 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. Therefore, the timing of the various remedial actions would affect the total socioeconomic impacts. This means that the socioeconomic impacts of the selected alternative 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 15,200 employees. This level 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 2001. 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 5-30 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 remediation 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 remediation activities are completed.

The Restricted Future Land-Use Alternative would have minimal impact (0.1%) on taxable retail sales (Figure-31). The maximum impact for the Unrestricted Future Land-Use Alternative would be about 0.6%.

Figure 5-30. Predicted Increases in Nonagricultural Employment.

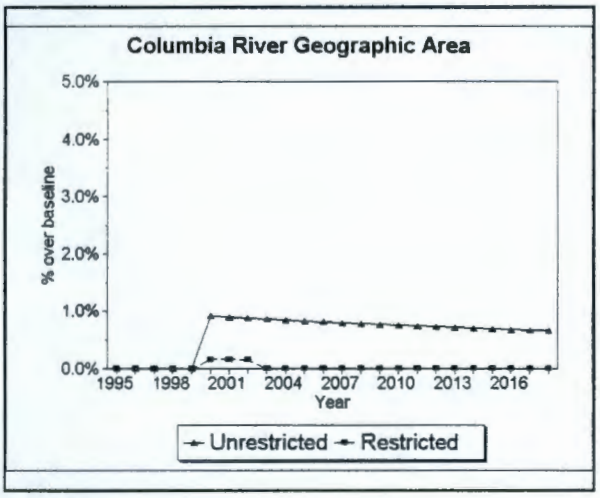
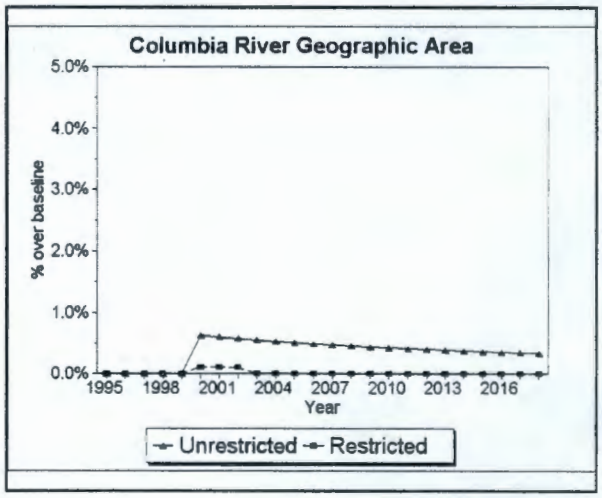


Figure 5-31. Predicted Increases in Taxable Retail Sales.



5.6.3.2 Population and Housing. The Restricted Future Land-Use Alternative would have minimal impact on the Tri-Cities population, while the Unrestricted Future Land-Use Alternative would have a maximum increase of 0.6% above the baseline (Figure 5-32). 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 5-33). 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 5-34).

Figure 5-32. Predicted Increases in Population.

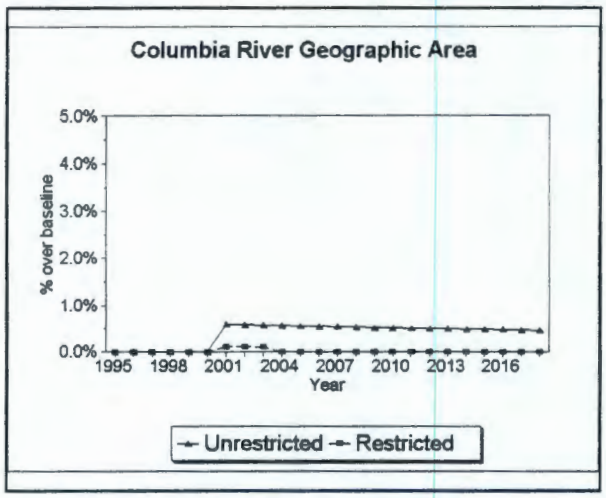


Figure 5-33. Predicted Increases in Home Prices.

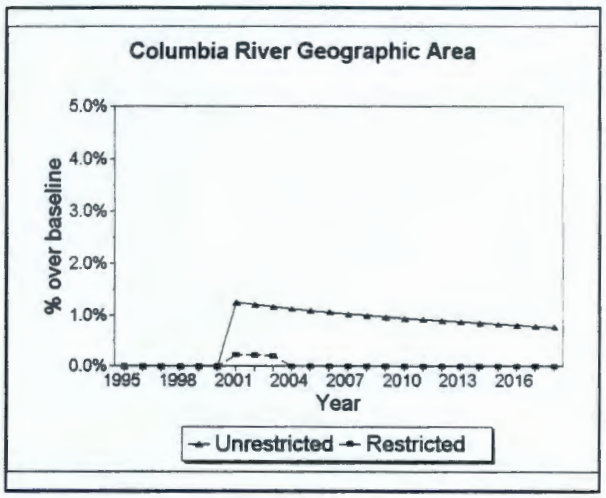
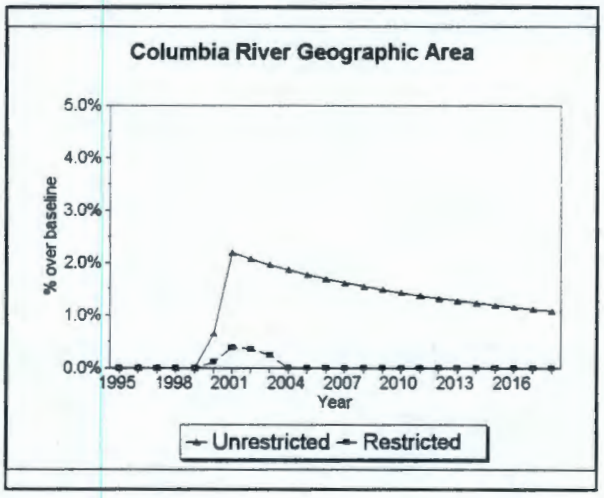


Figure 5-34. Predicted Increases in Housing Starts.



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. The Restricted Future Land-Use Alternative (R2) requires substantially more workers because cap construction is relatively labor-intensive.

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. Some of the increased employment would likely be staffed by the existing workforce.

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 5-35).

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 5-36).

Figure 5-35. Predicted Increases in Nonagricultural Employment.

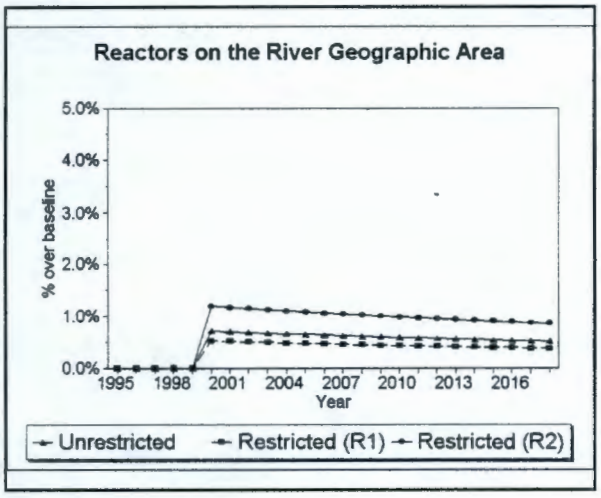
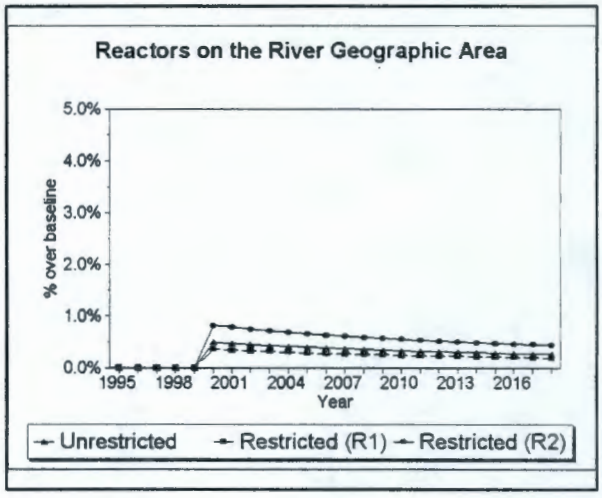


Figure 5-36. Predicted Increases in Taxable Retail Sales.



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 5-37). 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 5-38). 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 5-39). For the Restricted Future Land-Use Alternative (R2), the maximum predicted increase in housing starts would be about 2.8%, which could be a significant, although

Figure 5-37. Predicted Increases in Population.

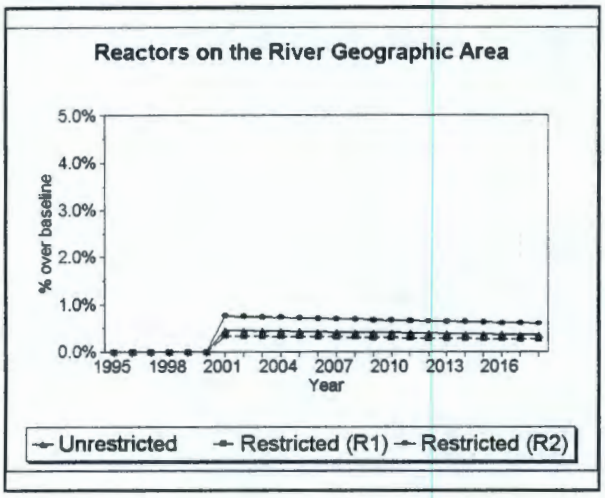


Figure 5-38. Predicted Increases in Home Prices.

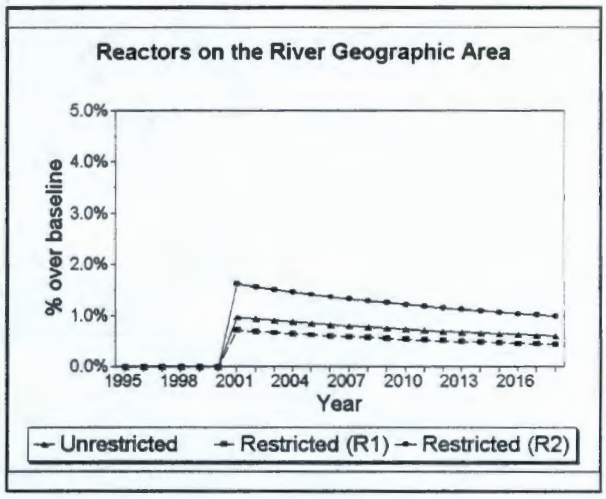
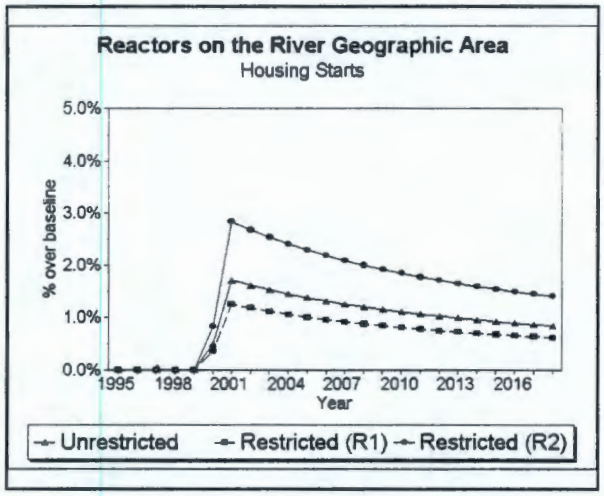


Figure 5-39. Predicted Increases in Housing Starts.



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 additional 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,[9] 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 5-40). The maximum impact on general economic activity, as measured by taxable retail sales, would be about 0.3% (Figure 5-41).

Figure 5-40. Predicted Increases in Nonagricultural Employment.

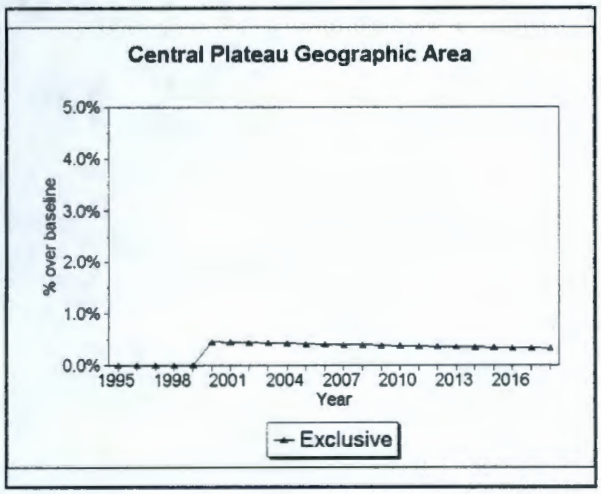
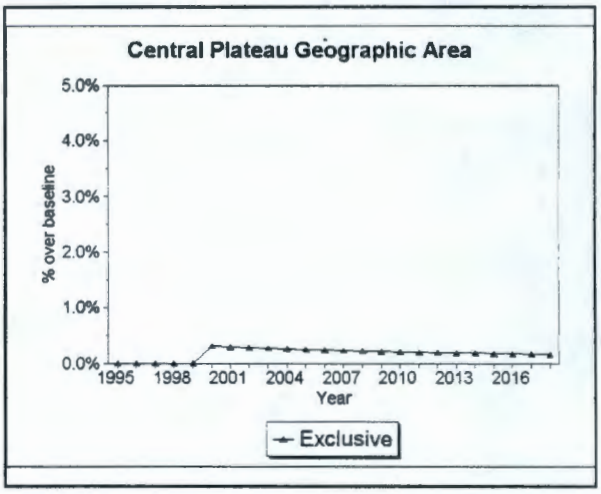


Figure 5-41. Predicted Increases in Taxable Retail Sales.



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 5-42). Average home prices would increase by a maximum of about 0.6% (Figure 5-43). Housing starts would increase by a maximum of 1.1% (Figure 5-44).

5.6.5.3 Public Services, Infrastructure, and Utilities. The small increase in population for the Exclusive Future Land-Use Alternative would not adversely affect public services, infrastructure, or utilities.

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[9]This employment figure is based on BHI's baseline planning estimates (BHI 1995b), 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 required.

Figure 5-42. Predicted Increases in Population.

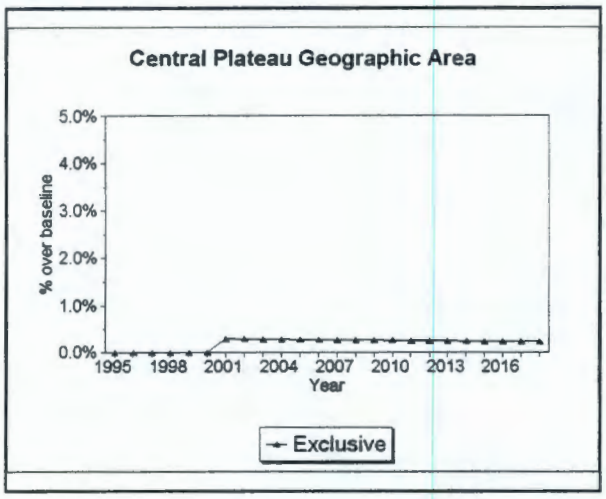


Figure 5-43. Predicted Increases in Home Prices.

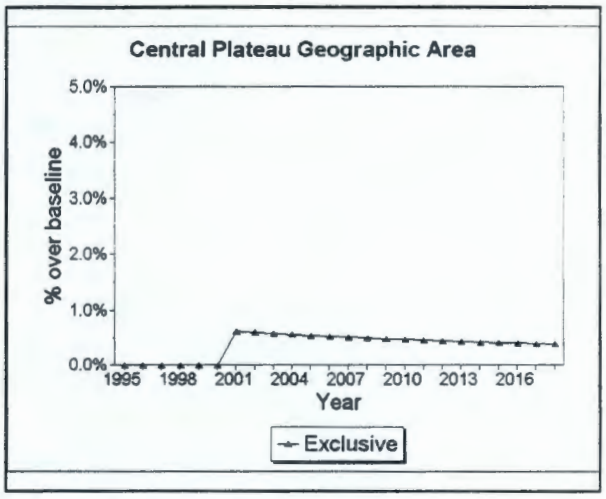
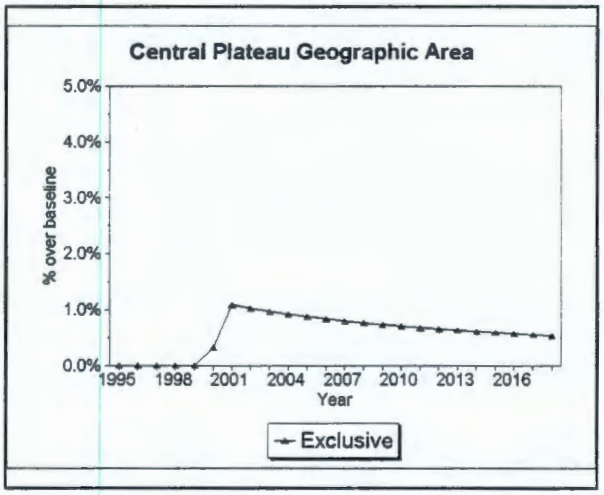


Figure 5-44. Predicted Increases in Housing Starts.



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 requirement for 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 5-45). 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 5-46).

Figure 5-45. Predicted Increases in Nonagricultural Employment.

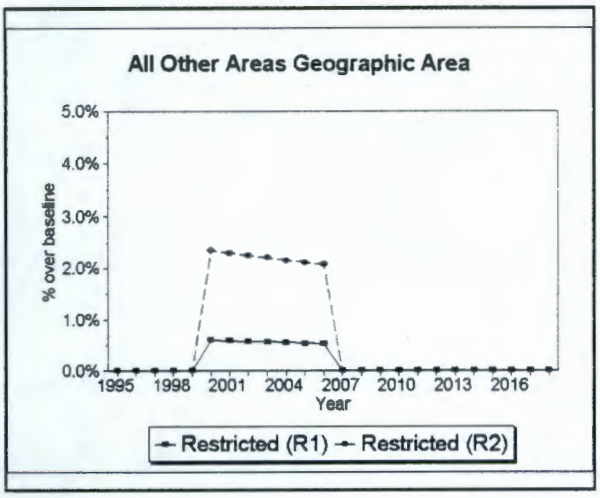
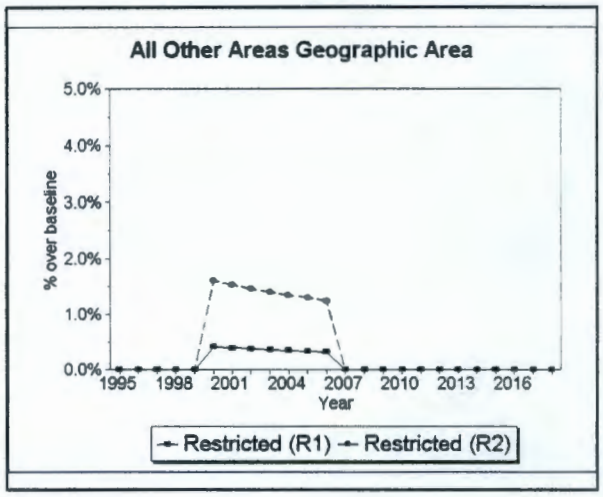


Figure 5-46. Predicted Increases in Taxable Retail Sales.



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 5-47). 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 5-48). 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 5-49).

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. The Restricted Future Land-Use Alternative (R2), however, would cause 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.

Figure 5-47. Predicted Increases in Population.

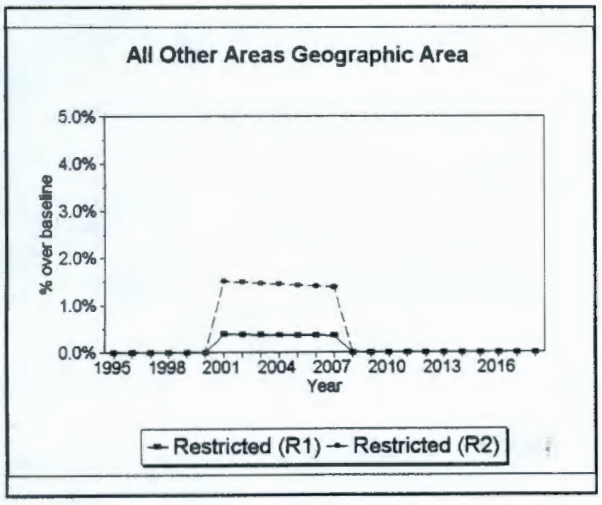


Figure 5-48. Predicted Increases in Home Prices.

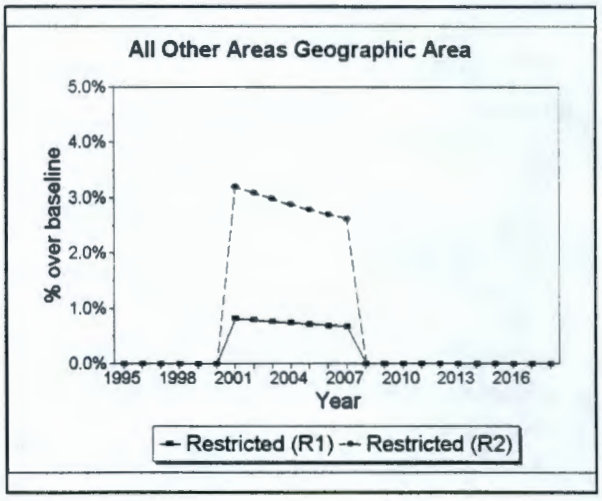
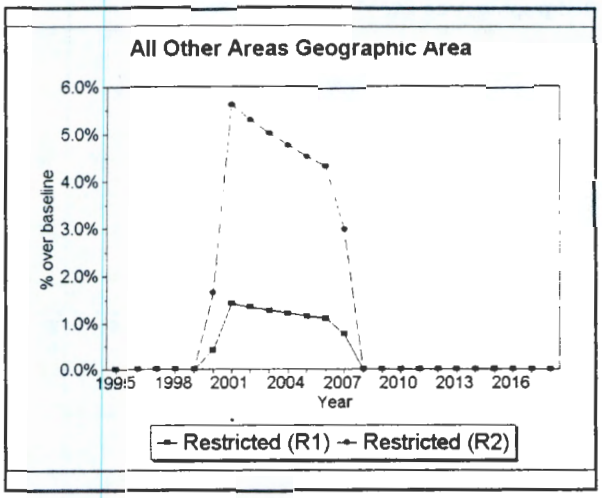


Figure 5-49. Predicted Increases in Housing Starts.



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, should the additional workers required for the remedial activities have to leave the area after the work is completed in 2006.

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 continue beyond the year 2006, and could absorb some of the workers available when remediation is completed in the All Other Areas geographic area. The extent of socioeconomic impacts is largely dependent on the timing of remediation and the degree to which concurrent remediation activities occur across the Hanford Site.

5.7 Exposure Under Routine Conditions

Estimates of radiation doses to workers under routine conditions (incident-free risk) presented in this EIS were based on actual worker exposure data from 1995. During 1995, several large environmental restoration projects were conducted, including activities with a wide range of radiological exposures to workers. The radiation doses received by workers during these environmental restoration projects were monitored and reported by BHI (BHI 1995a). Information obtained included the collective dose and average worker dose for crafts (directly involved workers), subcontractor, management, and professional personnel. Data from the 3rd quarter of 1995 (the quarter with the greatest collective dose and greatest average worker dose) were used to estimate radiological exposure and associated health effects for remediation workers under each alternative in this EIS. Radiological exposures were significantly higher than is

Doses

Dose Rate--The rate at which you receive the dose. For example, dose rate in this section of the EIS is expressed as mrem/quarter.

Collective Dose--The sum of individual doses in an exposed population. Collective dose is usually expressed as person-rem.

usual during this period because workers were involved in cleaning out the 100-N Basin, which involved substantial radiation exposure (approximately 99% of the total accumulated dose for the quarter). The average dose to crafts workers was approximately 64 mrem. Subcontractor personnel received an average dose of 41 mrem and management and professional personnel received an average dose of 4 mrem.

Assumptions. The following assumptions were used in the analysis of radiological exposure to workers from remediation under routine conditions in this EIS.

- Radiological exposure rates for crafts, subcontractor and professional personnel would be comparable to exposure rates experienced for the 3rd quarter of 1995 (i.e., crafts and subcontractor personnel would receive a dose of 64 mrem/quarter and professional personnel would receive a dose of 4 mrem/quarter).

- To provide a bounding analysis, crafts and subcontractor personnel are assumed to receive the same dose (64 mrem/quarter).

- Estimates of field labor hours presented in Appendix H include hours worked by crafts and subcontractor personnel.

- Labor hours used in the analysis are the field labor hours for truck haul identified in Appendix H. This provided a conservative analysis, because labor hours required for truck haul are higher than those for rail haul.

- A worker puts in 500 labor hours during each quarter.

- In accordance with guidance from the *Annals of the ICRP* (ICRP 1991), health effects resulting from exposure to radiation would occur at a rate of 0.0004 LCFs/person-rem of exposure.

- To provide a bounding analysis, exposure rates for capping alternatives would be equivalent to exposure rates for excavation alternatives. In actuality, capping alternatives would result in significantly lower exposures to remediation workers.

- Mitigation measures (discussed below) would be implemented to ensure that no worker received a dose in excess of allowable standards.

Calculations. These assumptions were used to develop estimates of collective dose for different classes of workers, which were in turn used to estimate potential health effects. A sample calculation is provided below:

Collective dose = labor hours (from Appendix H) * 1 labor quarter/500 labor hours * dose rate/quarter (BHI 1995a).

Latent cancer fatalities = collective dose * 0.0004 LCF/rem (ICRP 1991) .

Radiological exposure and associated health effects for personnel involved in remediation activities under each future land-use alternative are presented in Table 5-53. Noninvolved workers (such as management and professional workers) are not anticipated to be exposed to significant radiation as a result of remedial activities.

Table 5-53. Risks to Workers from Radiation Exposure Under Routine Conditions.

Geographic Area	Future Land-Use Alternative	Directly Involved Workers (Crafts and Subcontractors)			Professional Workers (Managers and Professional)		
		Labor Hours	Collective Dose (person-rem)	LCFs	Labor Hours	Collective Dose (person-rem)	LCFs
Columbia River	Unrestricted	10,233,386	1,310	0.52	3,183,597	25	0.01
	Restricted	213,396	27	0.01	28,065	0.2	0.00
Reactors on the River	Unrestricted	8,886,850	1,138	0.46	4,429,611	35	0.01
	Restricted (R1)	6,414,602	821	0.33	3,464,449	28	0.01
	Restricted (R2)	12,054,899	1,543	0.62	1,841,379	15	0.01
Central Plateau	Exclusive	6,339,920	812	0.32	640,030	5	0.00
All Other Areas	Restricted (R1)	2,161,073	277	0.11	1,682,551	13	0.01
	Restricted (R2)	5,487,262	702	0.28	1,611,205	13	0.01

LCF = latent cancer fatality.

Radiation exposure of the general public would be expected to remain comparable to exposure rates reported in recent Hanford Site annual environmental monitoring reports, such as the *Hanford Site Environmental Report for 1994* (PNL 1995). In 1994, the total potential radiation dose to the hypothetically maximally exposed individual of the public (located across the Columbia River from the 300 Area) was calculated to be 0.05 mrem\year. The primary pathways contributing to this dose were consumption of fish and foods irrigated with Columbia River water, and inhalation of airborne radionuclides, principally from 200 Area releases (PNL 1995).

Mitigation Measures. Worker exposures would be monitored and workers would be rotated among jobs to ensure that individual exposures were maintained within allowable limits. In addition, measures such as dust suppression, interim stabilization activities, temporary enclosures, and the use of protective clothing and fresh air equipment would all contribute to reductions in potential exposures to levels that are as low as reasonably achievable.

5.8 Human Health 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 human health risk assessment was performed for the Reactors on the River, Central Plateau, and All Other Areas geographic areas (Appendix B). The risk assessment provides a

baseline against which the proposed action can be compared. 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*[10] (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 to future generations were calculated after removal of institutional controls at periods of 40, 100, 140, 1,000, and 10,000 years into the future.

The discussion of the human health risk assessment presented here includes four subsections, as follows: Section 5.8.1 provides background information on the health effects of radiation exposures; Section 5.8.2 discusses health effects from chemical exposures; Section 5.8.3 presents tabulated risk assessment results for each geographic area; and, Section 5.8.4 presents the risk assessment results graphically using risk isopleth maps of the Hanford Site.

5.8.1 Radiation Exposure Effects

The health effects of radiation exposure are a concern 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. Additional information is provided in the Helpful Information Section at the beginning of this EIS.

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 by a given amount 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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[10]At the time of this writing, the *Hanford Site Baseline Risk Assessment Methodology* (DOE-RL 1993a) was used to conduct the human health risk assessment. Since that time, the methodology has been updated and revised in the *Hanford Site Risk Assessment Methodology* (DOE-RL 1995a). The revision reflects new EPA guidance on the preparation of ecological risk assessments and experience gained through performing qualitative risk assessments. The revisions did not alter the exposure parameters used in the risk analysis for this EIS.

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 affected by the individual's proximity to a source, the duration of exposure, and the presence or absence of shielding between the source and the individual. 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 time. The dose from internal exposure is calculated over 50 years following the initial exposure.

Comparing Radiation Doses

Background radiation: The average U.S. resident receives 300 mrem/yr from all sources combined, including natural and medical sources of radiation.

X-rays: A chest x-ray results in an approximate dose of 83 mrem.

DOE Standard: The maximum annual allowable radiation dose to the members of the public from all sources at DOE-operated nuclear facilities is 100 millirem/yr (DOE 1993a).

Fatal dose: 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 Calendar Year 1994* (PNL 1995) as "a hypothetical member of the public residing near the Hanford Site who, by virtue of location and living habits, could receive the highest possible radiation dose from radioactive effluents released from Hanford." 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. This human health risk assessment focuses on the potential cancer risks associated with radiation exposures. Risk factors for radiation exposures vary from source to source, but typically range from 10^{-3} to 10^{-5} excess lifetime cancer risk per person-rem of radiation exposure. Similar factors were used in the human health risk assessment to estimate cancer risk from exposures to radioactive contamination at waste sites in each geographic area (Appendix B4). The radiological cancer risks were added to the chemical cancer risks to determine the ILCR.

5.8.2 Chemical Exposure 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.

5.8.2.1 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. The EPA has developed slope factors for chemical carcinogens based on available data for chronic exposures to high dose levels. The slope factors assume a linear relationship between dose and response (i.e., the greater the dose, the greater the possibility of carcinogenic effect). Slope factors conservatively assume that there is no threshold exposure level below which carcinogenic effects will not occur. The slope factors were used to estimate cancer risks as follows:

$$\text{Cancer Risk} = \text{Intake} \bullet \text{Slope Factor}$$

The cancer risks from chemical carcinogens were added to the estimated cancer risks from radiation exposures to determine the ILCR.

5.8.2.2 Chemical Noncarcinogenic Effects. Noncarcinogenic and criteria pollutant health effects are presented using the method described in the *Hanford Site Baseline Risk Assessment Methodology* (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 below which even sensitive populations are unlikely to experience adverse health effects (i.e., the reference concentration). If the exposure level (E) exceeds this threshold (that is, if E/RfC > 1), there may be concern for potential noncancer health effects. As the value of E/RfC increases, the level of concern increases.

To assess the overall potential for offsite (public) noncarcinogenic effects posed by more than one chemical, an hazard index approach was used following the *Hanford Site Baseline Risk Assessment Methodology (HSBRAM)* (DOE-RL 1993a). This approach assumes that, although exposures to individual chemicals may not exceed the threshold of concern, simultaneous exposures 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 E/RfC ratios of the individual chemicals. The hazard index is equal to the sum of the hazard quotients where exposure level and the reference concentration represent the same exposure period.

5.8.3 Human Health Risk Assessment Results

Risk assessment results for the Reactors on the River, Central Plateau and All Other Areas geographic areas are presented in Tables 5-54, 5-55, and 5-56. Noncancer health effects are expressed as a range of hazard indices. Cancer effects are also expressed as a range, in terms of the ILCR. However, the linear relationship between exposures to carcinogens and carcinogenic risk is valid only at low risk levels (i.e., risks below 1×10^{-2}) (EPA 1989). Therefore, for the purposes of this human health risk assessment, ILCR values that exceed 1×10^{-2} are reported simply as $>1 \times 10^{-2}$, to reflect the uncertainty associated with estimating high cancer risk levels.

5.8.3.1 Reactors on the River Geographic Area. The removal of institutional controls in the Reactors on the River geographic area under the No-Action Alternative has the potential to result in significant human health risks. The results of the human health risk assessment for the Reactors on the River geographic area are summarized in Table 5-54. Cancer risks and hazard indices for current and future times range over several orders of magnitude. The wide variation is due to the distribution of waste sites and groundwater plumes. Significant cancer risks, exceeding the 10^{-4} to 10^{-6} acceptable risk range, occur in all exposure scenarios and timeframes.

Table 5-54. Cancer Risk and Hazard Index Ranges for the No-Action Alternative, Reactors on the River Geographic Area.

Reference Time	Exposure Scenario	Hazard Index Range	ILCR 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

NOTE: These values are presented in scientific notation for brevity. In scientific notation, a value of 3.83 E+03 corresponds to 3,830; a value of 5.91 E-01 corresponds to 0.591.
ILCR = incremental lifetime cancer risk.

5.8.3.2 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 risk assessment results for the Central Plateau geographic area are summarized in Table 5-55. The results of the human health 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.

Table 5-55. Cancer Risk and Hazard Index Ranges for the No-Action Alternative, 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

NOTE: These values are presented in scientific notation for brevity. In scientific notation, a value of 3.83 E+03 corresponds to 3,830; a value of 5.91 E-01 corresponds to 0.591.
ILCR = incremental lifetime cancer risk.

Hazard indices in the Central Plateau geographic area for current and future times, like ILCRs, range over many orders of magnitude (see Table 5-55) 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 hazard index exceed 1.0 for some portions of the area, indicating a potential for noncancer health effects in these locations.

5.8.3.3 All Other Areas Geographic Area. The results of the human health 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 (Table 5-56).

Hazard indices for current and future times, like ILCRs, range over many orders of magnitude (see Table 5-56). This wide variation is due to the distribution of waste sites and groundwater plumes. Maximum values of the hazard index exceed 1.0 for certain portions of the area, indicating a potential for noncancer health effects for these locations.

Table 5-56. Cancer Risk and Hazard Index Ranges for the No-Action Alternative, 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

NOTE: These values are presented in scientific notation for brevity. In scientific notation, a value of 3.83 E+03 corresponds to 3,830; a value of 5.91 E-01 corresponds to 0.591.
ILCR = incremental lifetime cancer risk.

5.8.4 Human Health Risk Isopleth Maps

Figures 5-50 through 5-53 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 exposure 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 for risk values of 10^{-6} to greater than 10^{-2}. The shading indicates the risk range between adjacent contour lines. The isopleth maps were generated using the cancer risk calculated for each 1-km^2 (0.4-mi^2) cell containing waste sites in the grid (Figure 5-54). For cells without waste sites, risks were interpolated from adjacent cells.

Interpreting Risk Isopleth Maps

The risk isopleth maps were developed to enable general comparisons among land-use scenarios and timeframes, and 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). Contour information is most accurate for locations containing higher concentrations of waste sites. 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 presented in other documents (e.g., site-specific risk assessments), and such comparisons should be treated with caution.

Figure 5-50. No-Action Alternative - Baseline Risk Isopleths for the Agricultural Scenario at T_0 (Year 1989).

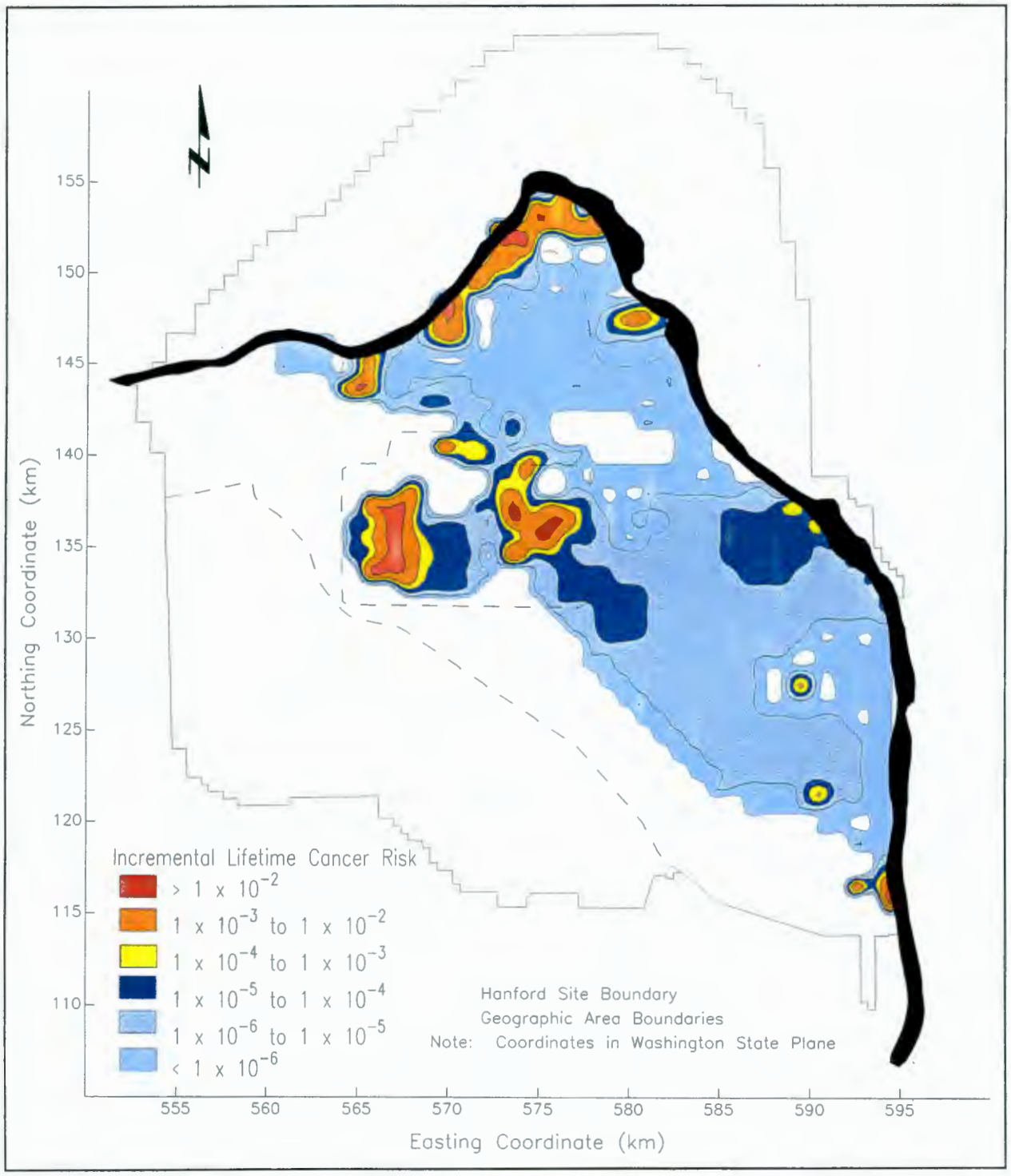

Figure 5-51. No-Action Alternative - Baseline Risk Isopleths for the Residential Scenario at T_0 (Year 1989).

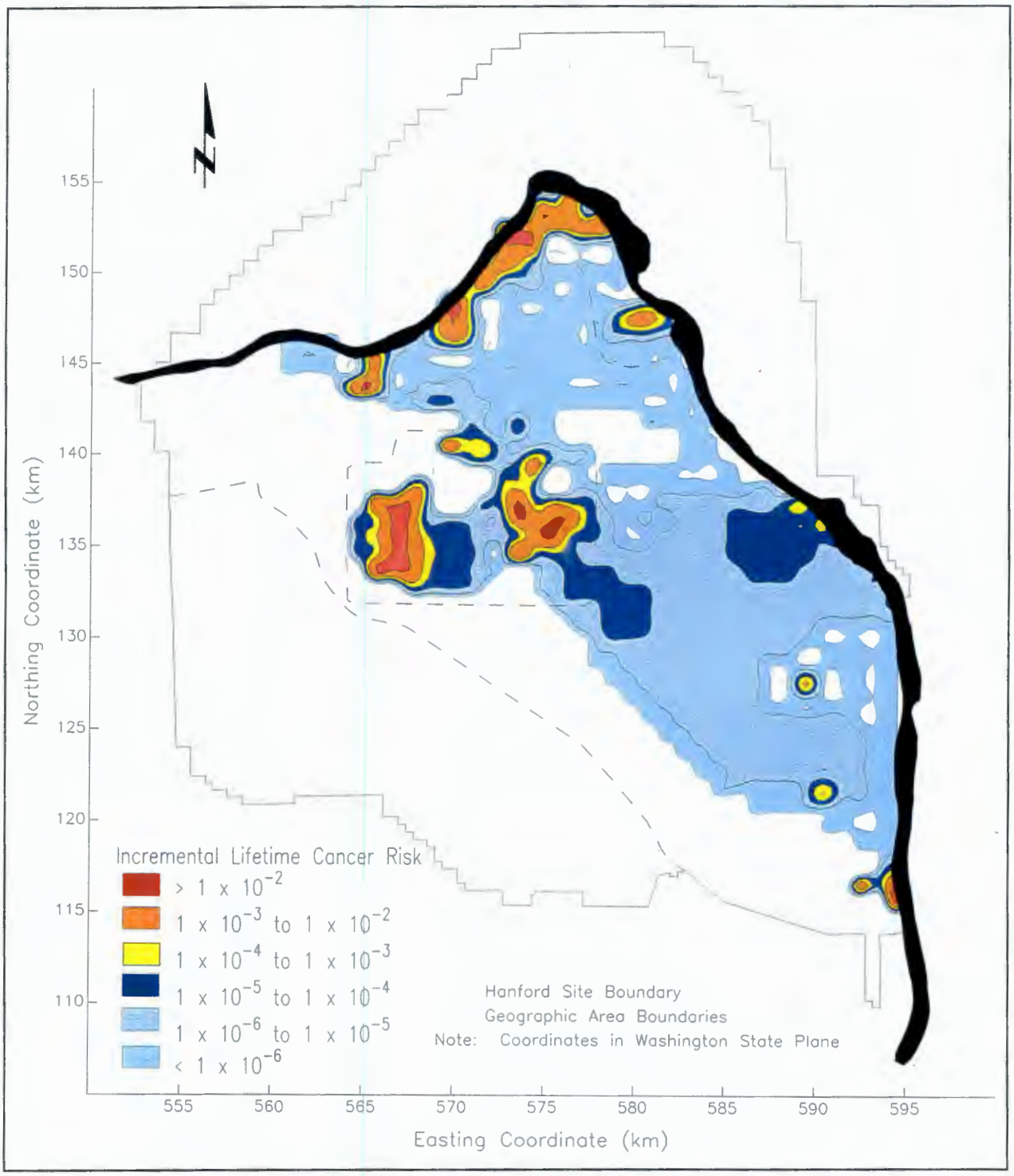

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Figure 5-52. No-Action Alternative - Baseline Risk Isopleths for the Industrial Scenario at T_0 (Year 1989).

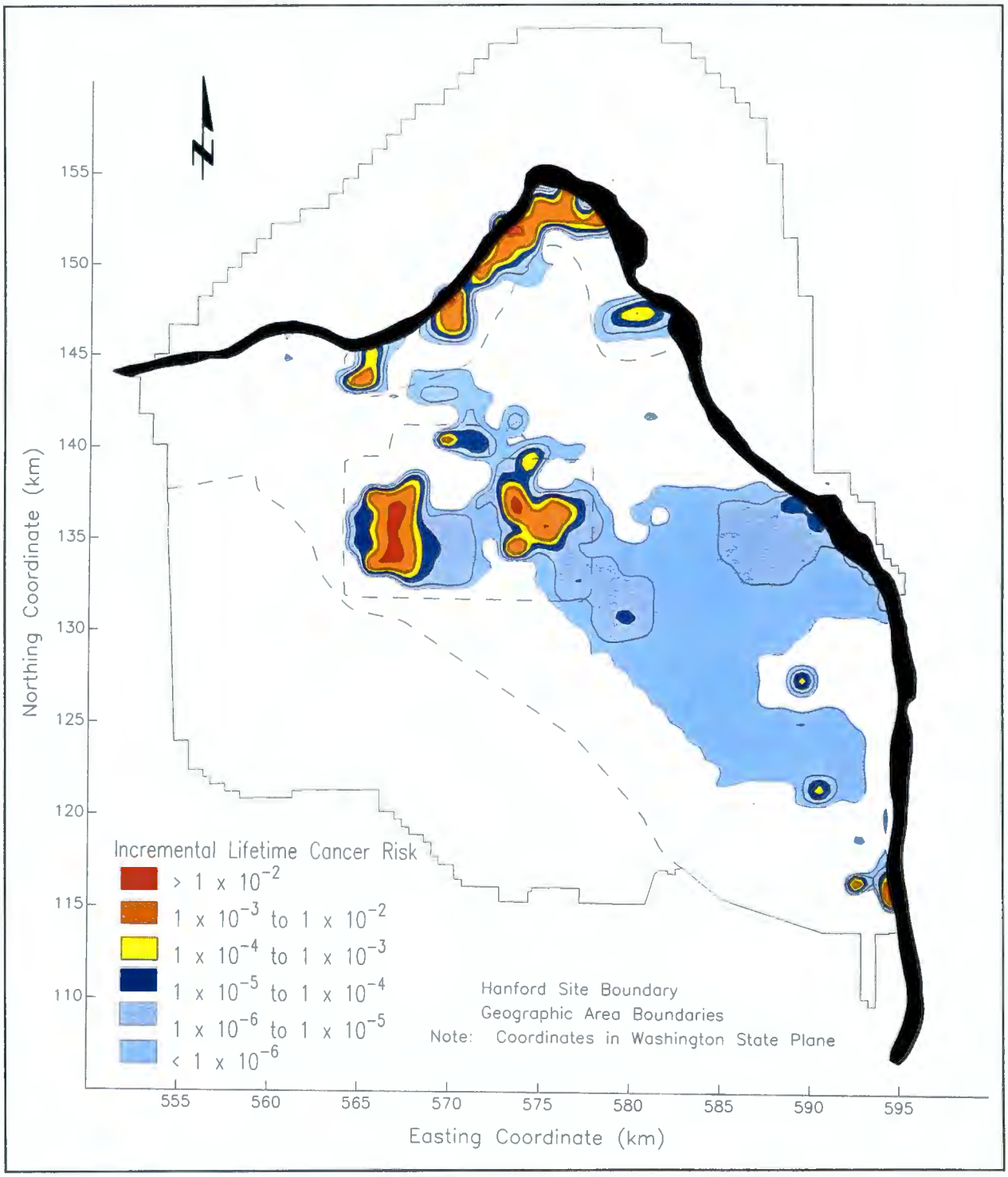


Figure 5-53. No-Action Alternative - Baseline Risk Isopleths for the Recreational Scenario at T_0 (Year 1989).

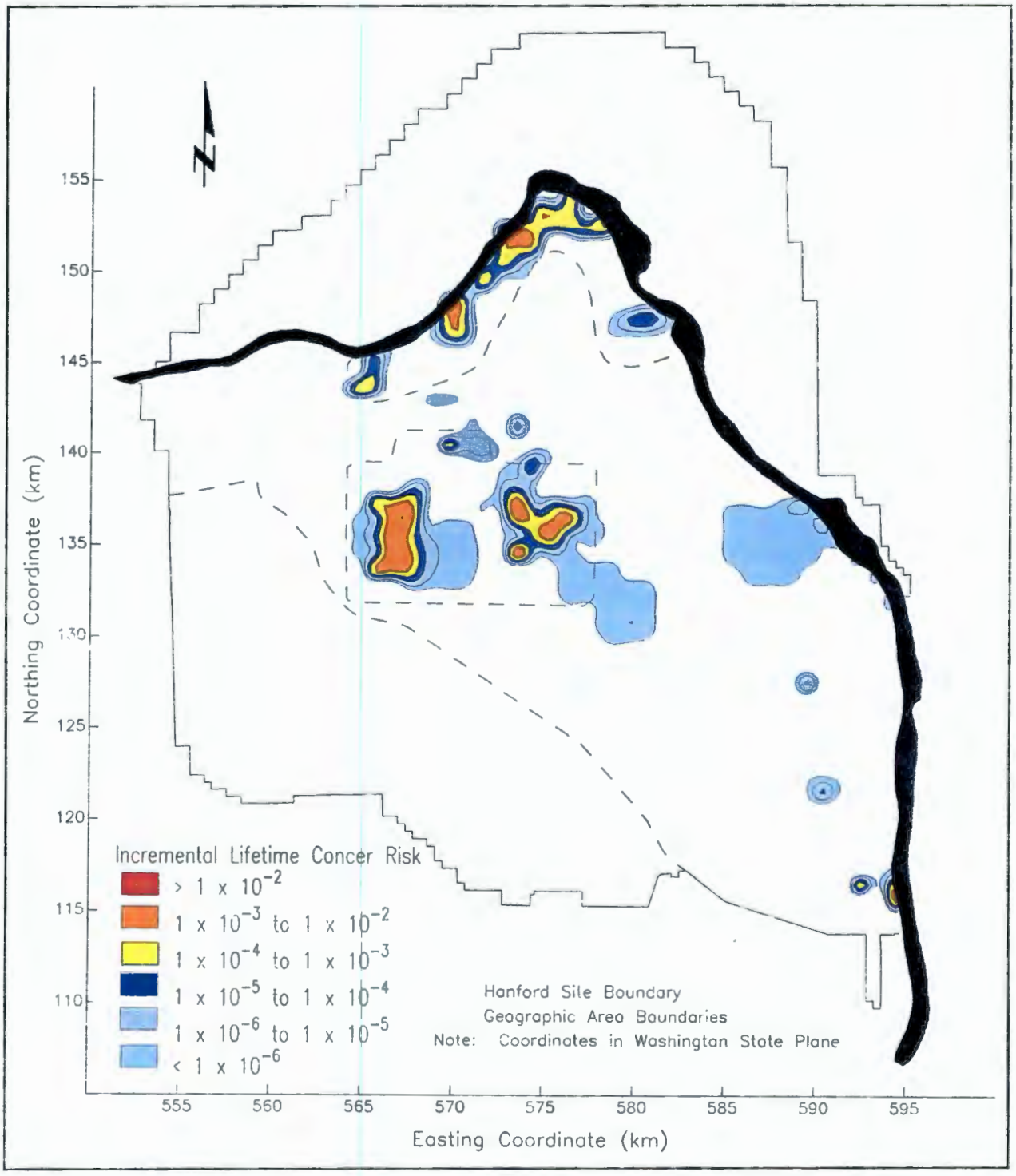
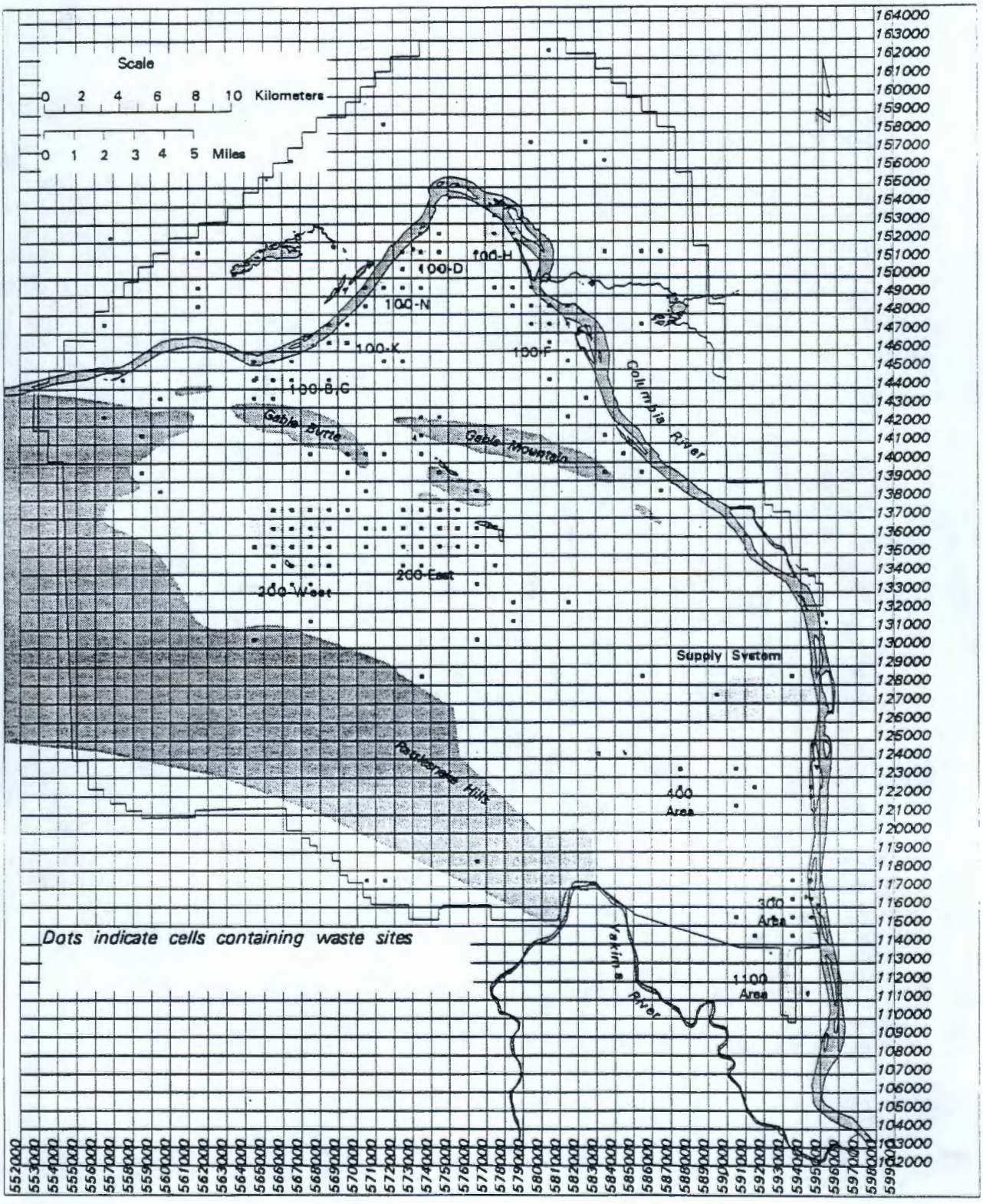


Figure 5-54. Cells Containing Waste Sites Analyzed for Health and Ecological Risks.



The risk isopleth maps (see Figures 5-50 through 5-53) 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 and Central Plateau geographic areas, and in isolated portions of the All Other Areas geographic area. Areas of higher risk within the geographic areas are located in the vicinity of reactor areas and processing facilities. This is to be expected because the risk distribution corresponds closely to the distribution of actual waste sites (see Figure 5-54).

Figures 5-55 through 5-74 depict (in the absence of institutional controls) the future distribution of risks for each exposure scenario with loss of institutional controls after 40, 100, 1,000 and 10,000 years. Isopleth maps generated for future timeframes indicate that over time, risks are redistributed. Figures 5-55 through 5-59 show how sitewide risks under the **agricultural scenario** change over time. 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 portions of the Reactors on the River and All Other Areas geographic areas. 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 5-51 and Figures 5-60 through 5-64) 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 5-52 and Figures 5-65 through 5-69 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. 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 day per year). Although the maximum cancer risk is greater than 10^{-2} under the industrial scenario for some future timeframes (see Tables 5-54, 5-55 and 5-56), the area at this risk level is very small (see Figures 5-65 through 5-69).

The final exposure scenario considered is the **recreational scenario** (see Figure 5-53 and Figures 5-70 through 5-74). 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 5-52). However, unlike the other scenarios, risk levels under the recreational scenario decrease to the target range within 40 years (see Figure 5-69). 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

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Figure 5-55. No-Action Alternative - Baseline Risk Isopleths for the Agricultural Scenario at T_{40} (Year 2029).

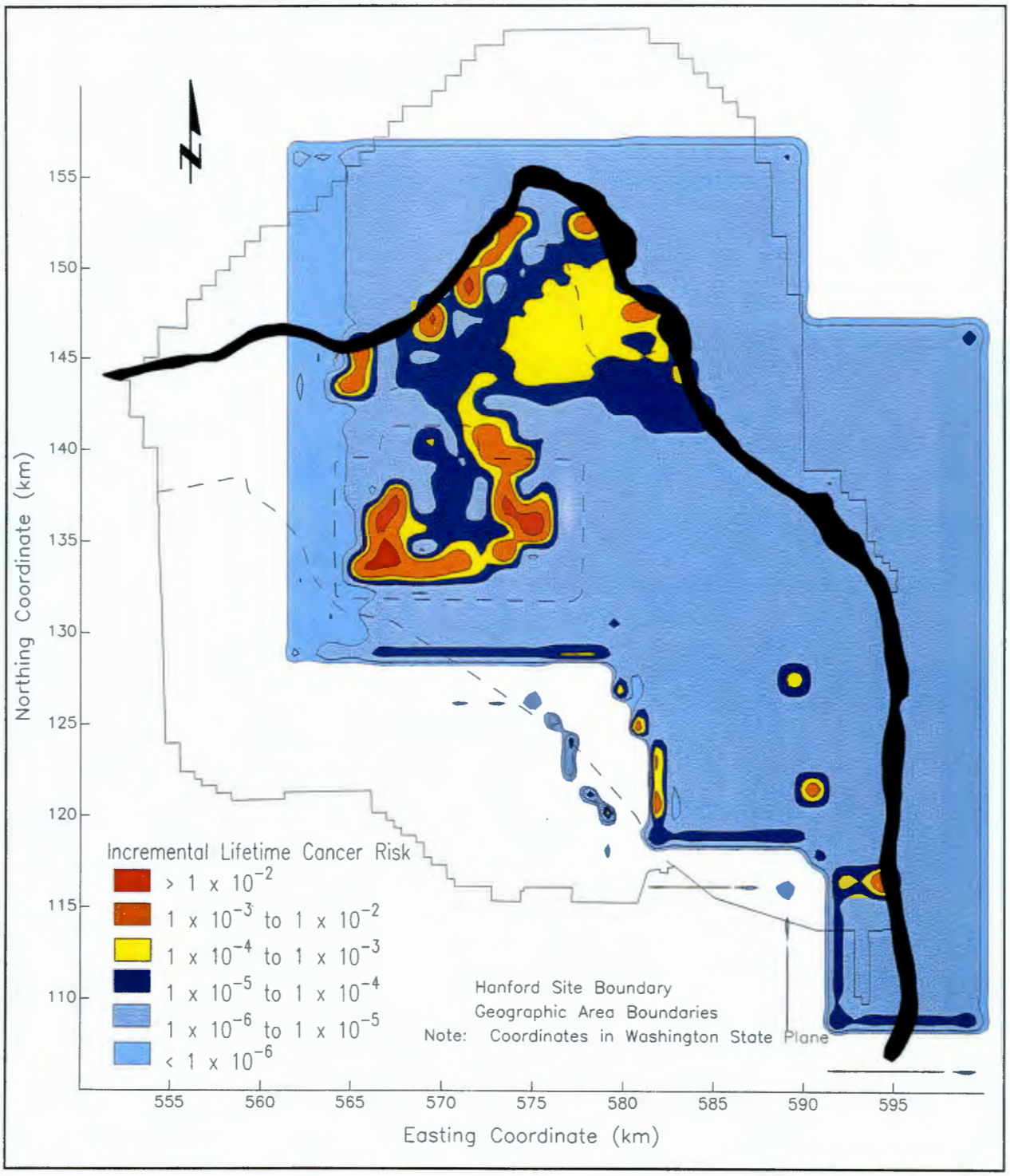

Figure 5-56. No-Action Alternative - Baseline Risk Isopleths for the Agricultural Scenario at T_{100} (Year 2089).

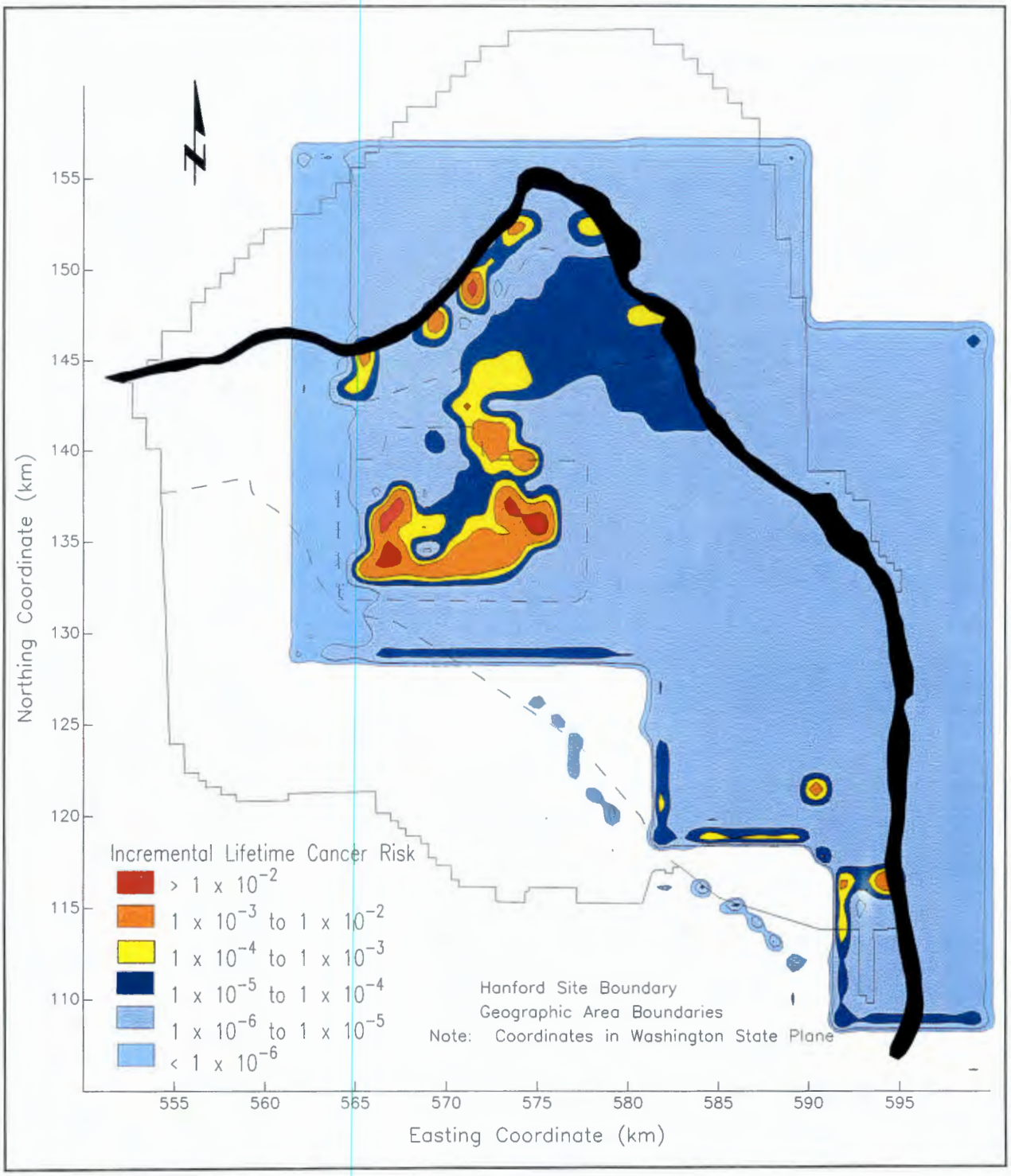

Figure 5-57. No-Action Alternative - Baseline Risk Isopleths for the Agricultural Scenario at T_{140} (Year 2129).

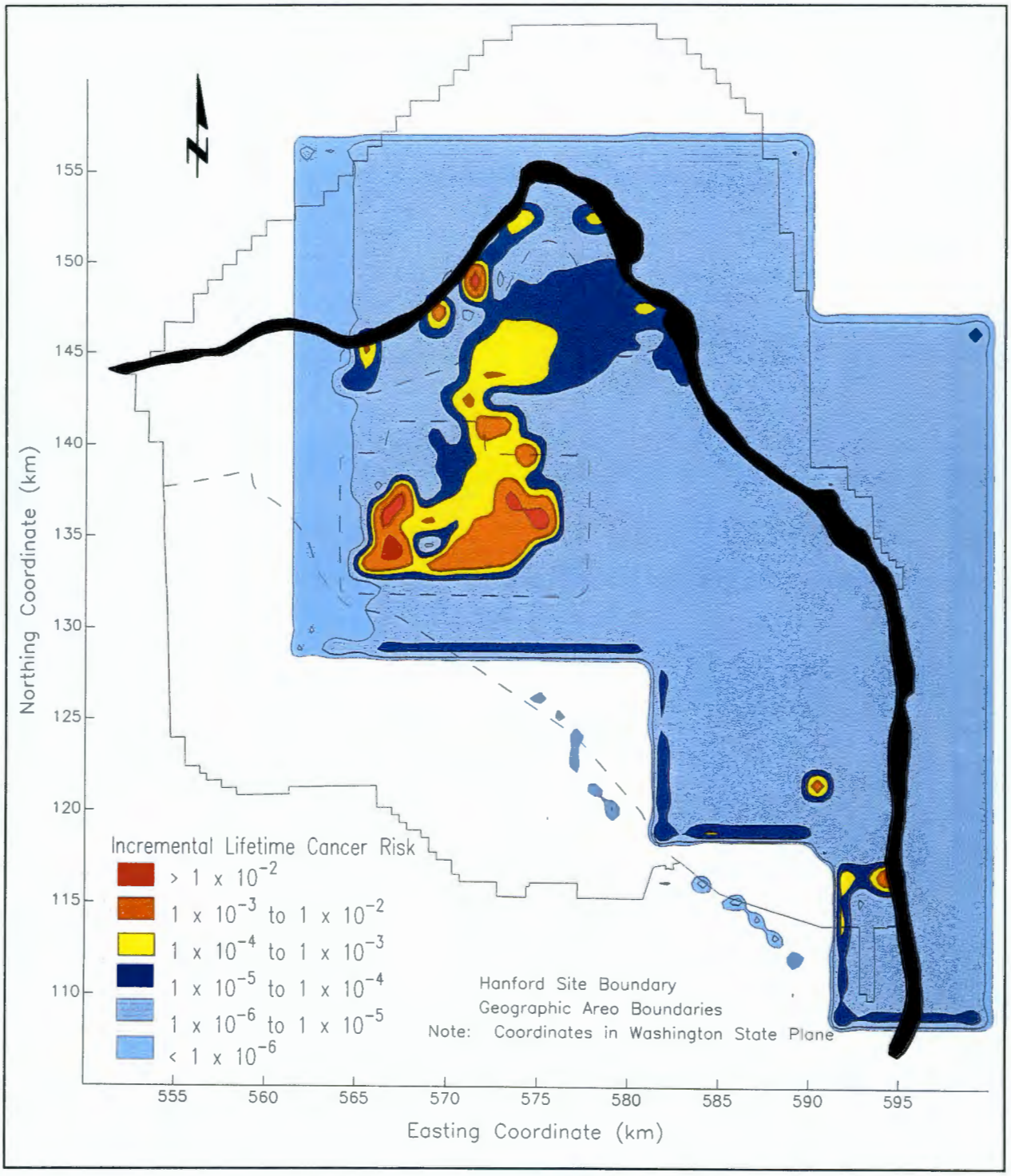

Figure 5-58. No-Action Alternative - Baseline Risk Isopleths for the Agricultural Scenario at T_{1000} (Year 2989).

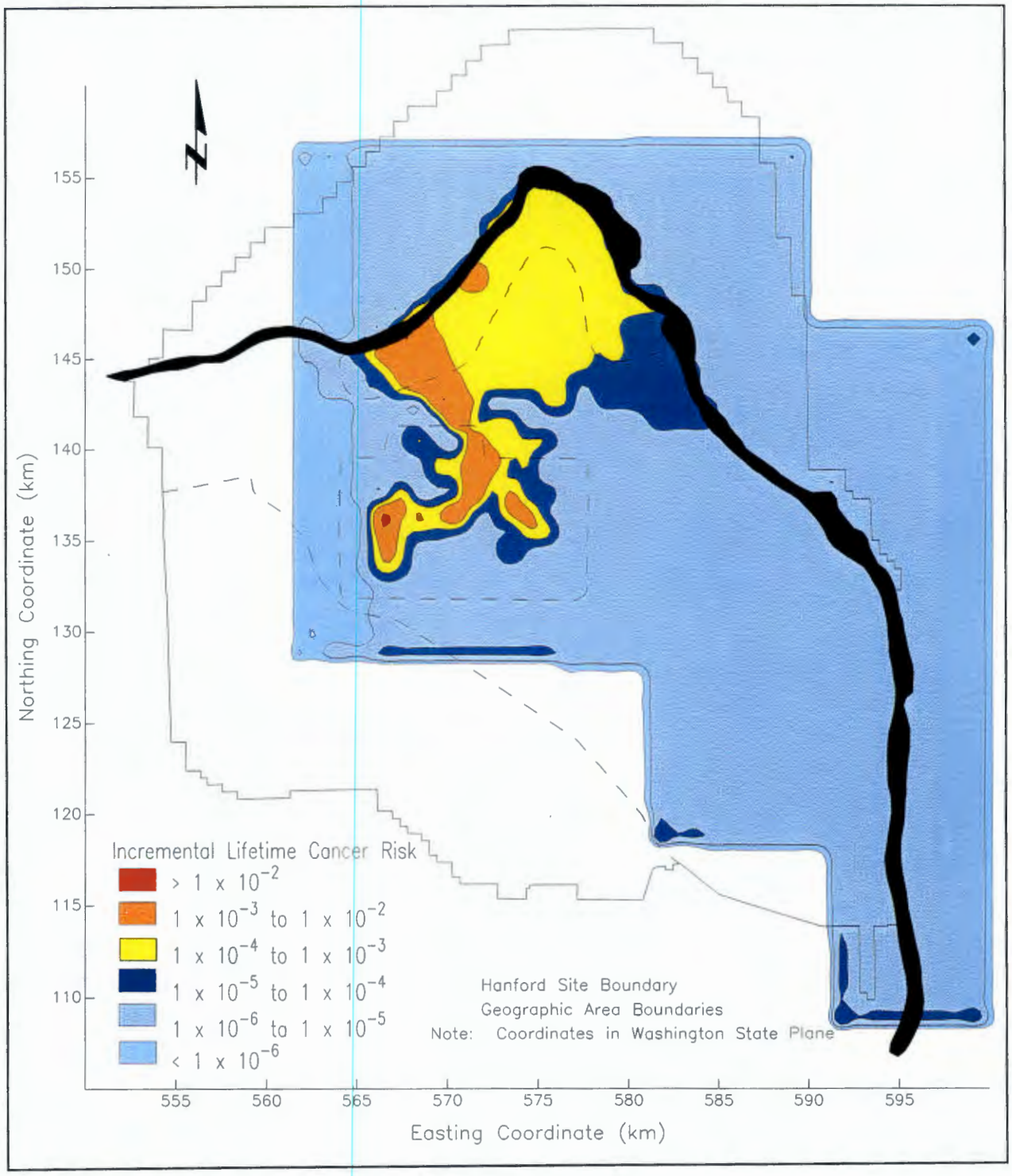

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Figure 5-59. No-Action Alternative - Baseline Risk Isopleths for the Agricultural Scenario at T_{10000} (Year 11989).

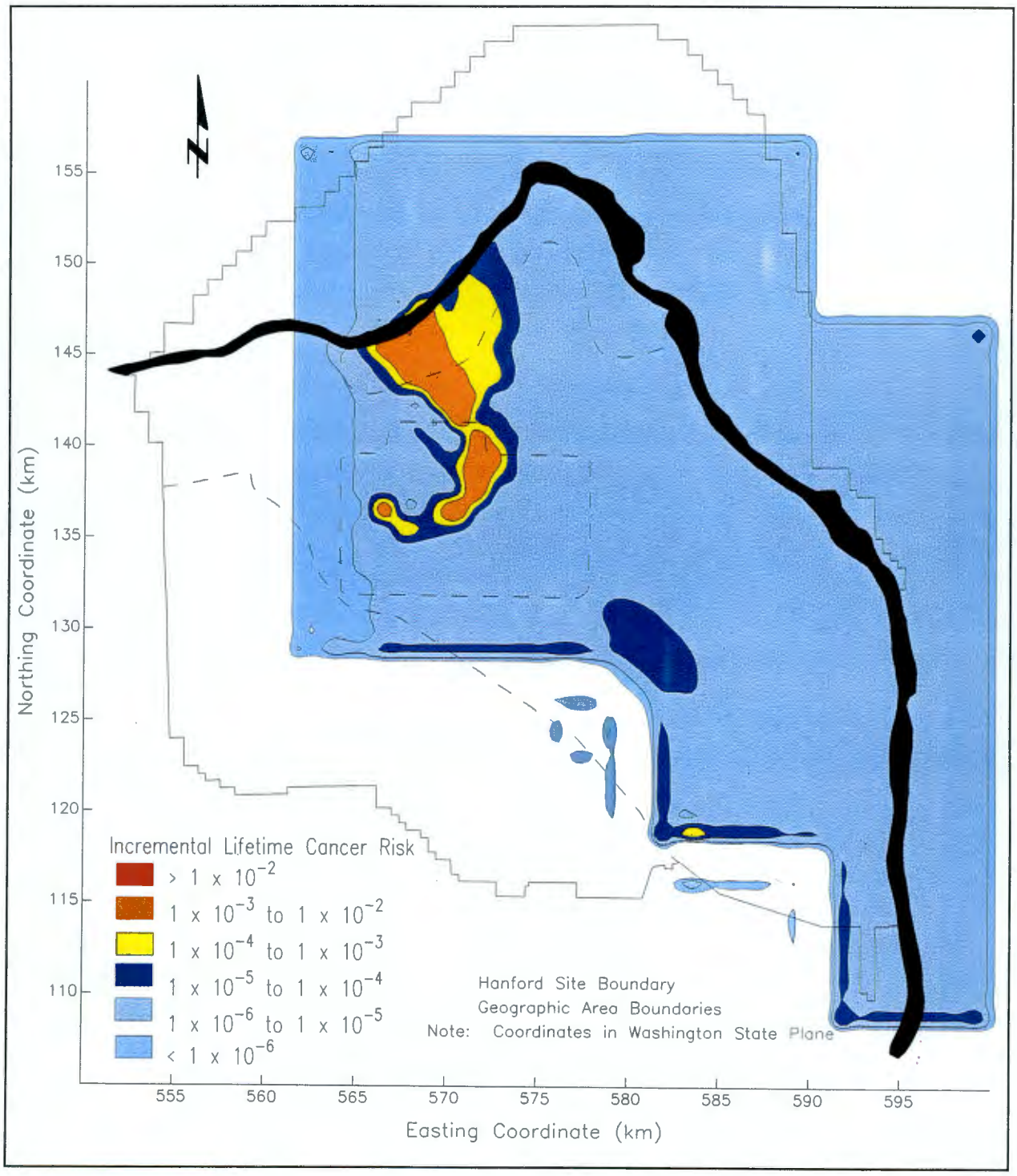

Figure 5-60. No-Action Alternative - Baseline Risk Isopleths for the Residential Scenario at T_{40} (Year 2029).

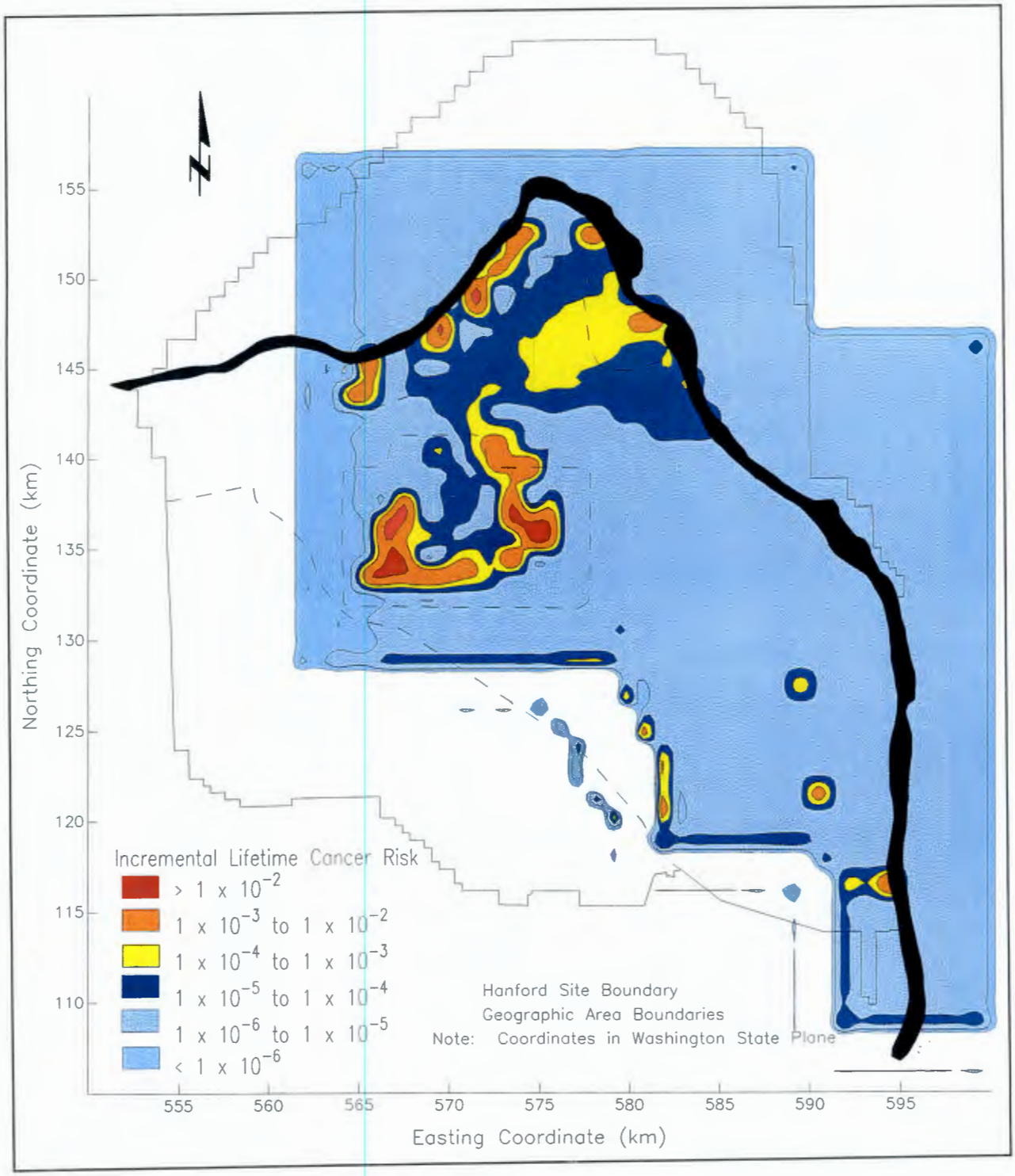

Figure 5-61. No-Action Alternative - Baseline Risk Isopleths for the Residential Scenario at T_{100} (Year 2089).

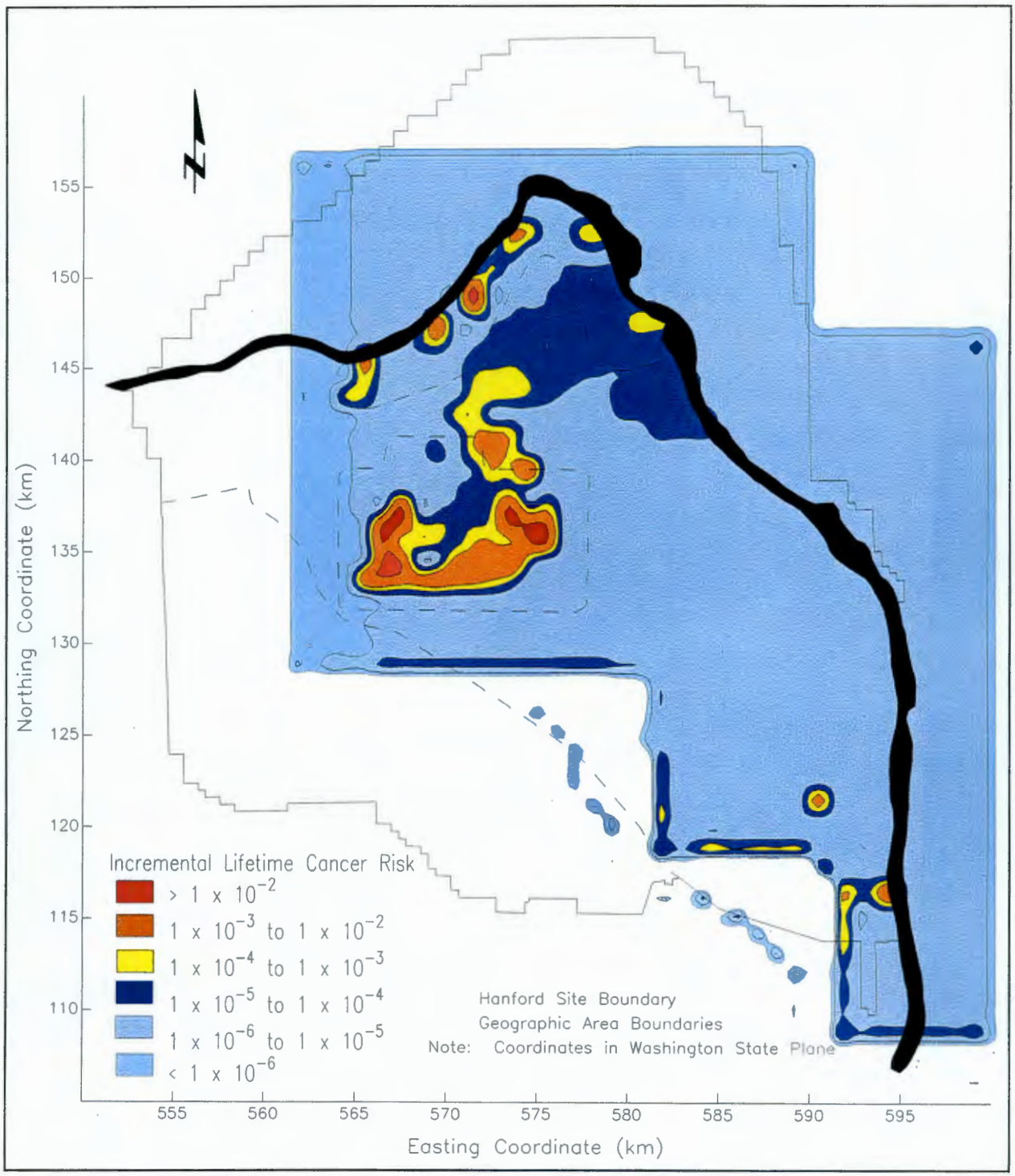

Figure 5-62. No-Action Alternative - Baseline Risk Isopleths for the Residential Scenario at T_{140} (Year 2129).

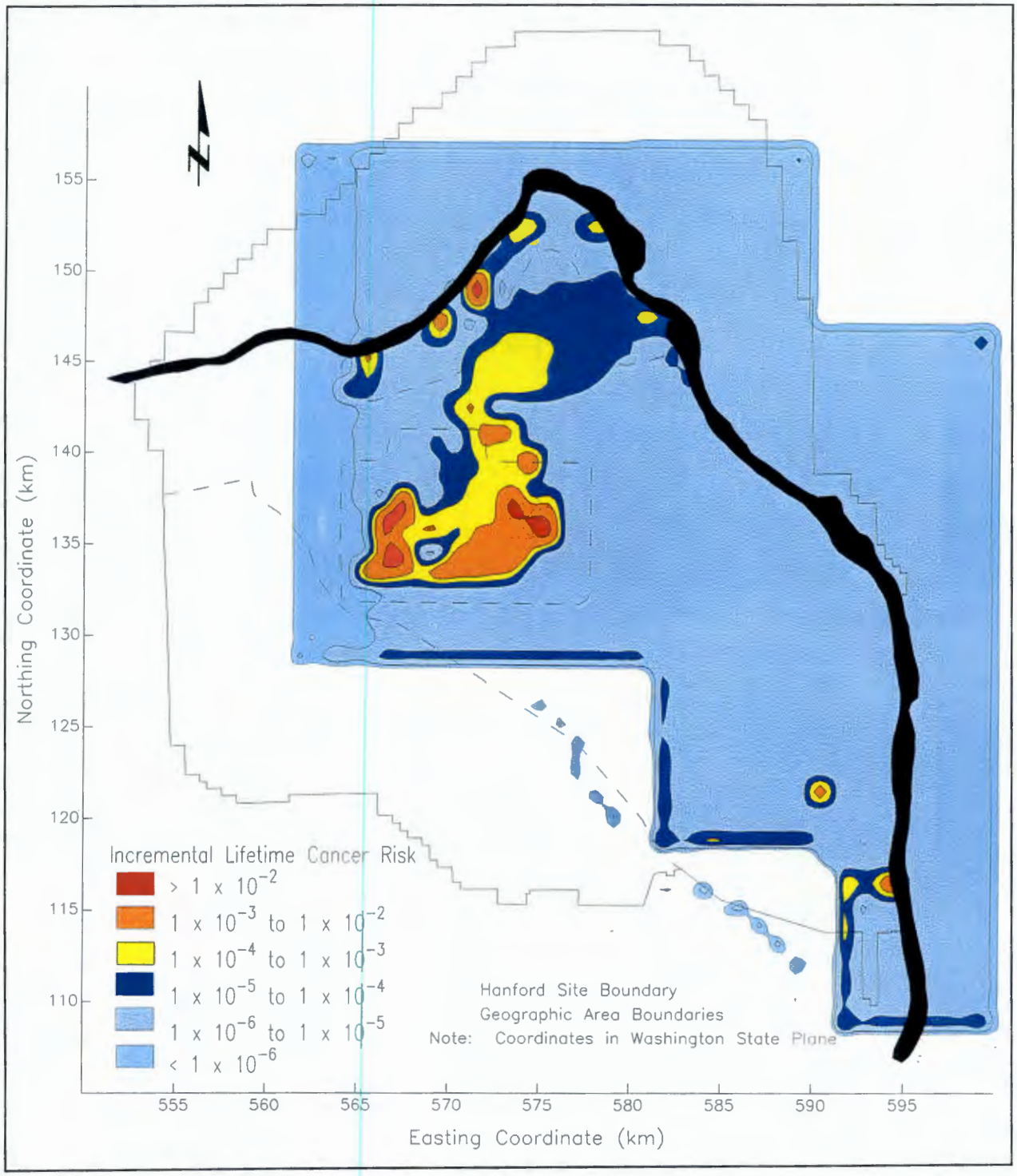

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Figure 5-63. No-Action Alternative - Baseline Risk Isopleths for the Residential Scenario at T_{1000} (Year 2989).

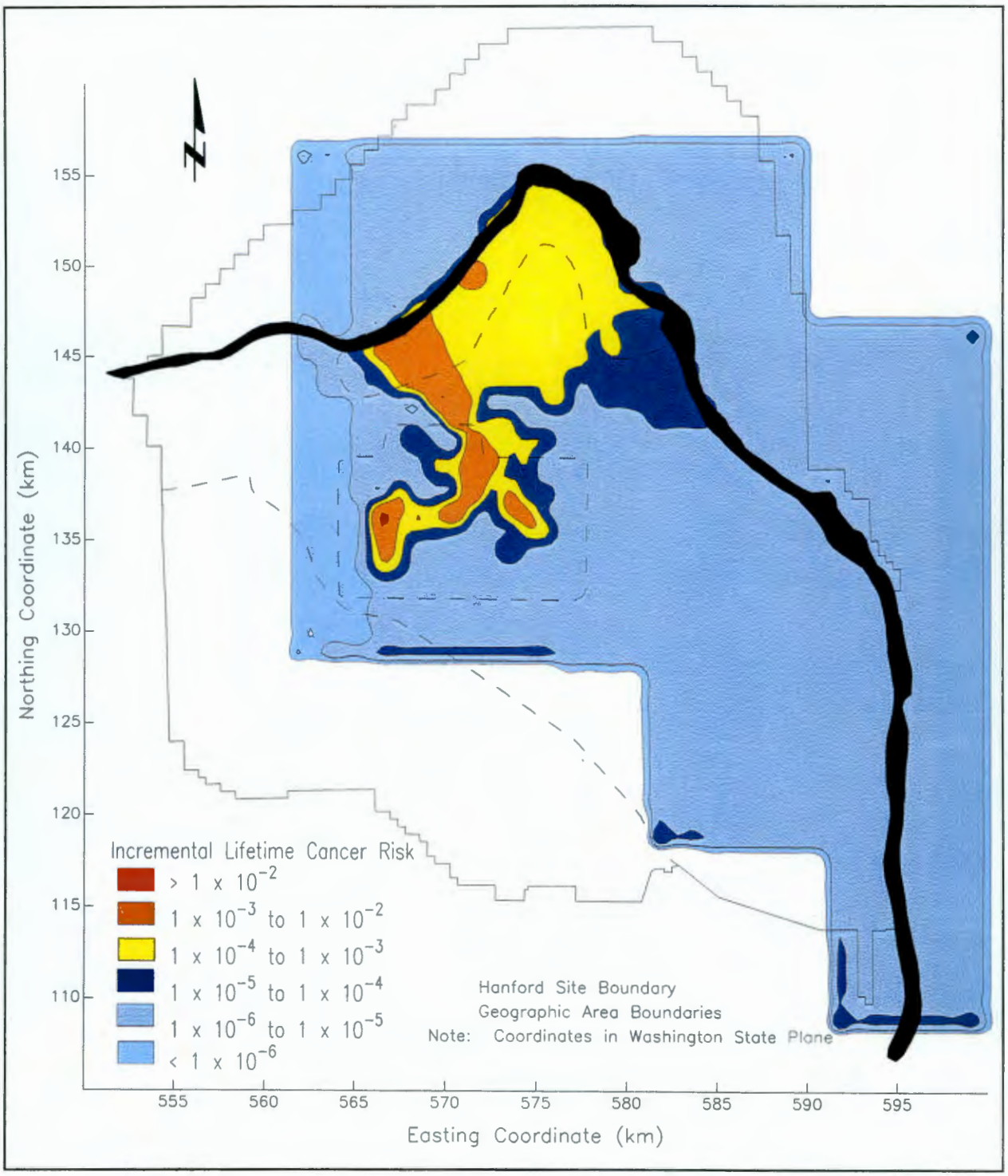

Figure 5-64. No-Action Alternative - Baseline Risk Isopleths for the Residential Scenario at T_{10000} (Year 11989).

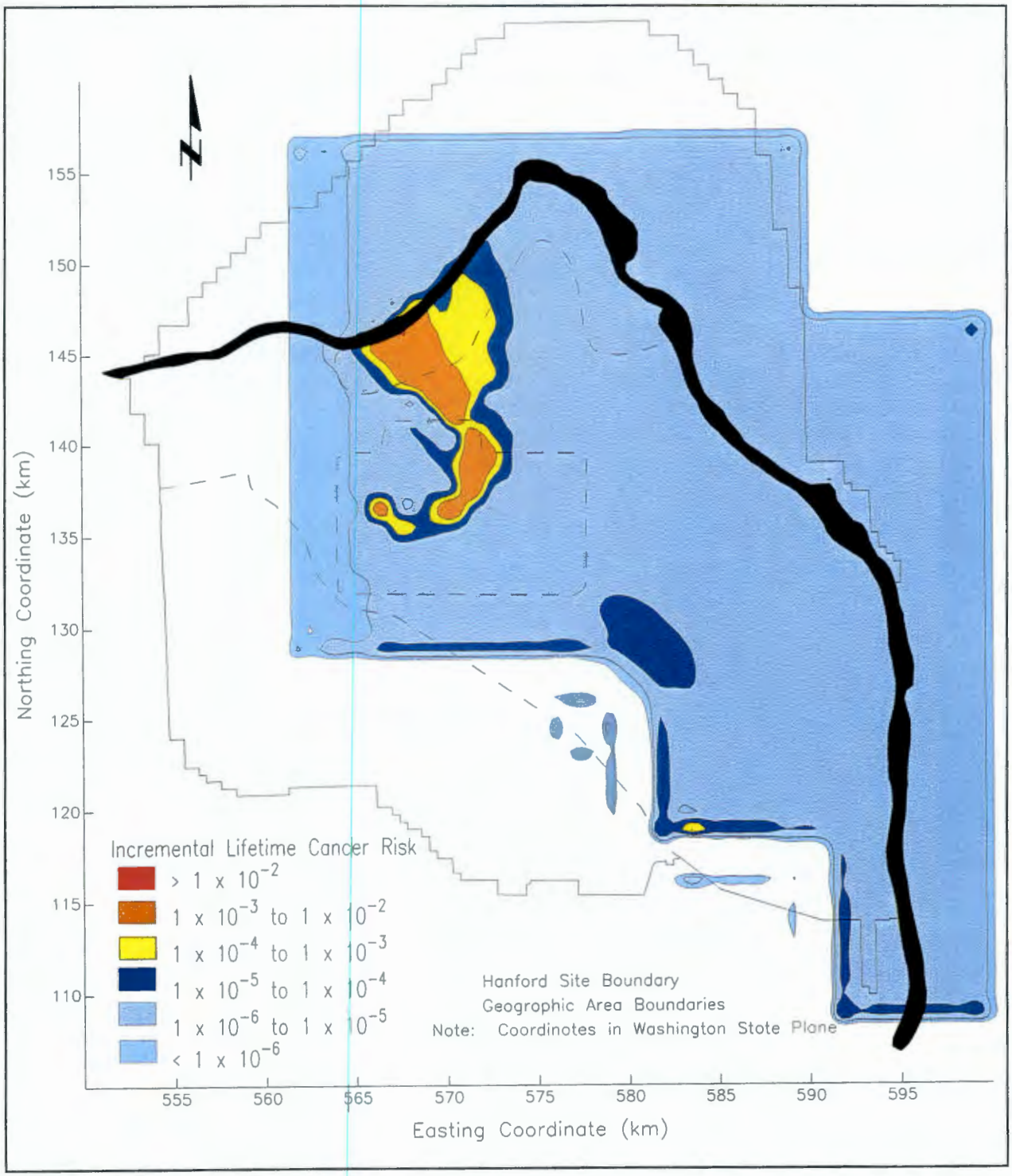

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Figure 5-67. No-Action Alternative - Baseline Risk Isopleths for the Industrial Scenario at T_{140} (Year 2129).

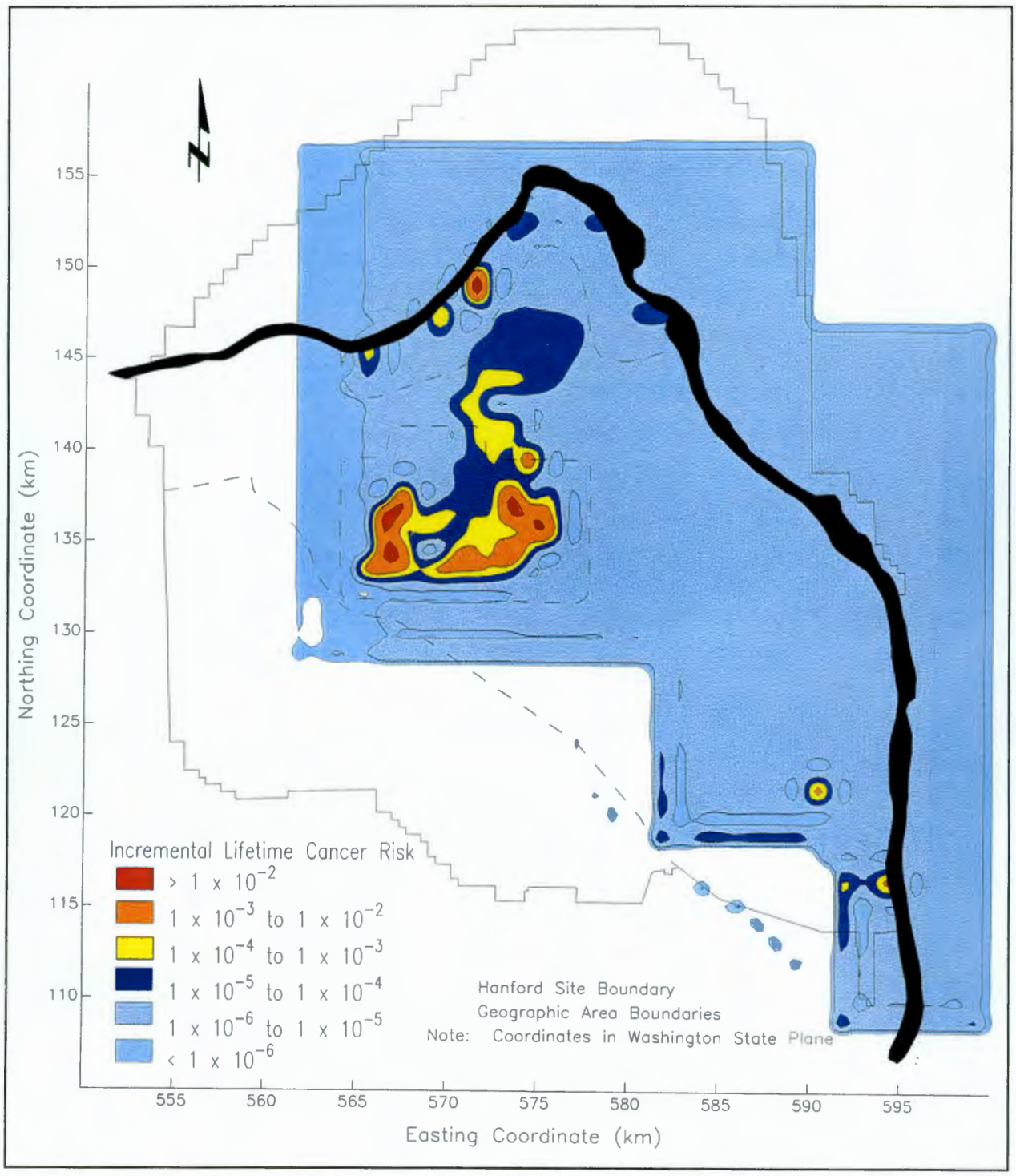

Figure 5-68. No-Action Alternative - Baseline Risk Isopleths for the Industrial Scenario at T_{1000} (Year 2989).

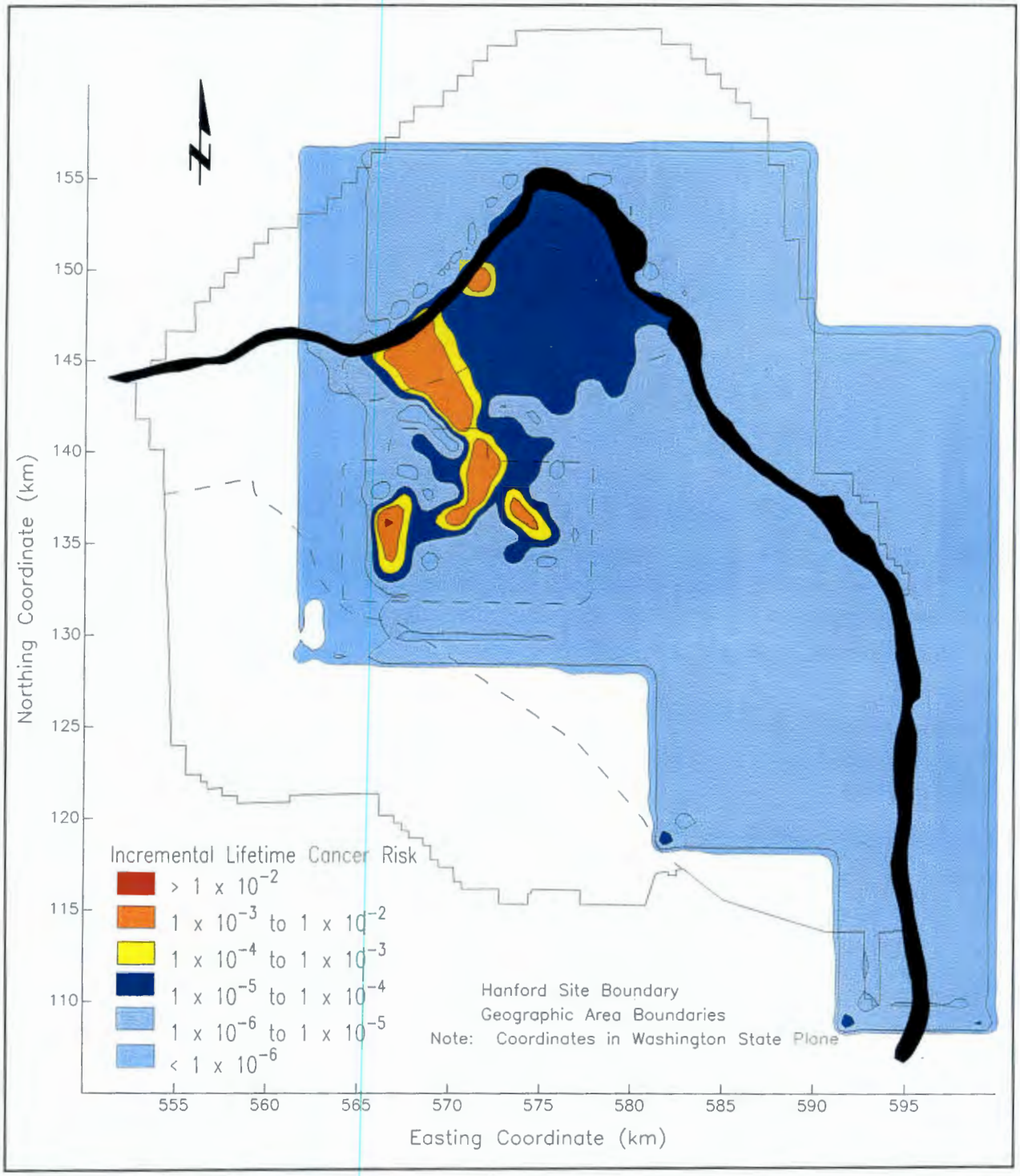

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Figure 5-69. No-Action Alternative - Baseline Risk Isopleths for the Industrial Scenario at T_{10000} (Year 11989).

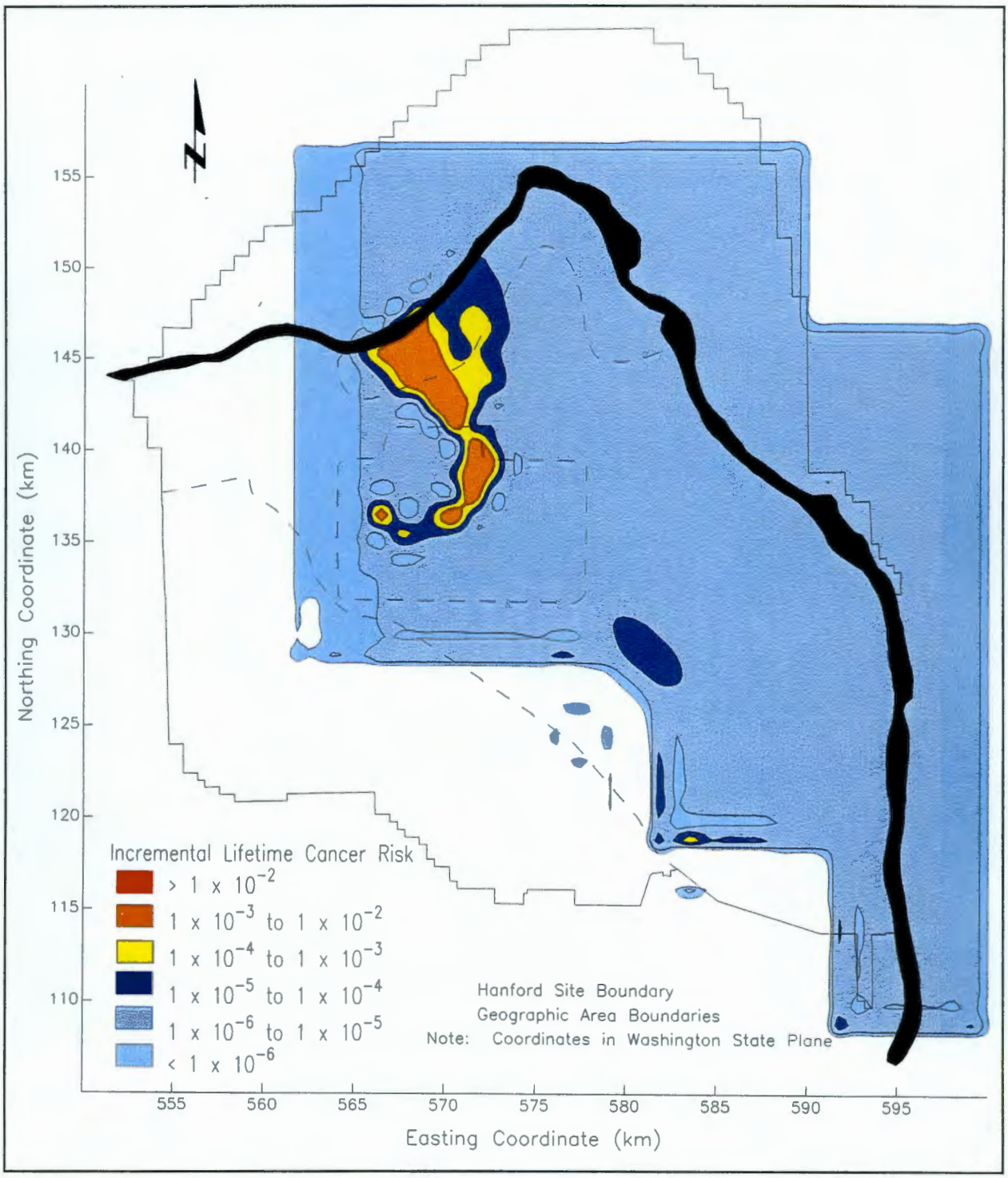


Figure 5-70. No-Action Alternative - Baseline Risk Isopleths for the Recreational Scenario at T_{40} (Year 2029).

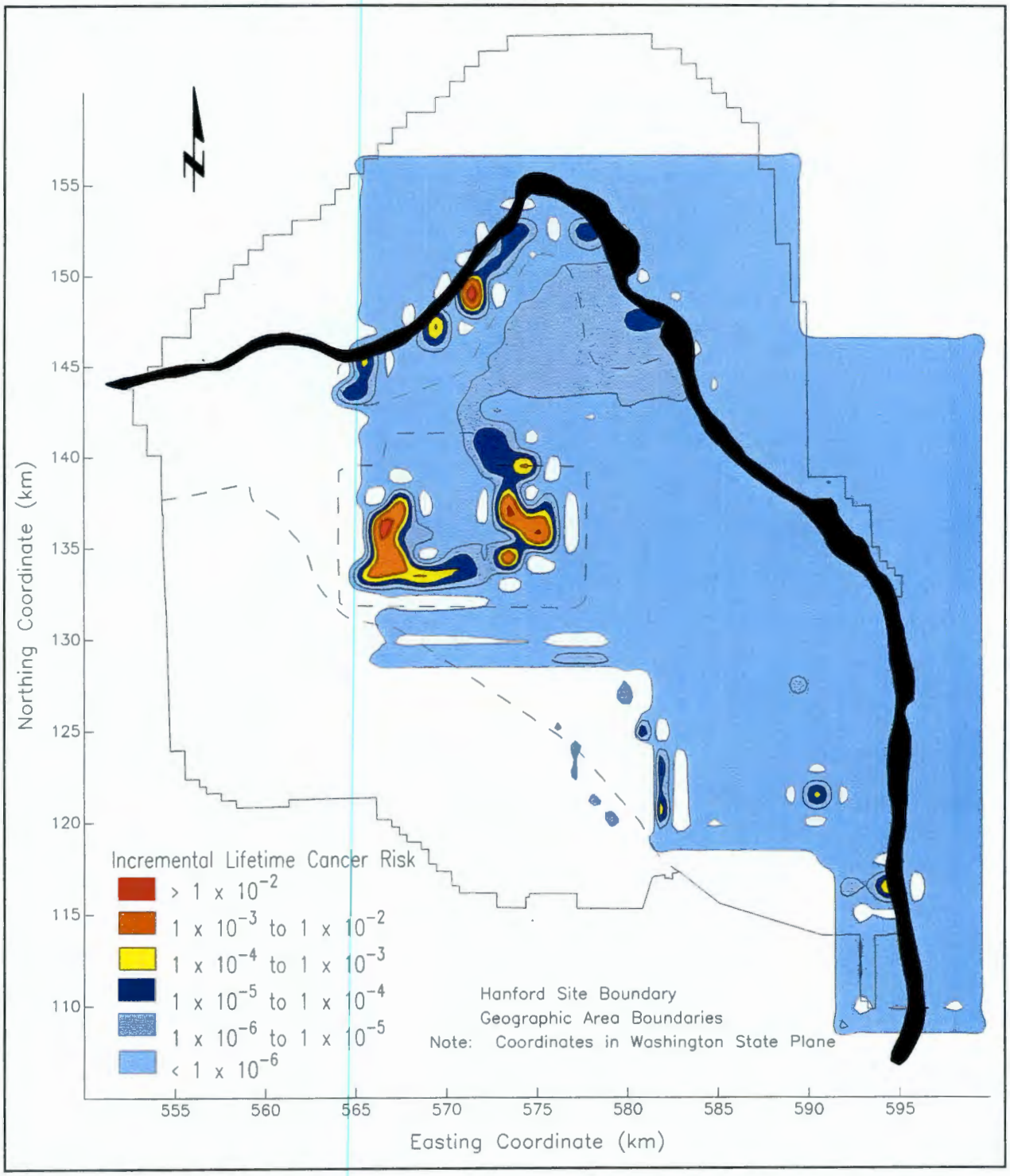


Figure 5-71. No-Action Alternative - Baseline Risk Isopleths for the Recreational Scenario at T_{100} (Year 2089).

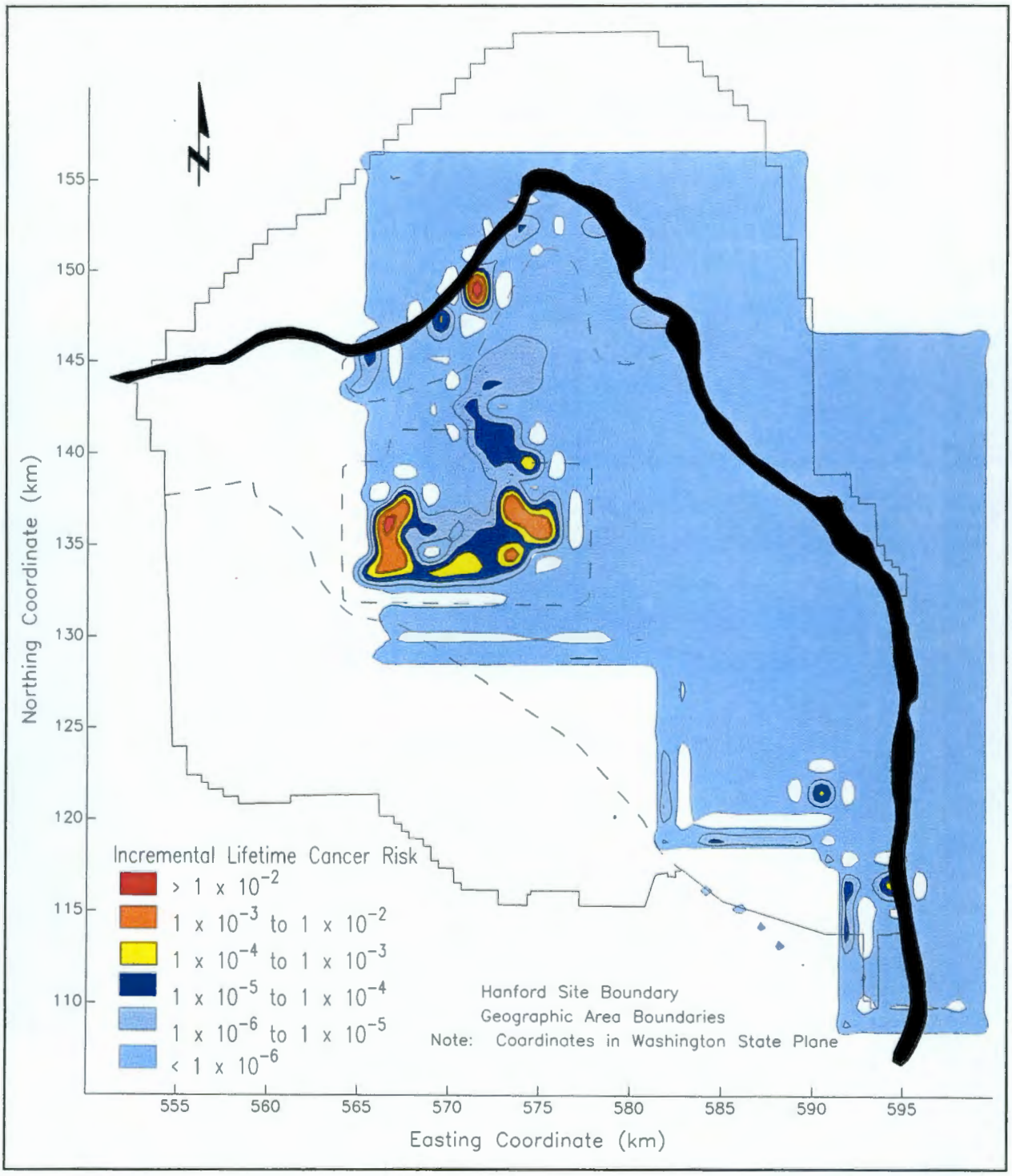


Figure 5-72. No-Action Alternative - Baseline Risk Isopleths for the Recreational Scenario at T_{140} (Year 2129).

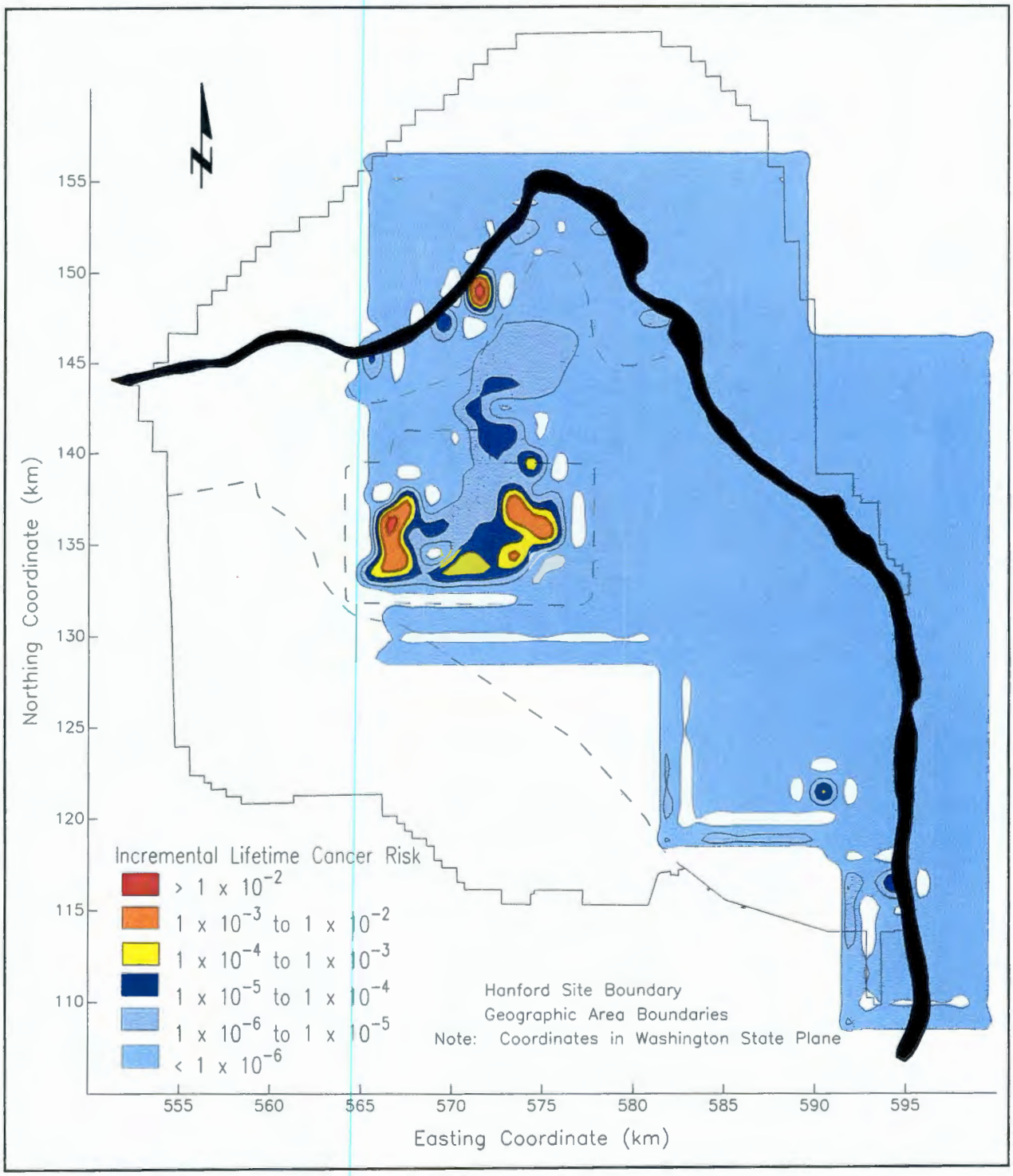


Figure 5-73. No-Action Alternative - Baseline Risk Isopleths for the Recreational Scenario at T_{1000} (Year 2989).

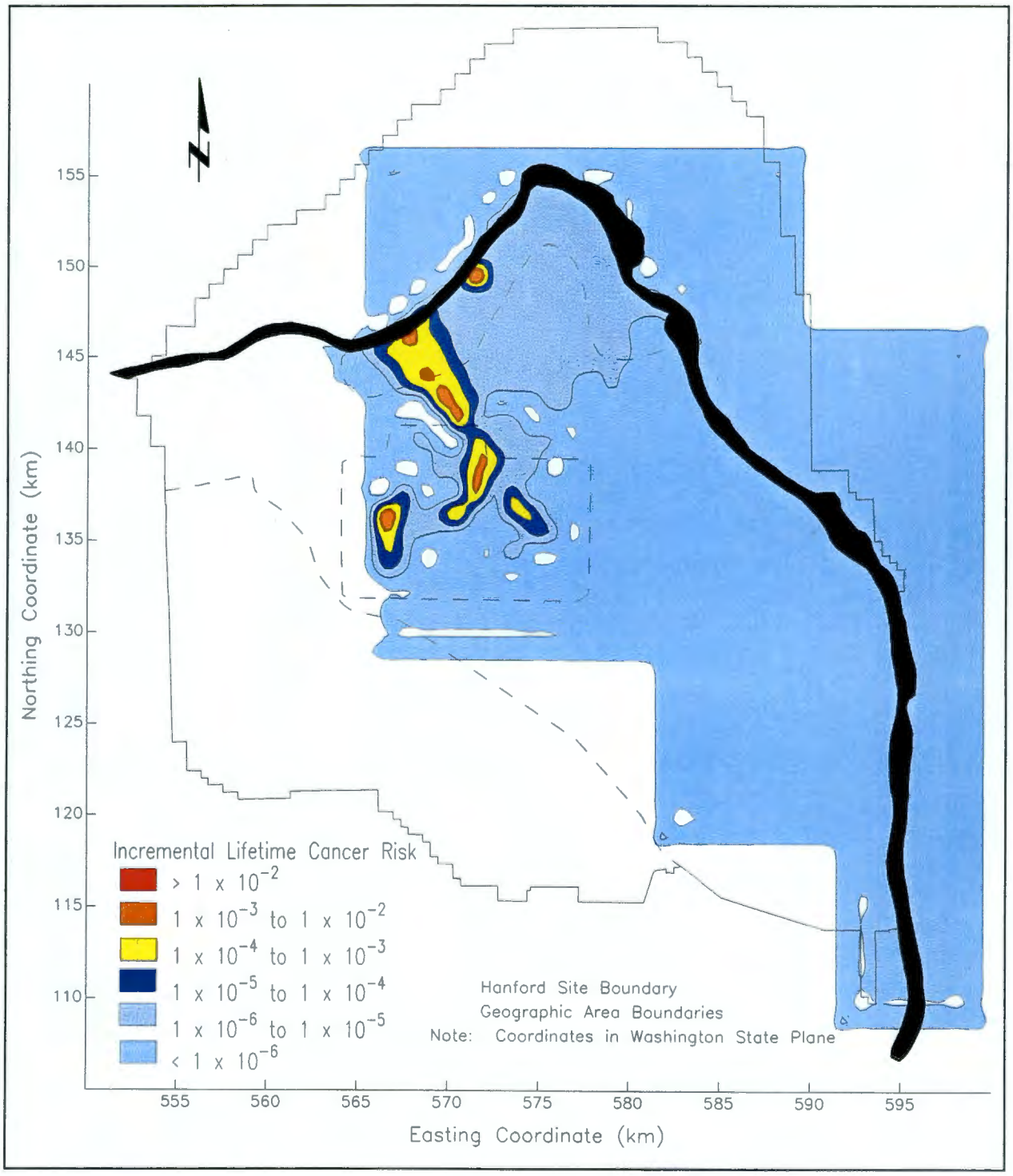
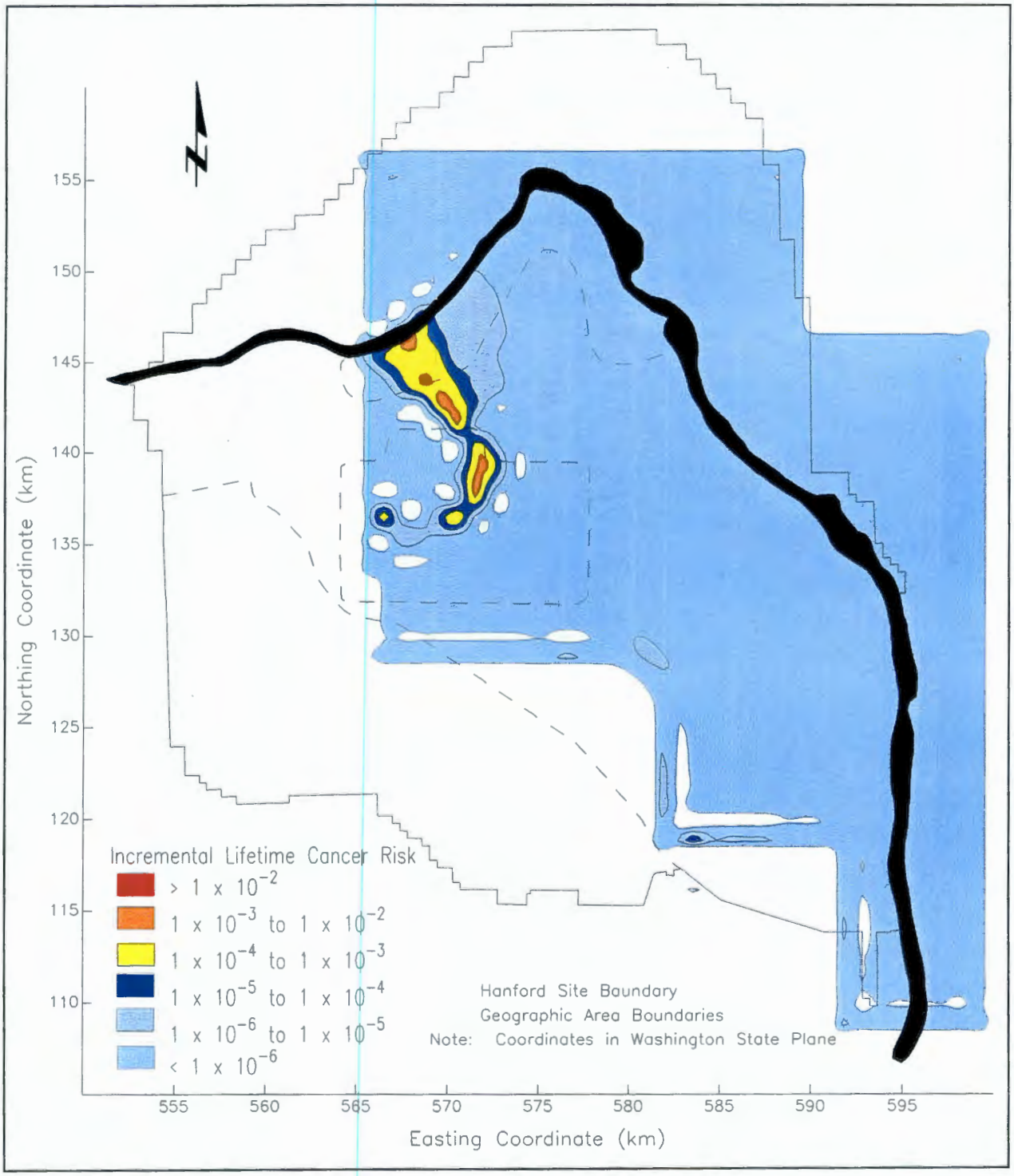


Figure 5-74. No-Action Alternative - Baseline Risk Isopleths for the Recreational Scenario at T_{10000} (Year 11989).



recreational activity. This greatly reduces the estimated future risk, compared to the other scenarios in which much more contaminated groundwater is consumed. It should be noted that the use of these groundwater ingestion scenarios are for the purpose of estimating hypothetical future human health risks. The DOE does not advocate the use of Hanford Site groundwater.

5.8.5 Potential Health Risk to Future Populations

The analysis of potential health risk to future Hanford Site users is of interest to the DOE, and many local community members and stakeholders. In order to conduct an assessment of potential long-term environmental impacts from residual contamination, two major issues must be addressed:

1. The risk level to which an individual waste site will be remediated (i.e., how clean is clean).

2. Future demographics (primarily population and occupation) of the Hanford Site.

> ***Why is a Risk Range Used?***
>
> The 10^{-4} to 10^{-6} risk range provides flexibility in determining appropriate remediation levels for contaminated sites. The 10^{-6} risk level is presented as a "point of departure," that is, the starting point for acceptable exposure levels. After factors such as uncertainty, population sensitivities, and technical limitations to remediation have been considered, the target risk may be revised upward within the risk range.

The risk estimates presented in this section are appropriate only for the analysis presented in this EIS, and do not pre-suppose any potential decisionmaking authority of CERCLA. All final decisions made regarding the level of and means by which remediation activities are conducted at the Hanford Site will be determined under the authority of CERCLA.

*5.8.5.1 **Risk Level Estimates***. An assessment of the risk and associated cancer incidence to future Hanford Site users has been conducted for each future land-use alternative. In conducting this assessment, impacts to the population within each geographic area of the Hanford Site have been considered in estimating the impacts from plumes that, after a loss of institutional control, might migrate from other geographic areas into the geographic area being assessed. (This plume migration will result in pockets of increased risk within the geographic area being assessed.) For example, if the Reactors on the River geographic area was remediated to the Restricted Future Land-Use Alternative (R1) level, the risk within that geographic area, following loss of institutional control, is assumed to be 10^{-4}. However, because institutional controls are assumed to be lost for the entire Hanford Site, groundwater contaminant plumes originating in the Central Plateau and All Other Areas geographic areas could freely migrate into the Reactors on the River geographic area. This situation eventually would result in pockets of increased risk (greater than 10^{-4}) in the Reactors on the River geographic area.

*5.8.5.1.1 **Risk Level Estimates for the Unrestricted Future Land-Use Alternative***. For remediation activities conducted under the Unrestricted Future Land-Use Alternative, it is assumed that a risk level of 10^{-6} would be achieved. This risk level (10^{-6}) would allow unlimited human use in the future. Risk reduction would be achieved through excavation and removal of contamination. This alternative does not incorporate the use of engineering and/or institutional controls. The migration of contaminants from other geographic areas also could result in a risk level that exceeds 10^{-6}.

5.8.5.1.2 Risk Level Estimates for the Restricted Future Land-Use Alternative (R1). The Restricted Future Land-Use Alternative (R1) assumes that remediation activities would result in a risk level of less than 10^{-4} as long as institutional and/or engineering controls are in place, and that risk would remain at 10^{-4} after loss of institutional control. The migration of contaminants from other geographic areas could result in a risk level that exceeds 10^{-4}.

5.8.5.1.3 Risk Level Estimates for the Restricted Future Land-Use Alternative (R2). The Restricted Future Land-Use Alternative (R2) assumes that a risk level of 10^{-4} would be achieved through the use of institutional and/or engineering controls (i.e., deed restrictions, fences, surface and subsurface barriers). The majority of waste and contamination in a given area would be left in place, and the use of engineering and/or institutional controls would reduce risk to an acceptable level (10^{-4}). If institutional and/or engineering controls are removed, risks associated with these areas could increase significantly, similar to what has been projected for the No-Action Alternative (see Section 5.8.3). The migration of contaminants from other geographic areas could result in a risk level that exceeds 10^{-4}.

5.8.5.1.4 Risk Level Estimates for the Exclusive Future Land-Use Alternative. The Exclusive Future Land-Use Alternative assumes that a risk level of 10^{-4} would be achieved through the use of institutional and/or engineering controls. The majority of waste and contamination in a given area would be left in place, and the use of engineering and/or institutional controls (i.e., deed restrictions, fences, surface and subsurface barriers) would reduce risk to an acceptable level (10^{-4}). However, once institutional and/or engineering controls are removed, risk associated with these areas could increase significantly, similar to what has been projected for the No-Action Alternative (see Section 5.8.3).

5.8.5.2 Future Demographic Estimates. An estimate of the population at the Hanford Site from 140 to 1,000 years, and from 1,000 to 10,000 years was developed. Once the population estimates were completed, risk from residual contamination (based on individual future land-use alternatives) was calculated. The risk then was applied to the respective population within each geographic area over the two time periods to determine the total number of potential cancer incidents. The future demographic estimates presented in this section are based on the prediction on climate associated biological carrying capacity, and current local demographics and demographic trends. These estimates were used in analyzing the potential impacts to future generations. Table 5-57 defines populations for 10,000 years from the present for all of the future land-use alternatives analyzed in this EIS. The population classifications include a residential farmer (based on the HSRAM agricultural exposure scenario), an industrial worker (HSRAM industrial exposure scenario), a resident (HSRAM residential exposure scenario) and a recreational user (HSRAM recreational exposure scenario).

In order to estimate the population that would be exposed to residual contaminants within each geographic area at the Hanford Site, a population density and generation time were assumed for residential, agricultural, industrial, and recreational exposure scenarios as follows:

- The residential exposure scenario assumed a population density of 150 persons/km^2; the typical resident was assumed to live at the same location on the site for 70 years.

- The agricultural exposure scenario assumed a population density of 4.97 persons/km^2 (TRIDEC 1994). This population density is similar to the present-day (1990s) population density in the farming areas surrounding the Hanford Site. For the analysis, exposure to the contaminants was assumed to occur for a period of 70 years of continuous farming.

Table 5-57. Population Characteristics Used in the Analysis of Potential Health Risk to Future Populations.

Exposure Scenario Geographic Area	Population Density (people/km^2)	Years per Generation	Population Size	
			140 to 1,000 yrs	1,000 to 10,000 yrs
Residential	150	70		
Reactors on the River			125,358	1,311,414
Central Plateau			212,003	2,217,833
All Other Areas			1,150,344	12,034,152
Agricultural	4.97	70		
Reactors on the River			4,154	46,831
Central Plateau			7,024	73,484
All Other Areas			38,115	398,732
Industrial[a]	1,700	30	48,739	510,000
Recreational	54.94	30		
Columbia River			163,800	1,714,128

[a]The industrial exposure scenario assumes that a large facility with 1,700 workers would be located within the geographic area. The employee population is the same for the Reactors on the River, Central Plateau, and All Other Areas geographic areas.

- The industrial exposure scenario assumed that a large industrial complex would be located at the site. This complex would facilitate a stable workforce of 1,700, and a typical worker would be employed at the facility for 30 years. The analysis assumed that the facility would be located within the boundaries of the highest risk area (of adequate size to accommodate an industrial complex) within each geographic area.

- The recreational exposure scenario for the Columbia River geographic area assumed that a total of 40,000 1-day visits occurred each year (NPS 1994), and that a representative individual made 7 of these visits or visited for 7 days every year for 30 years. The area visited consisted of 104 km^2 on the south and west banks of the river. Based on these assumptions, a population density of 54.94 persons/km^2 was calculated for the recreational exposure scenario. River shoreline users may be exposed to contaminants, which could result in increased risk.

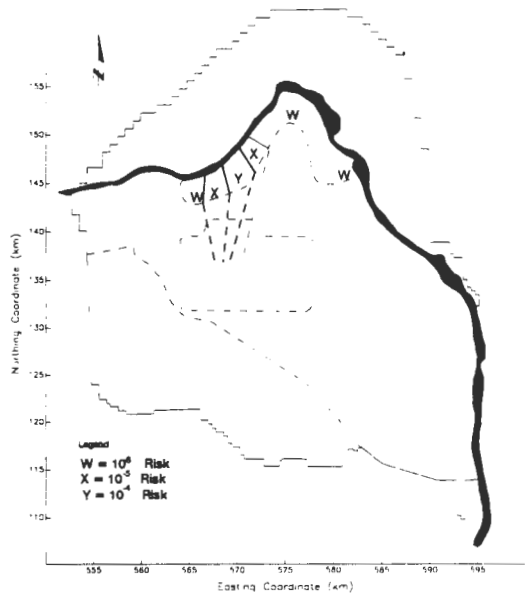
  Risk from exposure to contaminants was based on the No-Action Alternative throughout the Hanford Site. It has been determined that the most probable mechanism for contaminants to enter the Columbia River is through seeps and springs. Once contaminants reach the river, dilution will reduce contaminants to levels well below applicable standards that would pose little risk to future Hanford Site users. Appendix D provides estimates of contaminant concentrations in the Columbia River following treatment system effluent discharge.

The exposed population within each geographic area was calculated using the following relationship.

$$\text{exposed population} = (\text{population density})(\text{area})(\text{generations}).$$

Table 5-57 provides estimates of the total exposed population over the period from loss of institutional controls (assumed to be 140 years from now) through 10,000 years.

5.8.5.3 Analysis of Potential Health Risk to Future Populations. Using population density estimates for each future land-use alternative, the exposed individuals were assumed to be evenly distributed over the entire Hanford Site. To calculate the number of individuals exposed, the total area was multiplied by the estimated population density, and migration of contaminants (and associated risk) from other geographic areas following loss of institutional control was factored into the total risk calculation. The risk calculations (baseline risk for the geographic area and 'pockets' of increased risk resulting from contaminant migration from other geographic areas) then were applied to the population within each geographic area to estimate cancer incidences. This figure, and the following formula, provide additional detail on the methodology used to estimate risk to future populations from residual contamination.



The formula used to predict the number of cancer incidents for a given geographic area with a specific future land-use alternative at any particular time is as follows:

$$\begin{aligned}\text{Incidents} = {} & (\text{W area km}^2)(\text{population density people/ km}^2)(\text{generations})(\text{risk in area W}) \\ & + (\text{X area km}^2)(\text{population density people/ km}^2)(\text{generations})(\text{risk in area X}) \\ & + (\text{Y area km}^2)(\text{population density people/ km}^2)(\text{generations})(\text{risk in area Y})\end{aligned}$$

This calculation is performed for each time interval assuming risk remains constant over the periods from 140 to 1,000 years and from 1,000 to 10,000 years. Summing the incidences from the two time intervals produces the total expected cancer incidence for a given geographic area, assuming a specific future land use over a 10,000-year period.

5.8.5.3.1 Sample Calculation. Risk contours from future times of 140 and 1,000 years were used to estimate risk to future populations. These contours represent the boundaries of areas where the risk of contracting cancer by a receptor changes by a factor of 10. To calculate risk to future populations, the number of predicted cancers within each risk isopleth in the geographic area must be summed. Because interim contours were not available, risk contours at 140 years were used to estimate cancers that would occur within the period of 140 to 1,000 years. Similarly, risk contours at 1,000 years were used to estimate cancers for the period extending from 1,000 to 10,000 years. This method overcompensates for expected decay of radionuclide constituents. Cancer incidence was calculated using the method described above.

For the Reactors on the River geographic area residential exposure scenario under the Restricted (R1) Future Land-Use Alternative within the timeframe of 140 to 1,000 years, cancer incidence was calculated as follows (assuming a population of 150 people/km^2 and 12.3 generations within 860 years):

Risk	Risk Isopleth Area (km^2)
1 E-6	0.3
1 E-5	32.5
1 E-4	35.2

$$\begin{aligned} \text{Incidence} &= (0.3)(150)(12.3)(1\text{E-6}) = 0.0006 \\ &+ (32.5)(150)(12.3)(1\text{E-5}) = 0.60 \\ &+ (35.2)(150)(12.3)(1\text{E-4}) = \underline{6.49} \\ & \qquad\qquad\qquad\qquad\qquad\qquad 7.09 \end{aligned}$$

or approximately 7 cancer incidents over this timeframe.

The cancer incidence was calculated assuming that the risk isopleths have the same magnitude throughout the entire time period of 860 years. In reality, the risk isopleths are dynamic, and the calculated incidence could be either too high or too low depending on the relative size of the risk isopleths over time. This factor contributes to the uncertainty in the estimate of cancer incidence as discussed below.

5.8.5.4 Results of the Analysis. Cancer incidence for future populations in each geographic area are presented in Table 5-58. The groundwater plume emerging from the Central Plateau geographic area was determined to contribute significantly to future risk in the Reactors on the River and All Other Areas geographic areas. For comparative purposes, cancer incidences also were estimated assuming institutional controls were maintained in perpetuity for the Central Plateau geographic area (Table 5-59). These controls were assumed to involve ongoing groundwater treatment to prevent plume migration from the Central Plateau.

In addition to information presented in Tables 5-58 and 5-59, a recreational exposure scenario was evaluated for the Columbia River geographic area. The exposed population for the recreational exposure scenario was determined to be 163,800 and 1,714,128 people over the time periods from 140 to 1,000 years and 1,000 to 10,000 years, respectively. Cancer incidence from this exposure scenario was determined to be 15 cancers within the period from 140 to 1,000 years and 145 cancers in the period from 1,000 to 10,000 years. Because the calculation assumed no remediation, these estimates are believed to be high. During the period from 140 to 1,000 years, the majority of risk is the result of exposure to contaminants associated with the 100 Areas. Assuming these areas are remediated, cancer incidence during this period is 1 or fewer. During the period from 1,000 to 10,000 years, risk results from the groundwater plumes emanating from the Central Plateau and the 100-N Area. If the 100-N Area is remediated, and the plume from the Central Plateau is remediated or controlled, risk throughout the area would be less than 10^{-6}, and cancer incidence would be less than 2.

Table 5-58. Future Exposed Populations and Estimated Cancer Incidences for Each Geographic Area and Future Land-Use Alternative (assuming loss of institutional controls at the Hanford Site).

Geographic Area Future Land-Use Alternative	Residential Exposure Scenario		Agricultural Exposure Scenario		Industrial[a] Exposure Scenario	
	140 to 1,000 yrs	1,000 to 10,000 yrs	140 to 1,000 yrs	1,000 to 10,000 yrs	140 to 1,000 yrs	1,000 to 10,000 yrs
Reactors on the River						
Total Exposed Population	125,358	1,311,414	4,154	46,831	48,739	510,000
No Action	63	3,124	0	104	487	5,100
Unrestricted Future Land Use	3	2,658	0	88	0	5,100
Restricted Future Land Use (R1)	7	2,659	0	88	5	5,100
Restricted Future Land Use (R2)	63	3,124	0	104	487	5,100
Central Plateau						
Total Exposed Population	212,003	2,217,833	7,024	73,484	48,739	510,000
No Action	632	2,532	19	141	487	5,100
Exclusive Future Land Use	632	2,532	19	141	487	5,100
All Other Areas						
Total Exposed Population	1,150,344	12,034,152	38,115	398,732	48,739	510,000
No Action	114	2,984	6	92	49	5,100
Restricted Future Land Use (R1)	89	2,984	5	92	49	5,100
Restricted Future Land Use (R2)	114	2,984	6	92	49	5,100

[a]An industrial complex of 1,700 workers was assumed to be located above the portion of the geographic area with the highest risk.

Table 5-59. Future Exposed Populations and Cancer Incidences for Each Geographic Area and Future Land-Use Alternative (assuming institutional control is maintained in the Central Plateau, and that control prevents migration of contaminants to other geographic areas).

Geographic Area Future Land-Use Alternative	Residential Exposure Scenario		Agricultural Exposure Scenario		Industrial Exposure Scenario[a]	
	140 to 1,000 yrs	1,000 to 10,000 yrs	140 to 1,000 yrs	1,000 to 10,000 yrs	140 to 1,000 yrs	1,000 to 10,000 yrs
Reactors on the River						
Total Exposed Population	125,358	1,311,414	4,154	46,831	48,739	510,000
Unrestricted Future Land Use	0	1	0	<1	0	<1
Restricted Future Land Use (R1)	7	18	0	1	5[c]	51[c]
Restricted Future Land Use (R2)	63	360	2	13	487[c]	5,100[c]
Central Plateau	NA	NA	NA	NA		
Total Exposed Population					48,739	510,000
Exclusive Future Land Use					<5[b]	<51[b]
All Other Areas						
Total Exposed Population	1,150,344	12,034,152	38,115	398,732	48,739	510,000
Restricted Future Land Use (R1)	<11	92	0	3	<5[d]	<5
Restricted Future Land Use (R2)	27	92	1	3	49[d]	<5

[a]An industrial complex of 1,700 workers was assumed to be located above the portion of the geographic area with the highest risk.

[b]Institutional controls would maintain risk at 1E-04 or lower.

[c]Institutional facility situated within the 100-N Area remediated to 1E-04 for R1, and assumed to be equivalent to the No Action Alternative for R2; no institutional controls outside of the Central Plateau.

[d]Industrial facility located within the 300 Area or 400 Area zones of elevated risk.

5.8.5.5 Uncertainty in the Analysis. The calculated risk to future (post remediation) populations is dependent on multiple assumptions about exposures, toxicity, and other variables. Each of these assumptions contribute to the uncertainty associated with the estimated risk to individuals or populations that may reside on the Hanford Site at some future time. Uncertainty in the variables used to calculate risk is inherent in the risk assessment process, and also is associated with site-specific parameters. Factors requiring consideration in evaluating uncertainty are related to site-specific parameters, exposure assessment factors, toxicity assessment factors, and risk characterization factors. The following paragraphs provide a brief discussion of uncertainty factors. Additional discussion is presented in Appendix B of this EIS in association with the human health risk assessment for the No-Action Alternative (see Section 5.8.3).

5.8.5.5.1 Site-Specific Uncertainty Factors. Site-specific uncertainty factors include the source inventory, site contamination (i.e., types, concentrations, and distribution), and site-specific environmental conditions (i.e., climate, geology, and hydrology), along with the uncertainty in model application to the conditions at the site.

Because detailed characterization activities have not been completed at many of the waste sites within the scope of this EIS, considerable uncertainty is associated with the source inventory and site contamination factors. Cumulative effects of wastes in multiple sites were accounted for in the risk isopleth maps presented in Section 5.8.4. For example, groundwater plumes migrating from the Central Plateau, which contribute a significant portion of risk to future residents, consist of a composite of contaminants in overlapping plumes from individual waste sites. Conservative factors, based on available sample analyses and existing databases, were used to estimate these factors. Although the source term factors used in the analysis could overestimate or underestimate risk associated with any particular site, the method of assuming that the highest known or suspected contaminant concentration applied to the entire cell containing the site would substantially overestimate risk.

Factors related to environmental conditions at a site address the fate and transport of contaminants at that site. This risk assessment assumes that general environmental conditions apply to large geographic areas and that environmental conditions remained roughly the same for many years in the future. Uncertainty in environmental conditions includes factors associated with the microclimate at the site and factors associated with climate changes that could occur over the long term. Assumed factors regarding environmental conditions could overestimate or underestimate risks.

5.8.5.5.2 Exposure Assessment Uncertainty Factors. Numerous assumptions are involved in assessing exposure of receptors to contaminants and each of these assumptions has an associated uncertainty. Each of the following parameters contribute to uncertainty in the exposure assessment.

- Identification of land use and the likelihood of that future land use occurring. Default exposure parameters are specific to future land uses, and the assumed use pattern may have little chance of actually occurring in the future. The exposure parameters might, therefore, be excessively conservative.

- For risks to future populations, the estimate of the population density in the future is highly uncertain. Population risks are based on these estimates and could be overestimated or underestimated depending on the population that is actually exposed at some future date.

- Model assumptions that affect exposure point concentrations and the use of the upper 95% confidence limit as a representative exposure point concentration. In general, these assumptions are conservative and tend to overestimate risk to a receptor.

- Calculation of risk based on standard default parameters (e.g., 95% values for intake and contact rates, exposure frequency and exposure duration) tend to overestimate risk.

- Uncertainty related to bio-transfer factors might lead to an over- or underestimate of risk.

- Uncertainty related to production and distribution of food might over- or underestimate risk for a particular exposure scenario. In general, the agricultural exposure scenario assumes local production of a large percentage of foodstuffs and tends to overestimate risk.

- Individual diets and lifestyles modify the potential risk to specific individuals. For example, some individuals may consume either more or less water than the default estimate of 2 L/day.

5.8.5.5.3 Toxicity Assessment Uncertainty Factors. Most toxicity values used in risk assessment have a high degree of associated uncertainty. Frequently, these values have protective factors built in to account for these uncertainties and protect humans from health effects that might be associated with exposure to a particular toxin. Sources of uncertainty associated with published toxicity values include:

- Use of dose-response information from effects observed at high doses to predict the adverse health effects that might occur following exposure to low doses expected from human contact with the agent in the environment

- Use of data from short-term exposure studies to extrapolate to long-term exposure

- Use of data from animal studies to predict human effects

- Use of data from homogeneous animal populations or healthy human populations to predict effects in the general population

- Use of data that does not consider the potential presence of sensitive sub-populations.

5.8.5.5.4 Risk Characterization Uncertainty Factors. Slope factors used to determine risk for each chemical carcinogen were upper 95% estimates. Calculated risks were summed across chemicals and exposure pathways. This method tends to overestimate risk because the probability distributions relating exposure to effect for multiple chemicals are not strictly additive. Different chemicals frequently have different modes of action and affect different tissues within the receptor. Summing these risks assumes that the portion of the population that is sensitive to one chemical also is sensitive to the other chemicals. Assuming risks are additive for multiple chemicals makes the estimate of total cancer risk more conservative.

The analysis did not consider potential antagonistic or synergistic effects that exposure to multiple carcinogens might have. These types effects are poorly studied. However, if antagonistic effects occurred between two or more components, then risk could be overstated by the analysis. Conversely, if synergistic effects occurred between two or more components, then risk could be understated.

The uncertainty in the risk values for certain receptors increases as time into the future increases. Less uncertainty is associated with the risk values at 140 years than the risk estimate at 1,000 or 10,000 years into the future.

5.8.5.5.5 Uncertainty Factors Related to the Analysis. Uncertainty factors related to the analysis of risk to the future population inhabiting the Hanford Site include use of the risk from exposure to the groundwater plume from the Central Plateau for the No-Action Alternative in estimating future risks in other geographic areas and the assumption that all of the area between isobars presented a risk equivalent to the risk of the isobar bounding the area with the greatest risk. For example, people residing in an area bounded by isobars representing 10^{-4} and 10^{-5} were assumed to be exposed to a risk of 10^{-4}. These assumptions both tend to overestimate risk because groundwater remediation during the institutional control period would reduce or delay the risk to down gradient receptors and because the area between the isobars represents an area where risk is declining.

Assumptions about future populations exposed to the contaminants also introduce uncertainty into the analysis. These assumptions identify a particular land-use pattern and population density associated with that pattern. Population risks could be understated or overstated for each land use pattern and, in reality, a mosaic of land uses would likely occur within an area as large as the Hanford Site after loss of institutional control. Actual risks to future populations would depend upon the location of the areas developed for residential, agricultural, or industrial uses and the areas that were utilized for recreational purposes. As an example, it is unlikely that the entire Hanford site would be occupied by a residential population with a density of 150 people/km^2. In this case, risk to the exposed population over 10,000 years is likely to be overstated. Furthermore, the Hanford Site was assumed to be instantaneously colonized after loss of institutional control (at 140 years) with the entire population used in the analysis and this population was assumed to remain stable throughout the analysis period at a density that is highly unlikely after loss of institutional controls. Based on a realistic assumption of 10 ac/animal-unit-month for dry-land range agriculture, the site would support a maximum of 20 ranches. If each ranch supports four individuals, the actual density would be 0.4 persons/km^2, rather than the 4.97 persons/km^2 assumed for the agricultural exposure scenario. If loss of institutional controls is assumed, then the dry-land range agricultural exposure scenario is more plausible than other lifestyles that require modern technology.

Risk conditions at the 140-year future time were applied to the time period from 140 to 1,000 years and risk isopleths from the 1,000 year future time were applied to the period from 1,000 to 10,000 years. Risk isopleth maps for the No-Action Alternative indicate that the distribution of areas with higher risk change over these time periods. Depending on the precise location of the receptor population, the risk to that receptor might increase or decrease over the period due to migration of a groundwater plume into, or out of, the area and due to other factors, such as radioactive decay and environmental detoxification of other contaminants.

As an additional measure of conservatism, areas of the Hanford Site where risk (with or without remediation) would be lower were assumed to pose a risk to receptors of 10^{-6}. This factor tends to overestimate risk to future populations because portions of the site are uncontaminated.

In conclusion, estimates of health effects that might occur over the long term must be considered in light of the associated uncertainties. Uncertainties in toxicological factors are inherent in any analysis of risk. In this analysis, these inherent uncertainties may be overshadowed and dominated by uncertainties associated with assumptions used to define future conditions. The best and most scientific approach to estimating population risks is the use of probabilistic risk assessment

methodology. A probabilistic risk assessment could use the range of variation in contaminant information, exposure parameters, and toxicity data to provide a risk distribution curve. Use of a distribution of risk, rather than a conservative point estimation of risk, provides a better understanding of the uncertainty in the risk. Although the use of these probabilistic methods reduces uncertainty in near-term estimates of risk, uncertainty in the assumed distributions for factors contributing to long- and very long-term risks to populations would likely predominate.

5.9 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 1508.7). The cumulative impact analysis addresses effects of the proposed action in conjunction with effects of other actions in the same geographic area (DOE 1993b).

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 the land-use objectives. These remediation activities, conducted under the CERCLA process, are aimed at reducing the adverse environmental effects of past actions at the Hanford Site.

Present and reasonably foreseeable future actions at the Hanford Site are summarized in Section 5.9.1. Additional actions where analyses are not complete, but which, if implemented, could contribute to cumulative impacts, are described in Section 5.9.2. Present and reasonably foreseeable future actions adjacent to the Hanford Site are referenced in Section 5.9.3. Finally, potential cumulative impacts of the proposed remedial actions and the No-Action Alternative are summarized by resource in Section 5.9.4.

5.9.1 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 the Columbia River, Reactors on the River, Central Plateau, and All Other Areas geographic areas.

5.9.1.1 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 Environmental Impact Statement, Final - June 1994* (NPS 1994). This action addresses the need to protect the Hanford Reach as the last free-flowing stretch of the Columbia River. The preferred alternative would combine a Wild and Scenic River designation for the river and its immediate corridor with a National Wildlife Refuge (NWR) designation for 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 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 Hanford 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 water 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 communities.

- 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 contribute 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 remediation of the Hanford Site.

- Habitat protection and restoration efforts would benefit recreational use and access, as would increased river patrols, and improvements in public education efforts and recreational facilities.

In mandating the study in 1988, Congress provided interim protection of the Hanford Reach by prohibiting development until November 1996. Congress must determine the disposition of the Hanford Reach study area through legislative action (NPS 1994). However, the Hanford Reach No-Action Alternative (no special designation) would become effective in the absence of congressional action. In this case, the Hanford Reach would not be protected from development if the DOE relinquished control of this portion of the Hanford Site.

5.9.1.2 Reactors on the River Geographic Area. Present and reasonably foreseeable actions in the Reactors on the River geographic area include the following.

- **Decommissioning of Eight Surplus Production Reactors.** Present and reasonably foreseeable actions in the Reactors on the River geographic area include plutonium production reactor decommissioning. An EIS was prepared to address 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 1992a). The Record of Decision (ROD) for this action was published in 58 *Federal Register* (FR) 178. The DOE decided on safe storage, followed by deferred one-piece removal, as the preferred alternative. The DOE intends to complete this decommissioning action consistent with the schedule for remedial action in the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989). Therefore, the safe storage period would be for less than the 75-year time frame outlined in the Decommissioning of Eight Surplus Production Reactors EIS. This 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 associated with this action were estimated to be about 51 person-rem and short-term public radiation doses were estimated to be near zero (DOE 1992a). 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 the 8 reactors. Additional habitat disturbance would be required for construction of haul roads from the 100 Areas to the 200 Area that are capable of handling the movers required to transport the reactor blocks.

- **Deactivation of the N Reactor.** An Environmental Assessment (EA) was prepared to address all nonroutine activities associated with the shutdown of the 105-N Reactor (N Reactor) (DOE 1995b); the Finding of No Significant Impact (FONSI) was issued on May 1, 1995. The 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.

5.9.1.3 Central Plateau Geographic Area. Present and reasonably foreseeable actions in the Central Plateau geographic area include the following.

- **Safe Interim Storage of Hanford Tank Wastes.** A recently completed EIS analyzed the potential impacts of construction and operation of six new double-shell tanks (DST), the replacement of the cross-site waste transfer line between the 200 East and the 200 West Areas, and related actions (Ecology and DOE-RL 1995). Primary potential impacts are loss of shrub-steppe habitat and radiological air emissions. A ROD signed on November 22, 1995 (60 FR 61687) calls for construction of a new cross-site waste transfer system, continued operation of the existing cross-site transfer system in the interim, and continued operation of the mixer pump installed in Tank 101-SY. The DOE and Ecology have determined that additional DSTs will not be required for additional storage capacity. In addition, the DOE has deferred a decision on retrieving solids from Tank 101-SY.

- **Tank Waste Remediation System.** A draft EIS has been prepared to analyze alternatives for remediating the waste currently contained in the 177 single-shell tanks (SST) and DSTs in the Central Plateau geographic area and in about 60 active and inactive miscellaneous underground storage tanks, 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 1996). The EIS evaluates a range of waste retrieval and removal and in-place remediation options for the SST and DSTs. Potential impacts associated with this project are worker exposures to radiological and hazardous constituents during waste disposition and habitat disturbance.

  Worker exposures to hazardous and/or radioactive constituents were evaluated in the draft EIS. It is estimated that, depending on the alternative chosen, health effects due to radiation exposure would include from 0 to 4 LCFs to operational workers over the life of the project, and from 0 to 2 LCFs during transportation of waste materials over the life of the project. Overall, the continued management and minimal retrieval alternatives would result in lower health impacts during remediation than the extensive retrieval alternatives.

  The extent of shrub-steppe habitat disturbance also would depend on the alternative chosen. The amount of habitat lost would range from 10 to 41 ha (25 to 100 ac) for the continued management and minimal retrieval alternatives to 73 to 101 ha (180 to 250 ac) for the extensive retrieval alternatives.

- **Plutonium Finishing Plant Stabilization**. The DOE has issued a final EIS addressing stabilization of the radioactive materials present in the Plutonium Finishing Plant (DOE-RL 1996). Potential impacts include worker exposure and radiological air emissions.

  A ROD published on July 10, 1996 (61 FR 36352), documents the DOE's decision to implement a select group of stabilization alternatives identified in the Final PFP-EIS. Readily retrievable plutonium-bearing material contained within PFP process lines will be removed, and this and other plutonium-bearing material will be stabilized in a form suitable for interim storage. Material processing low-plutonium content, and meeting criteria established by the DOE, may be immobilized through a cementation process and transferred to an onsite solid waste management facility for storage. Decisions regarding ultimate disposition of this material will be made when the DOE determines the best disposition strategy for nuclear materials that are surplus to National defense requirements.

- **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 233-S; decommissioning of Building 232-Z will be addressed in separate NEPA documentation. 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 dismantled. 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.

  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 1.6×10^{-8} mrem to the 0.03 mrem dose to the hypothetical MEI reported by the *Hanford Site Environmental Report for Calendar Year 1994* (PNL 1995). The potential radiation dose to the MEI associated with routine operations at the 233-S Facility would add an estimated 5.94×10^{-6} mrem. This additional radiation dose, which is considered a conservative estimate, would not be expected to cause any adverse health effects.

- **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), with 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 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 draft EIS (USACE 1992). If this project resumes (it is currently on hold), 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 was constructed adjacent to the 200 Areas and started operation in August 1996. The facility provides for storage and disposal of waste generated during environmental restoration activities at the Hanford Site (EPA 1995b). 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 past-practice waste sites and CERCLA remedial activities will be placed in the ERDF. The Facility will accept only waste that originates within the Hanford Site. 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 south of the 200 Areas. Initial construction involved 65 ha (165 ac) of this area.

  The choice of future land-use alternatives will have indirect impacts on the native vegetation at the ERDF site. Indirect impacts are those impacts which are caused by the proposed action addressed by this EIS, and are later in time or farther removed in distance, but are still reasonably foreseeable. Because the selection of a site-wide future land-use alternative will help to determine the amount of remediation waste that is sent to ERDF, this EIS will play a role in the decision of when (or whether to) expand the ERDF trench. This decision will affect the overall acreage requirements (and resulting habitat destruction) at the ERDF site.

  Under current climate conditions, contaminants placed in the ERDF are expected to reach groundwater within 10,000 years. After 10,000 years, estimated human health risks are a maximum ILCR of 5×10^{-6} and a maximum hazard quotient for noncarcinogens of 0.2. Ecological impacts will 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 monitor 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 total 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. 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.

- **Programmatic 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 the Hanford Site has been identified as a participant in the management of spent fuel. The selected 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.

An amendment to the ROD (61 FR 9441) was issued to the public on February 28, 1996, to reflect modifications to the original decision resulting from a Settlement Agreement reached by the DOE, the State of Idaho, and the Department of the Navy. The amended ROD indicates that only 12 of the originally planned 524 shipments of spent nuclear fuel would be shipped from Hanford to Idaho. These 12 shipments will consist of the sodium-bonded FFTF fuel.

Land disturbance associated with this action at the Hanford Site 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 action would overlap with the time periods when the same type of resources would be required by remediation activities at the Hanford Site.

- **Hanford Spent Nuclear Fuel Management**. A Hanford EIS was prepared to tier from 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). The EIS analyzes the potential environmental impacts of the removal of SNF from the K Basins and subsequent management of the fuel for up to 40 years (DOE 1995i). The ROD for management of K Basin SNF was issued on March 4, 1996 (61 FR 10736).

  The ROD indicates that the preferred alternative identified and analyzed in the EIS, with minor modifications, will be implemented. This alternative consists of removing the SNF from the basins, vacuum drying, conditioning, and sealing the SNF in inert gas-filled canisters for dry vault storage in a new facility, to be built at Hanford, for up to 40 years pending decisions on ultimate disposition. The K Basins will continue to be operated during the period over which the alternative is implemented. The action also includes transfer of the basin sludge to Hanford's DSTs for management, disposal of non-SNF debris in a low-level burial ground at the Hanford Site, disposition of basin water, and deactivation of the basins pending decommissioning. A total of 3.5 ha (8.7 ac) of land and native vegetation would be disturbed of destroyed during land-clearing activities to provide new facilities for this project.

- **222-S Radioactive Liquid Waste Line Replacement and 219-S Secondary Containment Upgrade**. The DOE prepared an EA addressing replacement of the 222-S Laboratory (222-S) radioactive liquid waste line and 219-S Waste Handling Facility (219-S) 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 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.

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 generate low-level liquid mixed waste.

The 222-S is 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 selected action was divided into two phases. The first phase included installation of a new transfer line from the laboratory to the tank farms. This work has been completed. 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. Impacts associated with this action includes minor habitat disturbance and potential exposure concerns for workers.

- **200 Area Effluent Treatment Facility.** In 1992, the DOE prepared an EA and FONSI (DOE 1992b) that addressed environmental upgrades to liquid waste effluent systems, including the 200 Area Effluent Treatment Facility, located near the 200 East Area. This facility provides effluent treatment and disposal capability required to restart the 242-A Evaporator, which reduces tank waste volume by removing process condensate. The Effluent Treatment Facility provides for effluent collection, a treatment system to reduce the concentration of hazardous and radioactive waste constituents in the effluent streams to acceptable levels, tanks to allow verification of effluent characteristics before discharge, and a state-approved land disposal structure (SALDS) for effluents. The SALDS infiltration gallery consists of a 35- by 61-m (116- by 200-ft) rectangular drainfield, located north of the 200 West Area.

  Environmental impacts associated with this project include habitat destruction associated with the construction of the treatment facility, transfer piping, and the SALDS, and the discharge of small quantities of contaminants to the ground through the SALDS. In particular, the discharge of tritiated streams is of concern, but, because of tritium's relatively short half-life (12.3 years), the long residence time of the effluent in the groundwater is expected to be sufficient to attenuate the tritium before it reaches the Columbia River.

- **Operation of Low-Level Burial Grounds**. The low-level burial grounds located in the 200 West and 200 East Areas are an active, permitted 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, Inc. Commercial Low-Level Radioactive Waste Landfill for Offsite Commercial Waste**. US Ecology, Inc. operates a radioactive waste landfill that accepts commercially generated low-level wastes from states included in the Northwest Low-Level Radioactive Waste Compact. US Ecology, Inc. accepted 2,191 m^3 (77,418 ft^3) of naturally occurring wastes and 5,801 m^3 (204,981 ft^3) of low-level radioactive wastes in 1995 (TCH 1996). US Ecology, Inc.'s landfill is located directly east of the ERDF landfill. Habitat disturbance is the primary impact associated with the facility.

- **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 in the Central Plateau geographic area (DOE-RL 1995c). A FONSI was issued on September 28, 1995, which addresses the construction of 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 involve approximately 36 ha (89 ac), or about 5% of the 777 ha (1,920 ac) in the 200 West Area. Most activities will occur in previously disturbed areas. The waste storage facility, however, will be constructed on relatively undisturbed land, resulting in an incremental loss of shrub-steppe habitat essential for 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.

- **Tank 241-C-106 Sluicing and Waste Removal**. This project addresses the need to retrieve the high-heat waste in SST 241-C-106 and transfer the waste to DST 241-AY-102. 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 removal of the waste would stabilize this tank and eliminate the need to add cooling water. An EA (DOE 1994b) and FONSI were issued in February 1995.

  Tank 241-C-106, which is located in the 200 East Area, has a 31-cm (10-in) -thick dished bottom, and a useable waste depth of approximately 4.8 m (16 ft) at the sidewall. 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.

The high-heat waste will be sluiced from Tank 241-C-106 to a DST through a double-encased (pipe-in-pipe design), bermed line. The system will 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. Impacts associated with this action are potential worker exposure concerns.

- **Special Case Waste Storage Facility**. This EA addresses construction and operation of the Special Case Waste storage unit to handle high-activity remote-handled waste. The storage facility would provide a centralized remote-handled storage facility with monitoring and retrievability capabilities in solid waste management area of the 200 West Area.

5.9.1.4 All Other Areas Geographic Area. Present and reasonably 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 by the National Science Foundation for construction and operation of a LIGO (NSF 1993). A FONSI was issued in December 1993. The LIGO site occupies approximately 6 km^2 (2.3 mi^2), including a support facility 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. 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 near the Columbia River, in the southeast portion of the Hanford Site. 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 Native American 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. Another EA was prepared to address re-siting the facility (DOE 1994c) in the south part of the 300 Area; the FONSI was approved in July 1994. The facility is under construction at the new site. Approximately 200 to 250 employees will be located at the EMSL, including permanent staff and visiting scientists. The annual effective dose equivalent from the facility to the offsite MEI is estimated to be 1×10^{-4} mrem.

- **Inert/Demolition Waste Landfill (Pit 9)**. An EA was prepared for the proposal to construct a waste landfill (Pit 9) to accommodate inert and demolition waste for the Hanford Site (DOE 1995d). The DOE identified a need for convenient and economical disposal capacity of these types of waste to support the decommissioning 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 decommissioning activities on the Hanford Site will continue for up to 20 years; therefore, a replacement demolition landfill is required in the near term. 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. Based on current disposal projections, Pit 9 will be available for inert 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. Impacts associated with this action include minor habitat disturbances.

- **Disposition of Sodium Test Loops**. The DOE proposed to package the metallic sodium and sodium-potassium materials, 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. Residual sodium-wetted piping and associated equipment also will be packaged for recycling or disposal, as appropriate. Ancillary tankage will 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 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 action is to drain the sodium tanks and ship the sodium to a offsite buyer at a later date. Impacts associated with this action include the potential exposure of workers to metallic sodium (a hazardous material).

- **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 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 old piping in the existing 300 Area Process Sewer System.

  The 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. The process waste liquid effluent is 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.

- **Fast Flux Test Facility Standby**. The DOE has prepared an EA (DOE 1995g) addressing shutdown of the FFTF. The action will place the FFTF in a condition suitable for a long-term surveillance and maintenance phase before final decommissioning.

  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 in an inert gas atmosphere to prevent 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 units. Offsite TSD units also will be considered, as appropriate.

Although the FFTF was shut down as scheduled, certain deactivation activities have been put on hold while the DOE evaluates a proposal made by a consortium of private companies to operate the FFTF for the production of medical isotopes, and tritium for use in nuclear weapons.

5.9.2 Other Potential Hanford Site Actions

A number of other proposed actions at the Hanford Site are being evaluated in EAs, 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. However, actions in the All Other Areas geographic area may have indirect effects on the river.

5.9.2.1 Central Plateau Geographic Area. Actions that may contribute to cumulative impacts in the Central Plateau geographic area include the following.

- **Relocation of General Atomics Irradiated Test Reactor and Isotope Production 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).

- **Disposal of Decommissioned, Defueled Cruiser, Los Angeles Class, and Ohio Class Naval Reactor Plants**. This final EIS, prepared by the U.S. Navy, evaluates the potential impacts of disposing of defueled reactor plants from decommissioned naval vessels (Navy 1996). The preferred alternative is dismantling the vessels at the Puget Sound Navel Shipyard and transporting the reactor plants, by barge, to the Low-Level Burial Grounds at the Hanford Site. The DOE is a cooperating agency in the preparation of this EIS.

5.9.2.2 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 operations at 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).

5.9.3 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. The Siemens Power Corporation currently operates six wastewater lagoons to dispose of approximately 25,000 gal/d of effluent containing fluoride, nitrates, and minor amounts of radionuclides. This discharge is not considered during the analysis of cumulative environmental impacts, however, because the facility recently initiated a program to switch to a dry manufacturing system that will eliminate the waste stream. Siemens will complete conversion to the dry manufacturing system by 1998 and will phase out the use of lagoons completely by 2004 (TCH 1996).

City and county planning officials were consulted to assess other potential actions outside the Hanford Site boundary. The actions identified are primarily road, bridge, and sewer system improvements that are likely to have only minor impacts themselves and 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 5.9.4.9, there is considerable uncertainty associated with any analysis of such impacts, given available information on the scheduling of potential remedial actions.

5.9.4 Summary of Cumulative Impacts

This section summarizes potential cumulative impacts of the proposed action analyzed in this EIS 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., socioeconomic effects) depends on the scheduling of the many activities taking place or proposed to occur at the Hanford Site.

5.9.4.1 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 or TWRS, could have significant cumulative impacts on quarry sites and borrow pits. Existing sources of materials could be severely depleted or completely exhausted. Section 5.11 and Appendix E provide additional information on the potential impacts and quantities of materials that would be irreversibly and irretrievably committed for cap construction.

5.9.4.2 Soils. Potential cumulative impacts on soils would be similar to impacts on ecological resources (Section 5.9.4.4), 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 or expansion of waste management and disposal facilities. Additional activities contemplated in the Reactors on the River geographic area could have cumulative impacts on soils. These activities (i.e., reactor decommissioning) would be widely separated in time and could culminate with restoration or rehabilitation of the reactor sites.

5.9.4.3 Water Resources. Adverse impacts on groundwater could result from the proposed remedial actions and the reasonably foreseeable actions. Depending on the alternative selected, continued restrictions on the uses of Hanford groundwater would be required. Treatment of groundwater contaminant plumes would provide a long-term beneficial impact on the water resources of the Hanford Site. Pumping of contaminated groundwater and reinjection of treated water during groundwater remediation activities could lead to localized temporary changes in groundwater flow patterns, but the normal flow patterns are expected to become reestablished at the end of the treatment phase. The extent of cumulative impact to the groundwater would depend, in part, on the level of groundwater remediation selected under the CERCLA process. 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 adverse impacts to water resources are anticipated.

5.9.4.4 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, should the Unrestricted Future Land-Use Alternative be selected, could result in cumulative impacts on ecological resources by disturbance of wildlife and habitats that are not accessible by the public 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 cumulative impacts on shrub-steppe habitat, because reactor decommissioning would add to the areas expected to be lost under the Unrestricted Future Land-Use Alternative (29 ha [71 ac]), and Restricted Future Land-Use Alternatives (R1 and R2) (27 ha [68 ac] and 28 ha [70 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. After completion of remediation activities, extensive site restoration efforts would be undertaken to reestablish native plant communities. A similar effort would be undertaken after completion of reactor decommissioning activities. Site restoration efforts are expected to mitigate adverse cumulative effects and enhance the recovery of ecosystems in the Reactors on the River geographic area.

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 and SNF management (see Section 5.9.1.3). The total area disturbed under the Exclusive Future Land-Use Alternative would be 1,240 ha (3,100 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, 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 projects in the future. 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.

5.9.4.5 Air Quality. The potential for cumulative impacts on air quality, as with other resource areas, is critically dependent on the timing of the proposed remediation activities 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, remediation 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 (e.g., ERDF and TWRS construction in the Central Plateau geographic area) could cause air quality impacts proportional to the total level of activity. Although the cumulative impacts are potentially significant, the impacts could be reduced by appropriate mitigation measures as described in Section 5.3.5.2.1.

5.9.4.6 Noise. No potentially significant noise impacts were identified for any of the alternatives considered in this EIS. Therefore, no cumulative impacts are anticipated.

5.9.4.7 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 substantial impacts on cultural resources, and reasonably foreseeable other actions also could have adverse 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 could be expected to experience significant cumulative adverse impacts to cultural resources.

5.9.4.8 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.

5.9.4.9 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 might need to be evaluated on a continuing basis as schedules are developed for both the proposed remedial actions and other 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 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. 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.

5.9.4.10 Human Health Risk. Long-term impacts of the proposed action on human health risk are considered beneficial. Remediation of waste sites would reduce long-term risks by isolating contaminants from human populations.

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 workers under 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.

5.9.4.11 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.

5.10 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.

Remediation 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 1,614 ha (3,987 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 traditional use and religious 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.

5.11 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, and is the subject of exclusions from liability under Section 107(f) of CERCLA.

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. Most of these materials probably 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 required from each of the three sites are shown in Table 5-60. 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. Mining of cap materials 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 design used to make the estimates was assumed to be comparable to the reference cap design 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.

Under the Restricted (R2) and Exclusive Future Land-Use Alternative, the capped areas of the Reactors on the River, Central Plateau, and All Other Areas geographic areas would be irreversibly and irretrievably committed. The caps in several waste sites would irreversibly commit environmental resources (geologic and groundwater) in the Reactors on the River (137 ha [339 ac]), Central Plateau (1,138 ha [2,812 ac]), and All Other Areas (73 ha [180 ac]) geographic areas for long-term disposal of environmental remediation wastes.

Table 5-60. 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	13.7 (18.1)	2.5 (3.2)	2.4 (2.8)
All Other Areas	Restricted (R2)	3.4 (4.4)	1.0 (1.3)	4.3 (5.7)
Total[e]		24.5 (32.3)	5.64 (7.35)	16.3 (21.0)

[a]Based on volumes presented in Appendix H, Tables H-15 and H-16.
[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.
[e]Totals of each material type required for cap construction are dependent upon the cap design selected through the CERCLA process for each waste site.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*

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 capped. Losses of cultural resources would be irreversible and irretrievable. Mitigation measures could reduce, but not prevent, the loss of cultural resources.

Implementation of remediation 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, storage, 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 5-61. Selection of the alternative with the greatest amount of disturbance in each area would temporarily or permanently alter 462 ha (1,153 ac) of shrub-steppe habitat, 28 ha (69 ac) of wetlands, and 20 ha (50 ac) of aquatic habitat.

Table 5-61. Habitat Areas Disturbed Under Each Future 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 ha/1 ac of each habitat	Not applicable	Not applicable
Reactors on the River	1 ha/3 ac wetlands 3 ha/7 ac shrub-steppe	5 ha/12 ac wetlands 29 ha/71 ac shrub-steppe	4 ha/11 ac wetlands 27 ha/68 ac shrub-steppe	3 ha/7 ac wetlands 28 ha/70 ac shrub-steppe	Not applicable
Central Plateau	50 ha/125 ac shrub-steppe	Not applicable	Not applicable	Not applicable	437 ha/1,079 ac shrub-steppe
All Other Areas	5 ha/12 ac shrub-steppe	Not applicable	91 ha/229 ac shrub-steppe	108 ha/270 ac shrub-steppe	Not applicable

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 5-62. Significant expenditures also would be required under the No-Action Alternative. The estimated cost of monitoring and maintenance of the Hanford Site over a 100-year period is estimated to be greater than $2.4 billion.

Table 5-62. Estimated Expenditures for Each Alternative With Transportation Options.

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)	3,873 2,850 4,628	2,879 2,142 2,059
Central Plateau	Exclusive	1,696	Not applicable
All Other Areas	Restricted (R1) Restricted (R2)	1,037 3,162	678 797

Remediation 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 5-63. Actual quantities of fuel consumed would depend on the exact nature of actions implemented under CERCLA and the Tri-Party Agreement, and on the fuel efficiency of machinery used to implement those actions.

Table 5-63. Estimated Fuel Consumed for Each Alternative With Transportation Options.

Geographic Area	Alternative	Truck Transport million L (gal)	Rail Transport million L (gal)
Columbia River	Unrestricted Restricted	209.4 (55.1) 3.8 (1.0)	123.5 (32.5) 1.9 (0.5)
Reactors on the River	Unrestricted Restricted (R1) Restricted (R2)	161.1 (42.4) 116.3 (30.6) 226.1 (59.5)	111.0 (29.2) 78.7 (20.7) 112.1 (29.5)
Central Plateau	Exclusive	Not available	Not applicable
All Other Areas	Restricted (R1) Restricted (R2)	42.0 (11.1) 160.0 (42.1)	27.7 (7.3) 56.6 (14.9)

5.12 Conflict with Land-Use Plans of Other Federal, State, and Tribal Agencies

This discussion addresses possible conflicts between the proposed future land-use objectives for each geographic area and other land use plans.

Appendix M, "Hanford Site Comprehensive Land Use Plan," (Comprehensive Plan) is being developed to guide land- and facility-use decisions through an analysis of potential land-use opportunities and constraints. In a manner consistent with Council on Environmental Quality guidance (46 FR 18026), the Comprehensive Plan relies on the analysis of environmental impacts in this EIS. The Record of Decision issued for this EIS will be the decision process for finalization and adoption of the Comprehensive Plan.

Early community involvement in the evaluations in this EIS should result in a more participatory and better-informed decisionmaking process; greater community support for remediation activities; and more cost-effective remediation. The DOE, EPA, and Ecology will be able to rely on planned land uses during development of remedial alternatives, which should generally reflect the reasonably anticipated future land uses identified in this EIS.

5.12.1 Columbia River Geographic Area

Some future uses associated with the Restricted Future Land-Use Alternative of the Columbia River geographic area could be inconsistent with the proposed Wild and Scenic River designation. Under the Wild and Scenic River designation, recreational access points would be expanded but not improved, and additional facilities and programs for visitor interpretation and education would be provided (NPS 1994). Restrictions posed by residual contamination might require limitations on certain recreational uses.

Tribal treaty rights on the Hanford Site could be maintained under the Restricted Future Land-Use Alternative by controlling new development and preventing encroachment on traditional tribal fishing sites and religious sites, consistent with the implementation of DOE's missions. The Unrestricted Future Land-Use Alternative, which could facilitate unlimited uses, could encroach on and impact these traditional sites.

The Unrestricted Future Land-Use Alternative would allow complete access to natural resources by consumptive and nonconsumptive users. Increased recreational use could be expected under the Unrestricted Future Land-Use Alternative. Expanded access could conflict with the Wild and Scenic River designation.

The Restricted Future Land-Use Alternative would not significantly affect river-based recreation. Current restrictions on land-based recreation (e.g., hunting, wildlife observation, nature study, and similar activities) could continue.

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, the short-term impacts, as described in Section 5.2, are not considered significant. 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 designation. 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.

5.12.2 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 remediation activities. The adjacent county lands are separated from the Reactors on the River geographic area by the Columbia River and the North of the River geographic area (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, corridor development, and/or off-road activity could be incompatible with the proposed Wild and Scenic River and NWR designations.

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 Reactors on the River might not be consistent with Native American views regarding the exercise of treaty rights on the Hanford Site.

The No-Action Alternative would continue the restrictions on the use of the traditional fishing sites and religious sites of the Native Americans, and would not be consistent with Native American wishes to exercise asserted treaty rights on the Hanford Site.

5.12.3 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 Hanford Reach Recreational River and NWR designations.

The Exclusive Future Land-Use Alternative for the Central Plateau geographic area would not be consistent with Native American wishes to exercise asserted treaty rights on the Hanford Site. The No-Action Alternative would continue current waste management activities in this area, which would conflict with Native American views on the exercise of asserted treaty rights.

5.12.4 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. Proposals that included industrial development or waste management activities within 0.4 km (0.25 mi) of the Columbia River 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.

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, traditional use areas, 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.

5.13 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 to the greatest extent practicable and permitted by law

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.

5.13.1 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 the evaluation of environmental justice impacts, the area defined by this 80-km (50-mi) radius is considered the zone of potential impact.

5.13.1.1 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.

5.13.1.2 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.

5.13.1.3 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 the *Hanford Site National Environmental Policy Act* (NEPA) *Characterization* (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.

5.13.2 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 this 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 latent cancer fatalities, 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 remediation activities that would enable each future land-use scenario are evaluated with respect to health risks and environmental damage resulting from the scenario.

5.13.2.1 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.

5.13.2.1.1 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.

5.13.2.1.2 Health Impacts from Natural Motive Forces. Prevailing winds on the Hanford Site are from the northwest. The second most common wind direction is 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 southeast 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 an 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.

5.13.2.1.3 Health Impacts from Subsistence Consumption of Fish and Wildlife. The human health calculations presented in the *Hanford Site Environmental Report for Calendar Year 1994* (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 levels of radiation exposure. 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 5.1×10^{-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 eventually 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 remediation activities are unlikely to result in disproportionately high human health effects in minority or low-income populations from consumption of fish and game.

5.13.2.2 Environmental Impacts to Low-Income and Minority Populations. Low-income and minority populations in the vicinity of the Hanford Site could be affected by potential socioeconomic impacts and impacts to biological and cultural resources valued by Native Americans.

5.13.2.2.1 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 remediation 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.

5.13.2.2.2 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.

Under separate treaties signed in 1855, lands occupied by the present Hanford Site were ceded to the United States by the Confederated Tribes and Bands of the Yakama Indian Nation and by the Confederated Tribes of the Umatilla Indian Reservation. Under these treaties the tribes retained the right to fish in their usual and accustomed places in common with the citizens of the Territories. The treaties also retained to the tribes the privilege of hunting, gathering roots and berries and pasturing horses and cattle on open unclaimed lands. The 1855 Treaty with the Nez Perce also retained the right to fish at usual and accustomed places, and the Hanford Reach has been identified as containing such locations. The Wanapum People did not sign a treaty with the United States, and are not a federally recognized tribe. However, the Wanapums were historical residents of the Site when it was created in 1943 and their interests in the area have been acknowledged.

The tribal fishing rights reserved under the treaties have been recognized as effective within the Hanford Reach. The Privileges of gathering foods and medicines and of hunting and pasturing horses and cattle however, are, by the terms of the treaties, applicable to open unclaimed lands. Open and unclaimed lands are lands held in public ownership which are not reserved for uses inconsistent with the exercise of the treaty rights. The Hanford Site's past mission of nuclear materials production and its current mission of waste management have both been deemed by the DOE to be purposes inconsistent with the exercise of the treaty reserved privileges. Although tribal members have expressed interest in exerting the treaty rights on the Hanford Site, full exercise of such rights would not be consistent with Hanford's continuing waste management mission.

Regardless of access issues, reserved treaty rights are dependent upon the health of the ecosystems. 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 could occur under all alternatives for future land-use objectives at the Hanford Site. To the extent that the Tribes exercise their treaty rights to fish on the Hanford Site, the tribes could suffer disproportionate environmental justice impacts. The nature of the impacts to cultural and biological resources that are valuable to Native Americans would vary depending on the nature and extent of remediation activities that are actually implemented.

Restricted Future Land-Use and Exclusive Future Land-Use Alternatives could result in impacts by denying unlimited access to the geographic areas. However, these alternatives also would function to continue to protect cultural and biological resources that are located in the restricted areas.

The Unrestricted Future Land-Use Alternative might allow increased access to the geographic areas. However, injury to resources would likely result from the remediation activities that would be required to enable unrestricted use. Furthermore, upon completion of remediation activities, the DOE might relinquish control of the land and subsequent development could further damage cultural and biological resources.

High promontories that provide a commanding and panoramic view of the surrounding terrain are culturally significant to Native American tribes, which historically used the Hanford Site. Alteration of the viewscape from these sites could disproportionately impact Native Americans. This alteration could occur over the short term or the long term depending on the remedial activities that are undertaken at the Hanford Site. Short-term impacts could be associated with excavation and hauling activities (the magnitude of the impact would depend upon the amount of activity occurring at a given time). Long-term impacts could be associated with caps constructed over waste sites, which might be visible from the promontories. Permanent or temporary alteration of the viewscape represents a potential environmental justice impact to the Native Americans.

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 remediation 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, Gable Mountain or another significant basalt outcrop is selected as a source of basalt.

5.14 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 Action would be consistent with current industrial, research 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 future land-use 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 other similar, compatible uses and, thus, preclude its long-term use for other purposes.

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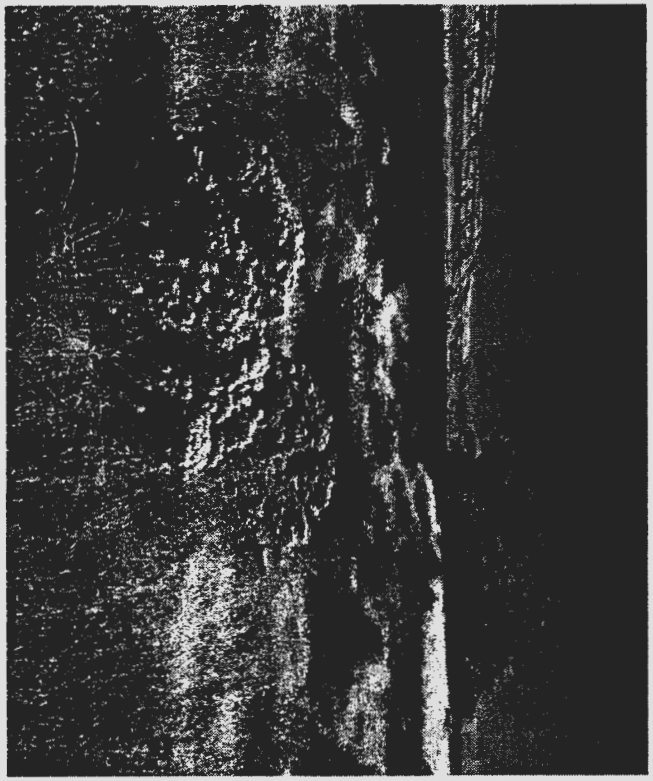

Consultations, Laws, & Requirements

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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 might 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

The *National Environmental Policy Act of 1969* (NEPA), as amended, establishes a national policy that encourages awareness of the environmental consequences of human activities and promotes consideration of those environmental consequences during the planning and implementing stages of a project. Under NEPA, federal agencies are required to prepare detailed statements to address the environmental effects of proposed major federal actions that might significantly affect the quality of the human environment. This EIS has been prepared in accordance with NEPA requirements and policies, and presents reasonable alternatives and the potential environmental consequences of the alternatives.

6.1.2 Clean Air Act of 1970

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 engaged in any activity 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 Section 109 of 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. Section 111 of the CAA requires 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 in 40 *Code of Federal Regulations* (CFR) 50-99, and radionuclide emissions and hazardous air pollutants are regulated under the National Emissions Standards for Hazardous Air Pollutants Program (40 CFR 61 and 40 CFR 63).

6.1.3 Safe Drinking Water Act of 1974

The primary objective of the *Safe Drinking Water Act of 1974* (SDWA), as amended, is to protect the quality of the public water supply and sources of drinking water. In the State of Washington, the EPA has the authority to implement regulations to establish standards applicable to public water systems. These regulations further establish the maximum contaminant levels, including maximum levels of radioactivity, allowed in public drinking water systems. Maximum contaminant levels 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 140-149. 40 CFR 141 specifies 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

The *Clean Water Act of 1977* (CWA), as amended, 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 with jurisdiction over properties or facilities 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 (40 CFR 122).

In 1987, the CWA was amended, and the EPA was required 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

Treatment, storage, and/or disposal (TSD) of hazardous and nonhazardous waste is regulated under the *Solid Waste Disposal Act of 1965,* which was amended by the *Resource Conservation and Recovery Act of 1976* (RCRA), as amended, 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 Washington State Department of Ecology (Ecology) has been delegated authority for implementing the federal RCRA program in the State of Washington. The EPA regulations implementing RCRA, define hazardous wastes and specify the transportation, handling, and waste management requirements of these wastes (40 CFR 260-280).

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 waste management used also influences the extent and complexity of the requirements.

The *Federal Facilities Compliance Act of 1992* (FFCA) amends RCRA, and 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.

6.1.6 Comprehensive Environmental Response, Compensation, and Liability Act of 1980

The CERCLA provides a statutory framework for the remediation 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 contaminated sites are ranked and may be included on the National Priorities List. The CERCLA requires federal facilities with contaminated sites to undertake investigations and remediation, as necessary.

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* are 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 certain 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* establishes a national policy for waste management and pollution control. This Act focuses first on source reduction, followed sequentially by environmentally safe recycling and treatment and, as a last resort, disposal or other release into the environment. The DOE has committed to participation in Section 313 of SARA, 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. Each DOE site is, therefore, establishing site-specific goals to reduce generation of all waste types.

6.1.10 National Historic Preservation Act of 1966

The *National Historic Preservation Act of 1966*, as amended, requires nomination for and placement of sites with significant national historic value on the National Register of Historic Places (NPS 1988). Permits and certifications are not required under this Act; however, consultation with the Advisory Council on Historic Preservation is required if a federal undertaking might 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 Office is undertaken to ensure that potentially significant sites are properly identified and appropriate mitigation measures are implemented.

6.1.11 Archaeological Resources Protection Act of 1979

The *Archaeological Resources Protection Act of 1979*, as amended, requires a permit for any excavation or removal of archaeological resources from federal 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 or the federal agency having authority over the land on which a resource is located before issuance of a permit; the permit must contain terms and conditions requested by the tribe or federal agency.

6.1.12 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 federal agencies in the repatriation of federal archaeological collections, and collections held by museums receiving federal funding, that are affiliated culturally to Native Americans. This Act established statutory provisions for the treatment of inadvertent discoveries of Native American remains and cultural objects. Specifically, when discoveries are made during

ground disturbing activities, the following must take place: activity in the area of the discovery must cease immediately, reasonable efforts must be made to protect the items discovered, notice of discovery must be given to the agency head (DOE) and the appropriate Tribes, and a period of 30 days must be set aside following notification for negotiations regarding the appropriate disposition of these items.

6.1.13 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 Native Americans to believe, express, and exercise traditional religions. This Act also requires that federal agencies should avoid interfering with access to sacred locations and traditional resources that are integral to the practice of religion.

6.1.14 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.

6.1.15 Endangered Species Act of 1973

The *Endangered Species Act of 1973*, as amended, is intended to prevent further decline of endangered and threatened species and restore those species and their habitats. This Act is jointly administered by the Departments of Commerce and Interior. Section 7 of this Act requires agencies to consult with the U.S. Fish and Wildlife Service (USFWS) or the National Marine Fisheries Service. This consultation determines whether endangered and threatened species or critical habitats are known to be in the vicinity of a proposed action, and whether an action will adversely affect listed species or designated critical habitats.

6.1.16 Migratory Bird Treaty Act of 1918

The *Migratory Bird Treaty Act of 1918*, as amended, 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.

6.1.17 Bald and Golden Eagle Protection Act of 1972

The *Bald and Golden Eagle Protection Act of 1972*, as amended, 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.

6.1.18 Wild and Scenic Rivers Act of 1968

The *Wild and Scenic Rivers Act of 1968*, as amended, 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.

6.1.19 Nuclear Waste Policy Act of 1982

The *Nuclear Waste Policy Act of 1982*, as amended, authorizes federal agencies to develop a geologic repository for the permanent disposal of spent nuclear fuel and high-level radioactive 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.

6.1.20 Atomic Energy Act of 1954

The *Atomic Energy Act of 1954* (AEA), as amended, 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 departmental 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 applicable environmental standards for protection of the general environment from radioactive materials. The EPA has promulgated several regulations under this authority.

6.1.21 Occupational Safety and Health Act of 1970

The *Occupational Safety and Health Act of 1970*, as amended, 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, each employer is required 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. The DOE maintains, and makes available, the various records of minor illnesses, injuries, and work-related deaths, as required by OSHA regulations.

6.1.22 Comprehensive Conservation Study of the Hanford Reach of the Columbia River, Public Law 100-605

Public Law 100-605, passed by Congress on November 4, 1988, authorizes a comprehensive study of the Hanford Reach of the Columbia River to identify the outstanding features of the Reach and its immediate environment, including fish and wildlife, geologic, scenic, recreational, natural, historical, and cultural values and examine alternatives for their preservation. The Secretary of the Interior shall consider the potential addition of the Hanford Reach to the National Wild and Scenic Rivers System.

For a period of 8 years after enactment, the Secretary of the Interior is charged with reviewing proposed actions within the study corridor to determine if there will be a direct and adverse effect on the values for which the Hanford Reach is under study, and if so, to provide recommendations for mitigation.

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 State Environmental Policy Act of 1971

The Washington State 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 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 Hazardous Waste Management Act of 1976

The federal RCRA program allows state enforcement if the state program is consistent with the federal program and at least as stringent. Through the *Hazardous Waste Management Act of 1976*, 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 260-280, and the state program, pursuant to the requirements of the *Hazardous Waste Management Act of 1976* and WAC 173-303, "Dangerous Waste Regulations."

6.2.3 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 *Model Toxics Control Act of 1989*, the State of Washington law supplements CERCLA. Under this Act, Ecology must 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 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 Water Pollution Control Act of 1945

The *Water Pollution Control of 1945*, as amended, 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 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 ahead for future growth.

6.2.6 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 CAAA (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 CAAA. In contrast to the Federal CAAA 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, Ecology refers to a list of over 450 individual chemicals that are deemed to be TAPs. The list overlaps with the Federal CAAA 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, "Radiation Protection--Air Emissions," (WAC 246-247) contain standards and permit requirements for the emission of radionuclides to the atmosphere from DOE facilities based on Ecology standards, "Ambient Air Quality Standards and Emission Limits for Radionuclides" (WAC 173-480).

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 also has been delegated authority to enforce the EPA's 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 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 Order further directs that floodplain impacts are to be avoided to the extent practicable.

6.3.2 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. The DOE has issued regulations for compliance with this Order and Executive Order 11988 (10 CFR 1022).

6.3.3 Executive Order 12088, Federal Compliance with Pollution Control Standards

Executive Order 12088 was issued on October 13, 1978. 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. This order was amended by Executive Order 12580, issued on January 23, 1987.

6.3.4 Executive Order 12372, Intergovernmental Review of Federal Programs

Executive Order 12372 applies to state review of NEPA documents and to the coordination of state and federal NEPA processes. The goal of this Executive Order is to foster an intergovernmental partnership and a strengthened coordination and consultation process.

6.3.5 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 National Priorities List and removal actions where the release is from a facility under the jurisdiction or control of executive departments and agencies.

6.3.6 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 waste stream; 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.

6.3.7 Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations

Executive Order 12898 directs all federal agencies, to the greatest extent practicable and permitted by law, 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 the extent permitted by existing law to develop strategies to

identify and address environmental justice concerns. The Order further directs each federal agency, to the extent permitted by existing law, 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.

6.3.8 Executive Order 13007, Indian Sacred Sites

Executive Order 13007 directs federal agencies to take measures to protect and preserve Native American religious practices. Federal agencies shall, to the extent practicable, permitted by law, and not clearly inconsistent with essential agency functions, accomodate access to and ceremonial use of sacred sites by Native American religious practitioners. Further, the Executive Order states that federal agencies will comply with presidential direction to maintain "government-to-government" relations with Native American Tribal governments.

6.4 U.S. Department of Energy Regulations and Orders

This section identifies DOE regulations 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 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"
- 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.

6.5 Consultations

NEPA and Council on Environmental Quality 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 6-1. Copies of several consultation letters are provided in Section 6.5.1. 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.

The Department of Justice recently reaffirmed a long-standing policy regarding the relationship between the Federal Government and Indian tribes (61 FR 29424). The policy states that the United States recognizes the sovereign status of Indian tribes as "domestic dependent nations" from its earliest days. The Constitution recognizes Indian sovereignty by classifying Indian treaties among the "supreme Law of the Land," and establishes Indian affairs as a unique area of federal concern.

In early Indian treaties, the United States pledged to protect Indian tribes, and established one of the bases for the federal trust responsibility in our government-to-government relations with Indian tribes. These principles continue to guide national policy towards Indian tribes. Consultations with tribal governments will be carried out in accordance with this policy.

Table 6-1. Agency Consultations.

Subject Area	Basis for Consultation	Agency
Endangered Species	*Endangered Species Act of 1973*	USFWS; National Marine Fisheries Service
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 Office; 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*	Corps; EPA
Prime and Unique Farmlands	*Farmland Protection Policy Act of 1981*	Natural Resource 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; Corps; 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; Corps; 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; National Marine Fisheries 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; 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*; *Toxic Substances Control Act of 1976*; *Federal Insecticide, Fungicide, and Rodenticide Act of 1975*	EPA; U.S. Department of Transportation; Ecology

Corps = U.S. Army Corps of Engineers.
Ecology = Washington State Department of Ecology.
EPA = U.S. Environmental Protection Agency.
USFWS = U.S. Fish and Wildlife Service.

1 ***6.5.1 Federal, Tribal, State, and Local Agency Consultation Letters***

STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

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August 2, 1991

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Mr. Steven H. Wisness
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Richland, Washington 99352

Dear Mr. Wisness and Mr. Day:

During the public comment period on the proposed changes in the Tri-Party Agreement (TPA), the Hanford Education Action League (HEAL) requested that land use be included in the TPA. Land use is inextricably linked to our efforts to remediate the Hanford Site, so it does seem appropriate to address the issue.

As I understand it, the three parties have cooperated to secure the services of a neutral facilitator to bring together a large number of stakeholders, including the agreement parties, other state and federal agencies, local governments, Indian Tribes, and private economic, environmental, and other interests.
This group will design a process to build their concerns and interests into future site use planning. This, in turn, will provide alternative visions or scenarios to help evaluate remedial actions.

To include specific land use milestones in the TPA in advance of the work of the stakeholders' group may adversely affect their willingness to participate. At the same time, we do need to call attention to the parties' commitment to address the issue. Perhaps we can include a near-term milestone, such as the following, to mark that commitment:

12/31/91 Initiate a facilitated process among federal, state, local, and Tribal governments, as well as effected economic, environmental, recreational, and other interests, to provide alternative visions for future land uses on and surrounding the Hanford Site.

We might also wish, in the Responsiveness Summary or some other document, to acknowledge that we expect to include further milestones relating to land use once the stakeholders have had an opportunity to develop recommendations.

I believe we should meet to set our approach to this questions prior to finalizing TPA changes on September 9. We will contact you to arrange a meeting.

Sincerely,

Timothy L. Nord
Hanford Project Manager

cc: Roger Stanley
Max Power
Dave Nylander

Board of County Commissioners
BENTON COUNTY
P. O. BOX 190 • PROSSER, WASHINGTON 99350-0190
PHONE (509) 786-5600 OR 783-1310 • FAX (509) 786-5625

Ray Isaacson
DISTRICT #1

Robert J. Drake, Sr
DISTRICT #2

Sandi Strawn
DISTRICT #3

May 11, 1992

Manual Lujan, Secretary
U.S. Department of Interior
1800 "C" Street NW
Washington D.C., 20240

Dear Secretary Lujan:

The Benton County Board of Commissioners respectfully requests that no action be taken to designate the Hanford Reach segment of the Columbia River as a Wild and Scenic River, or National River, or any other special management area until certain ongoing, and interwoven, state/local and U.S. Department of Energy planning programs for this area are complete.

Specifically, the Department of Energy, EPA, and Washington State Department of Ecology have signed an Agreement and Consent Order to clean-up the hazardous nuclear and non-nuclear wastes on the Hanford Reservation. In addition to, and within the context of the Federal Nuclear Weapons Complex Reconfiguration (Complex 21), the ultimate dollar cost, end product, nature and level of applied technologies, and the future land use potential of all the reservation lands are circular co-drivers of this clean-up program.

In order to define the relationships between the co-drivers of clean-up, the signatories to the Agreement and Consent Order have established and funded a Hanford Site Future Land Uses Working Group, which consists of diverse local, regional, state, and federal interests. Under its Charter, the Group's purpose is to, "articulate their vision of possible future site uses for Hanford, and to explore the implications of those visions on clean-up scenarios and priorities."

The Working Group's scope and objectives under its Charter encompass the Hanford Reach, and include, "the development of a finite set of alternatives for future site use and resulting clean-up scenarios for Hanford. The results of the Working Group will serve as input to the Hanford Remedial Action Environmental Impact Statement (HRA/EIS), the Hanford site planning process, and other relevant processes and decisions"(emphasis added). The Working Group's product will enter the HRA/EIS via the scoping process.

The Working Group has already segmented out the area of the Columbia River and its near-shore environments as a separate geographic area for study. Issues identified for discussion in this area include, historic use, soils and ground water contamination, federal divestiture of lands, fisheries preservation and enhancement, future nuclear energy production, public access and recreation, tribal rights, historic and prehistoric resources preservation, water rights and access, wildlife and habitat preservation, functional relation to upland resources and potential land uses, and agriculture.

In addition to the Future Site Uses Working Group process, Benton and Franklin Counties, and each of the cities therein, are currently preparing new Comprehensive Plans as required by the 1990 Washington State Growth Management Act. Political jurisdictions having coterminous boundaries with the Hanford Reservation are addressing specific resources and infrastructure issues which cross these boundaries, as well as the land use, socio-economic and infrastructure impacts which occur in the larger community as a result of Hanford program activities.

The state mandated planning program is also intricately woven into both current site facilities planning, and Future Land Use planning for the Hanford site. As part of its Comprehensive Planning program, Benton County has been directed by the state to inventory and map resource lands on Hanford. The state Act requires the protection of the biological and water quality resources of the Columbia and other rivers in the county. The Board of Commissioners has directed its planning staff to prepare a Land Use Map for Hanford lands, this map will also be based in whole or part on the information provided by the Working Group and the HRA/EIS.

In view of the above, it is the Board of Commissioner's position that the ultimate designation and management of the Hanford Reach portion of the Hanford Reservation is just one inextricable piece of a much larger and more complex state, local and federal planning program.

Consequently the commitment of the Reach to a specific federal designation and resources management program, with its attendant restrictions, prior to the conclusion of the larger planning program would be premature. In a myriad of ways it would needlessly prejudice and complicate the outcome of the Future Uses process and HRA/EIS, which is a more broad based, politically sensitive, and comprehensive planning effort.

Such an outcome is unnecessary. The Congressional Act which requires the Secretary of Interior to undertake the Comprehensive River Conservation Study establishes interim protections which protect the satisfactory status quo of the riverine resource values until 1996, which is one year longer than the planned schedule for the Record of Decision on the HRA/EIS. Accordingly no detrimental changes to the resource values of the Hanford Reach are likely to occur during this period.

The Benton County Board of Commissioners requests that the pending Draft EIS on the Hanford Reach be modified to include the above planning programs as "existing conditions" which have the potential to protect identified resource values. And that the Department of Interior consider the benefits of lengthening the decision schedule for designating the Reach so that it parallels and includes relevant information from the larger and more broadly based planning effort.

Sincerely,

Sandi Strawn, Chairman
Benton County Commissioners

Ray E. Isaacson, Member
Benton County Commissioners

Robert J. Drake, Sr., Member
Benton County Commissioners

cc: Governor Booth Gardner

Washington State Senate and House Representatives
8th, 9th,13th,15th, 16th Districts

U.S. Congressional Delegation for the State of Washington

9613459.2161

1 *This page intentionally left blank.*

PLANNING:
PLANNING ANNEX
P.O. BOX 910
PROSSER, WA 99350-0910

BUILDING:
COURTHOUSE ANNEX
5600 W. CANAL PLACE, SUITE C #105
KENNEWICK, WA 99336

May 14, 1993

Mr. Roger Freeberg
U.S. Department of Energy
P.O.Box 550, MSIN A5-19
Richland Wa. 99352

Dear Mr. Freeberg:

In reference to the IP for the HRA/EIS, the following comments are offered.

Future Uses Working Group Report
At this point in the process, the IP indicates that the work of the Future Uses Group will play a significant role in the HRA/EIS and perhaps decisions which shall be made based upon the FEIS. This is encouraging.

Socio-economic Issues(page 3-4)
Relative to the issue of socio-economic impacts: a reading of the IP indicates that a relatively narrow assessment of socio-economic impacts may be intended rather than a broader and more useful assessment. Specifically, the HRA/EIS should provide a rigorous analysis of the impacts of Clean-up Program on the cost/revenue circumstances of local service providers and special districts.

At present, the increases in public services and facilities necessary to serve Hanford driven growth is stressing the capabilities of several service sectors including schools, fire, and certain municipal services. This circumstance is forcing a commitment by these providers to construct new facilities and commit to staff and operating costs. This in itself is a significant impact. Once the commitments are made, a reduction in the Hanford budget could have even more significantly adverse consequences.

Long Term Economic Stability (page 4-43)
A successful completion of clean-up and concurrent transition of the local economy to one no longer primarily dependent upon a federally operated Hanford facility is essential and desired. However, achievement of these goals without regard to local conditions could heighten the impact issues identified under Socio-economic issues above. "Long Term Economic Stability" should not be defined merely as "achieving economic diversity while cleaning -up." Economic stability has other essential characteristics which should be identified.

PLANNING:
PROSSER OFFICE (509)786-5612
(FROM TRI-CITIES) 783-1310

Cultural and Historic Resources (page 4-44)
"Cultural" as inferred in the IP is too narrowly defined. It seems to apply only "on-site," and to native american resources. The HRA/EIS should identify the potential impacts to the "custom and culture" of the residents of Benton County's unincorporated lands. The custom and culture of these lands is "agriculture," which is the second major leg of the county's bi-modal economy. Potential impacts to agriculture extend both on-site (Hanford), and off-site.

On-site impacts may occur if lands that were either in, or viable for agriculture at the time of federal purchase, are not returned to agriculture once the clean-up is completed. Factors which may prevent resumption of agriculture include: the lack of a water right(s), the transfer of lands from DOE to other parties for uses other than agriculture, the inability to practice agriculture as a result of constraints due to residual contamination. Much of Hanford is now, or will be cleaned, to "unrestricted use." These are lands suitable for agriculture. If placed in production their value could help mitigate both the potential losses of tax revenues to the county from clean-up driven municipal annexations, and Hanford driven off-site impacts to agriculture.

Potential off-site impacts are those associated with the loss to agriculture of essential resources as a result of Hanford driven urban expansion (i.e., loss of farmable lands, irrigation water, food processing/waste disposal capacity, farm to market transport capacity, etc.)

If you have any questions with reference to this matter, do not hesitate to contact this office.

Sincerely,

TERRY A. MARDEN, Director
PLANNING/BUILDING DEPT.

TAM:pm

cc: Benton County Board of Commissioners
Claude Oliver, Benton County Treasurer

1

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue
Seattle, Washington 98101

July 2, 1993

Reply To
Attn Of: HW-124

John D. Wagoner, Manager
~~Leo E. Little~~
~~Assistant Manager for~~
~~Environmental Management~~
U.S. Department of Energy
P.O. Box 550, ~~A3-42~~
Richland, Washington 99352

Re: EPA Region 10 Comments on "Draft Implementation Plan for the Hanford Remedial Action Environmental Impact Statement -- April 22, 1993".

Dear Mr. Little:

The Environmental Protection Agency (EPA) Region 10 Hazardous Waste Division staff has reviewed the referenced document, and the following comments are offered for your consideration. Since you are proceeding with implementation of the Hanford Remedial Action Environmental Impact Statement (HRA-EIS), we believe it is important that we share some of our more significant concerns with the approach being taken by the Department of Energy (DOE).

Our primary concern has not changed since we voiced it to DOE several months ago. This concern is that both DOE and EPA will be evaluating remediation alternatives for the same waste sites, using two different processes (NEPA and CERCLA), over a different time period, and with a different knowledge base. DOE will issue a Record of Decision (ROD) under NEPA, while EPA will issue a ROD under CERCLA. As you can see, this provides opportunity for confusion, both to the parties involved and to the public. In the worst case scenario, we could end up with inconsistent or conflicting decisions in the RODs.

As a result of the scoping process, DOE has apparently reduced the original scope of the EIS by eliminating the goal of actually setting cleanup standards. However, the scope still includes an analysis of all remediation alternatives. We do not believe this is advisable for two reasons. First, much information is lacking at this time about the various waste sites, the waste forms, the waste volumes, and the site characteristics (geology/hydrogeology). The feasibility and efficacy of remediation techniques is heavily dependent on all these factors. It is for this reason that we go through a process of extensive site characterization and treatability tests

before making final decisions in the CERCLA process. We do not believe that one can make responsible decisions about remediation without this detailed information. In some cases, such information will not be available for several years.

EPA is not opposed to the portion of the Hanford Remedial Action EIS (HRA-EIS) which will deal with the Future Site Uses Working Group Report. In this context, we view the HRA-EIS as an appropriate and valuable tool for soliciting broad public input and values regarding future site uses. The information gained through this process, along with the site specific information mentioned above, will assist the parties in selecting appropriate remedial action alternatives and implementing cleanup under the CERCLA program. If the HRA-EIS were limited to the single issue of potential future site uses, we believe it would provide a more focused document for the public to review and it would provide support to the CERCLA decision making process.

We appreciate the opportunity to review the implementation plan, and hope we have provided clear direction that will result in a successful EIS on which EPA can concur. If you have questions or comments on any of the above, please contact me at (206) 553-1261.

Sincerely,

Randall F. Smith

Randall F. Smith, Director
Hazardous Waste Division

cc: Kathy Veit, EPA
George Hofer, EPA
Andy Boyd, EPA
Gordon Davidson, EPA
Jim Bauer, DOE
Paul Dunigan, DOE
Dan Silver, Ecology
Dru Butler, Ecology
Dave Nylander, Ecology

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

DEC 16 1993

Dear Stakeholders:

U.S. DEPARTMENT OF ENERGY (DOE) AND BUREAU OF LAND MANAGEMENT (BLM) PROPOSED INTERCHANGE

BLM has presented a proposal regarding the possible transfer of ownership responsibility for portions of the current Hanford Site. The proposal, as it has been presented, appears to offer a long term gain in flexibility in the ultimate disposition of the Hanford Site as it is remediated and becomes available for other uses.

However, before we determine whether we should support this proposal we are interested in knowing what you, our stakeholders, think of it. Attached is a short briefing paper to present information on the proposal for your consideration. We would hope that this information will enable us to frame and identify the issues which should be considered in reaching a decision. We will be holding a public information meeting at the Federal Office Building in Richland, Washington, on January 18, 1994, at 7:00 p.m. to discuss this proposal. Representatives from both BLM and DOE will be present to respond to your questions. In the interim, written comments can be submitted to:

Mr. Charles Pasternak
Realty Officer
U.S. Department of Energy
Richland Operations Office
P.O. Box 550 M/S A7-27
Richland, Washington 99352

Sincerely,

John D. Wagoner
Manager

SID:CRP

Attachment

Introduction

As DOE's mission at the Hanford Site has changed from defense production to environmental cleanup the need to maintain the Site land holdings has diminished. Every year DOE must evaluate the need for its land holdings and release those areas determined to be unnecessary to the needs of its mission. On September 30, 1993, DOE signed a draft agreement committing to clean up the North Slope and Arid Lands Ecology Reserve of the Hanford Site by October 1994, so these lands can be released for other uses. As DOE moves forward to implement these commitments, interested citizens need to understand the situation and alternative actions and present their ideas, issues and concerns.

Current Situation

The Hanford Site land holdings consist of two different real property classifications:

1) lands acquired in fee by the U.S. Department of Energy or its predecessor agencies, and

2) public lands withdrawn or acquired by the Interior Department, under management authority of the Bureau of Land Management (BLM) and Bureau of Reclamation (BoR).

The withdrawn public lands are roughly arranged in square mile checkerboard patterns on various portions of the site (see map). These lands are currently administered by DOE under a superseding public land withdrawal. These withdrawn lands revert back to BLM or BoR when DOE no longer needs them.

Issue

As future economic diversification projects are developed, the alternating square mile sections in Benton County which revert to BLM management upon release by DOE seriously complicate land use planning. Because the lands are owned by another government agency, DOE can not authorize uses of the property beyond the mission needs of DOE itself.

Proposal

BLM has proposed an interchange of lands which would simplify the underlying land pattern within the Hanford Site. The proposal would consolidate BLM withdrawn land and DOE acquired land to eliminate the current checkerboard arrangement. This would not change DOE's future ability to dispose of the DOE acquired lands; it would consolidate areas to facilitate future development.

The proposal, as submitted by BLM, would exchange the acquired lands within the Arid Lands Ecology Reserve (Reserve) for the withdrawn BLM lands east of State Route 240.

Process

BLM has proposed the exchange be accomplished through legislation which would also designate the Reserve as a National Conservation Area (Area). Under the

BLM proposal the Area would be withdrawn from mineral exploration and development. Other resource disturbing activities, such as grazing and vehicle use would also be severely limited. The legislation would require the development of a management plan which is anticipated to be similar to the existing RL plan. Under this plan the Area would be managed and maintained for continued scientific research and educational use, traditional Native American cultural and religious practices, and other uses which would not impair the integrity of the resources.

There is historical precedent for exchanging underlying land ownership to facilitate the development at Hanford. In 1964, under Public Law 88-557, DOE and BLM exchanged BLM sections on the 200 Area Plateau for DOE acquired lands on the North Slope. The Washington State leased lands in the 200 Area were a result of that action.

Public Process

Because of the public interest in the Hanford Site and future use of the Hanford lands, DOE will not support this proposed exchange until the stakeholders have had an opportunity to discuss the potential impacts and advantages of such an arrangement over the current situation.

Some of the issues and questions to be answered include:

How might this proposal simplify cleanup planning and future economic diversification efforts?

Which interests presented in the Future Site Uses Working Group report can be preserved through this arrangement? How?

Are there ways that this arrangement could expedite land use planning and save taxpayer money?

Are there ways that DOE and BLM can assure the protection of various interests if this proposal is pursued?

Would exercise of Indian treaty rights be more easily pursued through this avenue? What about public access?

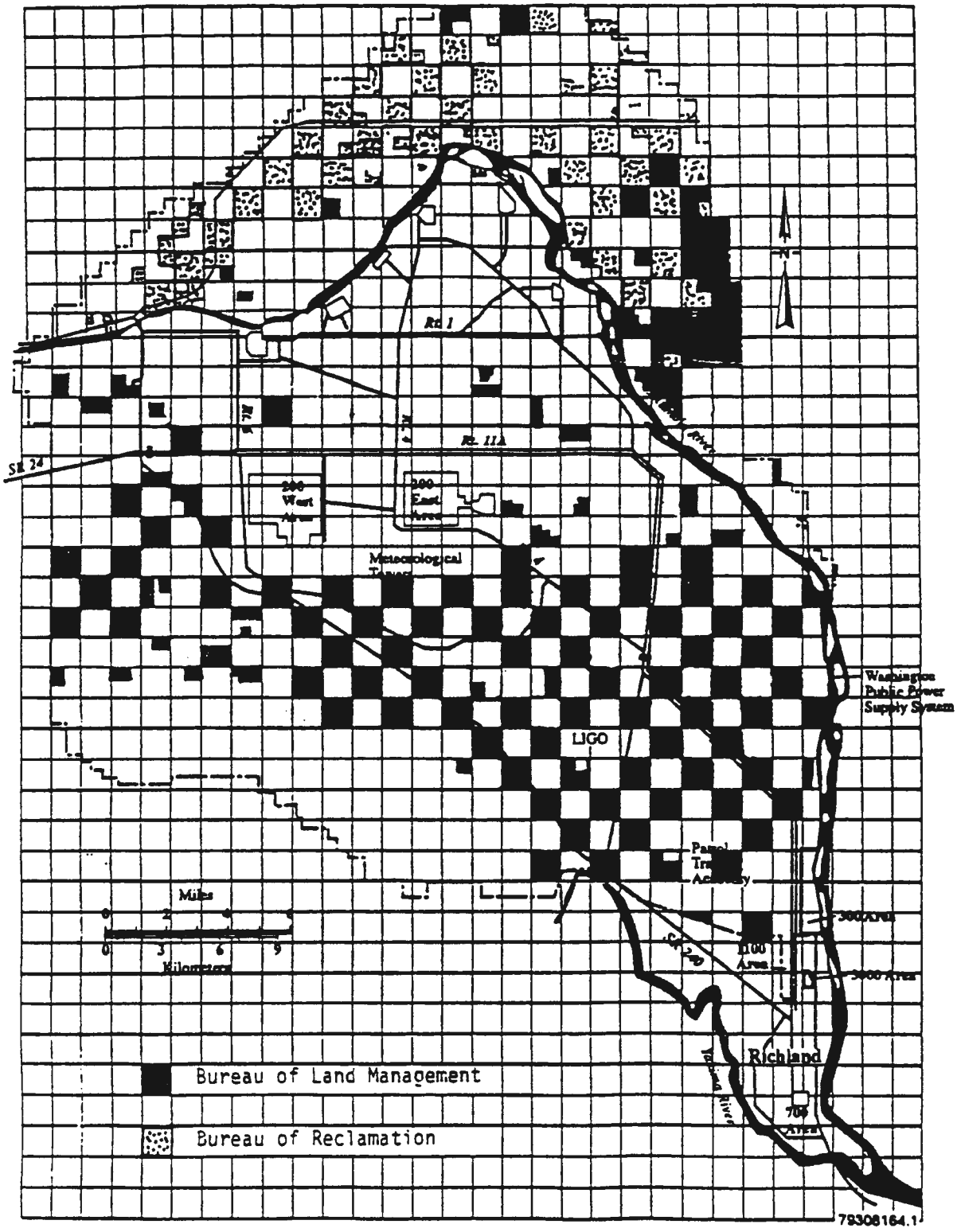
How would the maintenance of access roads, fences and fire breaks, etc., be maintained if this proposal were pursued?

Are there other alternatives that RL should consider to facilitate the future development of Hanford as outlined in the Future Site Uses document?

DOE and BLM want to know how you feel about this proposal. We will be meeting with all affected stakeholders to determine if this proposal should be supported. We also welcome written comments. They should be addressed to:

Mr. Charles Pasternak, Realty Officer,
U.S. Department of Energy
P.O. Box 550 M/S A7-27
Richland, WA 99352

9613459.2165



Board of County Commissioners
BENTON COUNTY
P.O. BOX 190 • PROSSER, WASHINGTON 99350-0190
PHONE (509) 786-5600 OR 783-1310 • FAX (509) 786-5625

Raymond E. Isaacson
DISTRICT #1

Robert J. Drake, Sr.
DISTRICT #2

Sandi Strawn
DISTRICT #3

January 12, 1994

Mr. Charles Pasternak
Realty Officer
U.S. Department of Energy
Richland Operations Office
P.O. Box 550 M/S A7-27
Richland, Washington 99352

Subject: U.S. Department of Energy and U.S. Bureau of Land Management Proposed Transfer of Land Ownership

Dear Mr. Pasternak:

This letter is to bring your attention to land use planning and legal responsibilities that we ask you to include in your deliberations regarding land transfers with the Bureau of Land Management. As the local land use authority primarily responsible for land use planning on lands no longer necessary to the current DOE mission on Hanford, the Benton County Board of Commissioners recognizes the merits of the transfer as being principally the consolidation of lands for planning and future uses. To that end we support the transfer in principal.

As you are aware, the mission, size and ownership of Hanford lands is in flux. The county, City of Richland, and DOE are struggling with the need to accommodate these changes in a manner which rationally forwards the cleanup program, while giving deliberate attention to the nearer, and long term impacts on the local communities. The county is well into the initial stages of assembling the staff and funds essential for the planning required by these changes. Interlocal agreements between parties, including DOE, setting forth roles and responsibilities under joint planning are being drafted. This is not the time for federal actions which may prejudice even the discussion and exploration of local land use planning options.

Arid Lands Ecology Reserve has a purpose and the Board of Benton County Commissioners supports that purpose. Much of the area on the Arid Lands Ecology reserve is not arable because of steepness of slope. In addition, we recognize that Native American cultural issues must be given consideration.

On a square mile to square mile basis, the transfer of BLM interests must be limited to an equal area transfer. That transfer should only include sections from the Hanford Site boundary at the crest of Rattlesnake Ridge down the slopes to the western limit of the Cold Creek syncline and the northern limit of the former Ford ranch in the vicinity of Rattlesnake Springs. Those areas that are vineyards, should be reserved for agricultural purposes. Agriculture would also serve as a buffer zone, protecting the ALE reserve from fires along highways (SR 24 and SR 240) and providing food and forage for wildlife.

The Board is concerned that the lands in the direction towards Highway SR 24, should not be transferred automatically and arbitrarily to the BLM, but rather should be evaluated for their potential economic benefit to the county. As the Board of Commissioners, we would be concerned if these arable lands were arbitrarily and unilaterally precluded from beneficial use, without planning considerations and process.

These considerations should be discussed with Benton County in detail as part of the joint lead agency consideration for land use planning.

The Board suggests that a unilateral decision not be made without land use planning input. The present borders of the ALE Reserve were arbitrarily extended to Highway SR 24 because that area was beyond the immediate need for defense materials production purposes. SR 240 was similarly established as the eastern geographic border of the ALE Reserve.

Please allow land use planning input from the County in the process. Particularly when the U.S. DOE must, by law, release their control of the land when it is in excess to their needs for isolation and security purposes. There are many economic issues and economic impacts on the local jurisdictions to be considered in that decision making process. In addition, transfer of excess property to local jurisdictions must be considered under NEPA and CERFA public law.

We look forward to your cooperation in land use planning for the entire Hanford Site and look forward to your early cooperation relative to the BLM land transfer decisions.

Sincerely,

BOARD OF BENTON COUNTY COMMISSIONERS

Sandi Strawn, Chairman

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

January 28, 1994

94-EPB-017

Mr. Randall F. Smith
U.S. Environmental Protection Agency
1200 Sixth Ave., HW-114
Seattle, Washington 98101

Dear Mr. Smith:

HANFORD REMEDIAL ACTION ENVIRONMENTAL IMPACT STATEMENT (HRA-EIS)
IMPLEMENTATION PLAN (IF)

Thank you for your comments concerning the IP far the HRA-EIS. We understand your policy concerns regarding the U.S. Department of Energy's (DOEs) application of the National Environmental Policy Act (NEPA) to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) projects.

Your first concern, the applicability of NEPA to the CERCLA actions, has been, and is still being, discussed at the highest levels of government. On November 1, 1993, the DOE Richland Operations Office (RL) NEPA Compliance Officer sent a memorandum to Dr. Tara O'Toole, Assistant Secretary for Environment, Safety, and Health, requesting the Assistant Secretary, "review and revise the current Department policy, as it relates to RL on implementation of NEPA for all activities performed under the CERCLA." This action would align the Department's policy with that of the U.S. Environmental Protection Agency (EPA), save time, money, and further advance RL's ability to function as a designated "reinvention laboratory.

Further, as part of the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) renegotiations, DOE is planning with the EPA and the State of Washington Department of Ecology, alternative regulatory frameworks to accelerate the process of siting, construction, and operation of the Environmental Restoration Disposal Facility (ERDF). If successful, the regulatory framework used to establish the ERDF will show that the CERCLA process can be adapted to provide functional equivalence for DOE's NEPA process.

Not everyone agrees, however, with the premise that the CERCLA process is the functional equivalent of the NEPA process. A comment on the tentative Tri-Party Agreement from the Confederated Tribes of the Umatilla Indian Reservation states, "The current DOE policy should not be changed. The Remedial Investigation Feasibility Study (RI/FS) process varies from the NEPA process in several significant ways."

A second concern expressed is the lower quantity and quality of data available during NEPA analyses, as opposed to the better data available during the CERCLA Record of Decision (ROD) formulation. This data quantity and quality discrepancy should not be a concern given the basic difference in intent between the two Laws. NEPA charges government agencies to consider trends in cumulative environmental impacts early in the planning process based on the best available data. Under NEPA, the Department Looks at all programs, in tote, to make programmatic decisions. Programmatic trends are, therefore, the purview of NEPA. Managing trends, such as cumulative habitat Loss, does not require the CERCLA ROD's site-specific engineering data. RI/FS's precede the CERCLA ROD to develop precise engineering design data in support of better site-specific decision making. At this time, DOE is exploring avenues to ensure there will not be public confusion and conflicting RODs under the sequential processes of NEPA and CERCLA.

Third, DOE, in addition to the environmental remediation mission, has Land management and CERCLA natural resource trustee responsibilities. As a CERCLA natural resource trustee, DOE must scope the HRA-EIS to include trustee responsibilities as well as future site uses.

If you have any questions or comments, please contact Mr. Paul Dunigan on (509) 376-6667.

Sincerely,
Original signed by:
John D. Wagoner
Manager
John D. Wagoner
Manager

EPD:TWF

cc: G. C. Hofer, EPA
D. Nylander, Ecology
D. Silver, Ecology

bcc:	EPD OFF File	DM Weissberg, EPD
	EPD Rdg File	PF Dunigan, EAP
	EPB Rdg File	RM Carosino, OCC
	CCC Rdg File	LE Little, AME
	MGR Rdg File	TWFerns, WHC
	File Code:	40.30.1 BL Foley, END

RECORD NOTE: EPA's comments on HRA-EIS & NEPA/CERCLA equivalency issue. This letter completes CC action #930693.0B and CCC action #9393434.

TOM.F\HRAEIS.017

Oregon Hanford Waste Board

Keith Burns, Chair
Patty Yraguen, Vice Chair
Mark Barnes
Richard Belsey
John Bevis
Shelley Cimon
Norma Jean Germond
Fuji Kreider
Mary Shaver
Jim Stearns
Glenn Youngman
Phil Keisling, Secretary of State
Sen. Joan Dukes
Sen. Ron Cease
Sen. Gordon Smith
Rep. Michael Payne
Rep. Ray Baum
Rep. Chuck Norris
John Savage, Acting Director OR Dept of Energy
Martha Pagel, Director, OR Water Resources Dept

February 7, 1994

John Wagoner
United States Department of Energy
Richland Operations Office
Federal Building Mail Stop: A7-50
Richland, WA 99352

Subject: Environmental Impact Statements Involving the Hanford Site

Dear Mr. Wagoner:

In recent weeks, members of our Board and staff have noted several severe problems with the Environmental Impact Statements (EISs) involving the Hanford site. The most critical of these are:

- There seems to be little or no integration of activities from the work areas encompassed by one EIS to those in another.

- The boundaries of the various EISs are not well defined. This creates problems in precisely defining what is covered by an EIS and what is not.

- There seems to be little comprehensive planning of the EISs to allow for logical divisions of work areas. This is particularly evident in these key examples:

  - The specific geographic boundaries between past and current practice units, especially involving groundwater and soil contamination.

  - The geographic boundaries and relationship between: the Hanford Reach EIS and the Hanford Remedial Action EIS; the single shell tank farms and other EIS areas; the double shell tanks farms and other EIS areas; and the Hanford Reach EIS and the Eight Production Reactors EIS.

- Several of the key EISs fail to include the impacts on the environment as related to the Natural Resource Damage Assessment (NRDA) provisions of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

625 Marion Street, N.E., Salem, OR 97310-0830
Telephone (503) 378-4040 Toll free 1-800-221-8035 Fax (503) 373-7806

- The USDOE Headquarters Environmental Restoration and Waste Management Programmatic EIS (EM-PEIS) fails to include the environment on the Hanford site in any way in its considerations. It also fails to include the NRDA provisions of CERCLA.

It is essential that all Hanford EISs be integrated. We believe this will encourage adherence and understanding of the systems approach to cleanup.

Sincerely,

Keith Burns, Chair
Oregon Hanford Waste Board

cc: Thomas Grumbly

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

FEB 28 1994

94-EPB-031

Mr. Merritt Tuttle
NOAA
National Marine Fisheries Service
911 NE 11th Ave. Room 620
Portland, Oregon 97232

Dear Mr. Tuttle:

HANFORD REMEDIAL ACTION ENVIRONMENTAL IMPACT STATEMENT (HRA-EIS)

The U.S. Department of Energy (DOE) is preparing the HRA-EIS to address environmental impacts associated with the remediation of over 1100 waste sites on the Department's Hanford Site in Southeastern Washington. These sites are related to the production of nuclear materials and many of the sites contain radioactive and dangerous wastes. In concert with the Endangered Species Act, the environmental impact statement will contain an analysis of the proposed action as it relates to listed and proposed, threatened, and endangered species.

DOE requests that the National Marine Fisheries Service provide a current list of species that could be affected by the proposed action. The proposed action could involve the Columbia River from river mile 342 to river mile 392.

This letter further authorizes the DOE's contractor, Advanced Sciences, Inc. (ASI), Richland, Washington, to obtain endangered species information from your office for the HRA-EIS on behalf of DOE Richland Operations Office.

If you have any questions or require additional information, please contact me at (509) 376-6667 or Mr. Larry Dean of ASI at (509) 946-7112

Sincerely,

Paul F. X. Dunigan, Jr.

Paul F. X. Dunigan, Jr.
National Environmental Policy Act
Compliance Officer

EPD:TWF

Attachment

cc: R. Kaldor, ASI

9613459.2169

94-EPB-032

Mr. Dave Fredericks, Field Supervisor
Olympia Field Office
U.S. Fish and Wildlife Service
3704 Griffin Lane S.E., Suite 102
Olympia, Washington 98501-2192

Dear Mr. Fredericks:

HANFORD REMEDIAL ACTION ENVIRONMENTAL IMPACT STATEMENT (HRA-EIS)

The U.S. Department of Energy (DOE) is preparing the HRA-EIS to address environmental impacts associated with the remediation of over 1100 waste sites on the Department's Hanford Site in Southeastern Washington. These sites are related to the production of nuclear materials and many of the sites contain radioactive and dangerous wastes. In concert with the Endangered Species Act, the environmental impact statement (EIS) will contain an analysis of the proposed action as it relates to listed and proposed, threatened, and endangered species.

DOE requests that the U.S. Fish and Wildlife Service provide a current list of species that could be affected by the proposed action. Attached is a list of the affected lands by Section, Range, and Township. The requested species list would facilitate the EIS analysis best if the species of concern are listed Section by Section, rather than a generic Hanford Site list.

In a Section 7 Consultation meeting, November 15, 1993, Mr. Jeff Maas and Ms. Kristi Swisher suggested that given the complex nature of the Hanford Site, the species list could be valid for one year rather than the usual 90 days. They also suggested that a DOE contractor could interface directly with the U.S. Fish and Wildlife Service with authorization from DOE. Therefore, this letter further authorizes Advanced Sciences, Inc. (ASI), Richland, Washington, to obtain endangered species information from your office for the HRA-EIS on behalf of DOE Richland Operations Office.

If you have any questions, please contact me at (509) 376-6667 or
Mr. Larry Dean of ASI at (509) 946-7112

Sincerely,

ORIGINAL SIGNED BY

Paul F. X. Dunigan, Jr.
National Environmental Policy Act
Compliance Officer

EPD:TWF

Attachment

cc: R. Kaldor, ASI

Range/Township	Sections
R26E T10N	1,2,3,4,5,10,11
R27E T10N	1,2,3,4,5,6,7,8,9,11,12
R28E T10N	2,3,4,5,6,7,8,9,10,11,14,15,16,17
R24E T11N	1,2,11,12,13,14,24
R25E T11N	1 - 25
R26E T11N	1 - 36
R27E T11N	1 - 36
R28E T11N	2,3,4,5,6,7,8,9,10,11,14,15,16,17,18 ,19,20, 21,23,26,27,28,29,30,31,32,33,34,35
R24E T12N	1,2,11,12,13,14,23,24,25,26,35,36
R25E T12N	1 - 36
R26E T12N	1 - 36
R27E T12N	1 - 36
R28E T12N	1,2,11,12,13,14,23,24,25,26,35,36
R24E T13N	1,2,9,10,11,12,13,14,15,16,22,23,24, 25,26, 35,36
R25E T13N	1 - 36
R26E T13N	1 - 36
R27E T13N	1 - 36
R28E T13N	5,6,7,8,17,18,19,20,29,30,31,32,33,3 4
R24E T14N	25,36
R25E T14N	1,2,10,11,12,13,14,15,16,17,19,20,21 ,22,23,24,25,26,27,28,29,30,31,32,33 ,34,35,36
R26E T14N	1 - 36
R27E T14N	1 - 36
R28E T14N	6,17,18,19,20,29,30,31,32
R25E T15N	36
R26E T15N	13,14,15,21,22,23,24,25,26,27,28,29, 30,31,32,33,34,35,36
R27E T15N	15,16,17,18,19,20,21,22,23,25,26,27, 28,29,30,31,32,33,34,35,36

9613459.2170

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
3704 Griffin Lane SE. Suite 102
Olympia, Washington 98501-2192
(206) 753-9440 FAX: (206) 753-9008

April 21, 1994

Paul F.X. Dunigan, JR.
Department of Energy
Richland Operations Office
P.O. Box 550
Richland, WA 99352

FWS Reference: 1-3-94-SP-342

Dear Mr. Dunigan:

This is in response to your letter dated March 1, 1994 and received in this office on March 4. Enclosed is a list of listed threatened and endangered species, and candidate species (Attachment A), that may be present within the area of the proposed Hazardous Waste Site Remediation Project on the U.S. Department of Energy's Hanford Site in Grant and Benton Counties, Washington. Unfortunately, our information is not in a form that could easily be used to list the species section by section, as requested. The list as presented fulfills the requirements of the Fish and Wildlife Service (Service) under Section 7(c) of the Endangered Species Act of 1973, as amended (Act). We have also enclosed a copy of the requirements for the Department of Energy (DOE) compliance under the Act (Attachment B).

Should the biological assessment determine that a listed species is likely to be affected (adversely or beneficially) by the project, the DOE should request Section 7 consultation through this office. If the biological assessment determines that the proposed action is "not likely to adversely affect" a listed species, the DOE should request Service concurrence with that determination through the informal consultation process. Even if the biological assessment shows a "no effect" situation, we would appreciate receiving a copy for our information.

Candidate species are included simply as advance notice to federal agencies of species which may be proposed and listed in the future. However, protection provided to candidate species now may preclude possible listing in the future. If early evaluation of your project indicates that it is likely to adversely impact a candidate species, the DOE may wish to request technical assistance from this office.

There may be other federally listed species that may occur in the vicinity of your project which are under the jurisdiction of the National Marine Fisheries Service (NMFS). Please contact NMFS at (503) 230-5430 to request a species list.

In addition, please be advised that federal and state regulations may require permits in areas where wetlands are identified. You should contact the Seattle District of the U.S. Army Corps of Engineers for federal permit requirements and the Washington State Department of Ecology for state permit requirements.

Your interest in endangered species is appreciated. If you have additional questions regarding your responsibilities under the Act, please contact Jim Michaels or Jodi Bush of this office at the letterhead phone/address.

Sincerely,

Lynn P. Childers

David C. Frederick
State Supervisor

jb/kr
Enclosures
SE/DOE/1-3-94-SP-342/Grant & Benton
c: WDFW, Region 2
WDFW, Region 3
WNHP, Olympia

ATTACHMENT A

LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES AND CANDIDATE SPECIES WHICH MAY OCCUR WITHIN THE VICINITY OF THE PROPOSED HANFORD HAZARDOUS WASTE SITES REMEDIATION PROJECT IN SOUTHEASTERN WASHINGTON IN GRANT AND BENTON COUNTIES, WASHINGTON (T10N R26-28E; T11N R24-28E; T12N R24-28E; T13N R25-28E; T14N R25-28E: T14N R24E S25/36; T15N R25E S36; T15N R26-27E)

FWS Reference: 1-3-94-SP-342

LISTED

Bald eagle (*Haliaeetus leucocephalus*) wintering bald eagles may occur in the vicinity of the project from about October 31 through March 31.

There are three bald eagle nesting territories located in the vicinity of the project at T13N R27E S9. T13N R27E S10; T14N R27E S29. Nesting activities occur from about January 1 through August 15.

There is a bald eagle wintering concentration located in the vicinity of the project at T13N R27E S23.

There are six bald eagle communal winter night roosts located in the vicinity of the project at T13N R26E S6; T13N R27E S23: T14N R26E S11; T14N R26E S14. T14N R27E S29; T14N R27E S18.

Peregrine falcon *(Falco peregrinus)* spring and fall migrant falcons may occur in the vicinity of the project.

Major concerns that should be addressed in your biological assessment of project impacts to bald eagles and peregrine falcons are:

1. Level of use of the project area by eagles and falcons.

2. Effect of the project on eagles' and falcons' primary food stocks, prey species, and foraging areas in all areas influenced by the project.

3. Impacts from project construction and implementation (e.g., increased noise levels, increased human activity and/or access, loss or degradation of habitat) which may result in disturbance to eagles and falcons and/or their avoidance of the project area.

PROPOSED

None

ATTACHMENT A (1-3-94-SP-342 cent.)

CANDIDATE

The following candidate species may occur in the vicinity of the project:
Black tern *(Chlidonias niger)*
Bull trout *(Salvelinus confluentus)*
California floater (mussel) *(Anodonta californiensis* (Lea. 1852))
Columbia pebblesnail *(Fluminicola (=Lithoglyphus)* columbianus (Hemphill in Pilsbry. 1899)) [great Columbia River spire snail]
Ferruginous hawk *(Buteo regalis)*
Loggerhead shrike *(Lanius ludovicianus)*
Pygmy rabbit *(Brachylagus idahoensis)*
Western sage grouse *(Centrocercus urophasianus phaios)*
Rorippa columbiae (Columbia yellow-cress)

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ATTACHMENT B

FEDERAL AGENCIES' RESPONSIBILITIES UNDER SECTIONS 7(a) AND 7(c) OF THE ENDANGERED SPECIES ACT OF 1973, AS AMENDED

SECTION 7(a) - Consultation/Conference

Requires:

1. Federal agencies to utilize their authorities to carry out programs to conserve endangered and threatened species;

2. Consultation with FWS when a federal action may affect a listed endangered or threatened species to ensure that any action authorized, funded, or carried out by a federal agency is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. The process is initiated by the federal agency after it has determined if its action may affect (adversely or beneficially) a listed species; and

3. Conference with FWS when a federal action is likely to jeopardize the continued existence of a proposed species or result in destruction or an adverse modification of proposed critical habitat.

SECTION 7(c) - Biological Assessment for Construction Projects *

Requires federal agencies or their designees to prepare a Biological Assessment (BA) for construction projects only. The purpose of the BA is to identify any proposed and/or listed species which is/are likely to be affected by a construction project. The process is initiated by a federal agency in requesting a list of proposed and listed threatened and endangered species (list attached). The BA should be completed within 180 days after its initiation (or within such a time period as is mutually agreeable). If the BA is not initiated within 90 days of receipt of the species list, please verify the accuracy of the list with our Service. No irreversible commitment of resources is to be made during the BA process which would result in violation of the requirements under Section 7(a) of the Act. Planning, design, and administrative actions may be taken; however, no construction may begin.

To complete the BA, your agency or its designee should: (1) conduct an onsite inspection of the area to be affected by the proposal, which may include a detailed survey of the area to determine if the species is present and whether suitable habitat exists for either expanding the existing population or potential reintroduction of the species; (2) review literature and scientific data to determine species distribution, habitat needs, and other biological requirements; (3) interview experts including those within the FWS, National Marine Fisheries Service, state conservation department, universities, and others who may have data not yet published in scientific literature; (4) review and analyze the effects of the proposal on the species in terms of individuals and populations, including consideration of cumulative effects of the proposal on the species and its habitat; (5) analyze alternative actions that may provide conservation measures; and (6) prepare a report documenting the results, including a discussion of study methods used, any problems encountered, and other relevant information. Upon completion the report should be forwarded to our Endangered Species Division, 3704 Griffin Lane SE, Suite 102, Olympia, WA 98501-2192.

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* "Construction project" means any major federal action which significantly affects the quality of the human environment (requiring an EIS), designed primarily to result in the building or erection of human-made structures such as dams, buildings, roads, pipelines, channels, and the like. This includes federal action such as permits, grants, licenses, or other forms of federal authorization or approval which may result in construction.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
3704 Griffin Lane SE, Suite 102
Olympia, Washington 98501-2192
(206) 753-9440 FAX: (206) 753-9008

December 7, 1994

Charles Clarke, Regional Administrator
U.S. Environmental Protection Agency
Region 10
1200 Sixth Avenue
Seattle, WA 98101

Dear Mr. Clarke:

This letter is in response to the October 1994 announcement from your agencies regarding the tentative agreement on the environmental restoration refocusing of the Tri-Party Agreement (TPA) negotiations at Hanford. While the U.S. Fish and Wildlife Service (Service) is supportive of the refocusing of the cleanup efforts at Hanford to waste sites along the Columbia River, we do have significant concerns regarding how natural resource issues are presently addressed in the cleanup process. The Service submits the following comments for your consideration during the finalization of the agreement.

Under the National Contingency Plan, the Department of Energy (Energy) as the land manager of the Hanford Reservation is the primary trustee for natural resources on the site. However, the Department of the Interior shares co-trusteeship with Energy for migratory birds, anadromous fish and endangered species on the Hanford Reservation. Other federal, state (e.g., Washington Department of Ecology (Ecology)) and tribal natural resource trustees also share co-trusteeship with Energy for specific natural resources. Although both Energy and Ecology, as trustees, have a regulatory obligation to protect and enhance the natural resources at Hanford, many of their trustee responsibilities have not been addressed in the cleanup process to date.

Cleanup of Hanford, as it is currently being conducted, will eliminate high quality habitat and, therefore, preclude important options for future use of the site for fish and wildlife resources and habitat protection. Recent actions such as the siting of the Environmental Restoration Disposal Facility (ERDF) exemplify the absence of consideration for environmental and habitat factors, and failure to consult with other natural resource trustees early in the project development process. The ERDF scoping document available for public review (Document number DOE/RL-93-101, revision 0) proposed a single site which would eliminate six square miles of the highest quality mature shrub-steppe habitat on the Hanford Reservation. Mitigation for habitat loss was limited to a single vague sentence about mitigating with habitat restoration.

As another example, consideration has not been given to cumulative impacts from multiple projects. Several developments are currently planned for the 200 Area plateau, including ERDF, the BC Crib site, the Tank Waste Remediation System, and several others. The 200 Area plateau is the location of the highest quality mature shrub-steppe habitat on the Hanford Reservation. This habitat is extremely limited in the state, and is irreplaceable. In-kind mitigation is not an option for the destruction of this habitat because comparable habitat does not exist at Hanford. Furthermore, restoration of degraded habitat is not an suitable option because those species requiring mature shrub-steppe habitat will be eliminated by the time restoration efforts produce mature shrubs. An irreplaceable ecosystem may be eliminated by the cumulative impacts of these projects.

The failure to address environmental regulations (e.g., National Environmental Policy Act), to minimize environmental impacts, to consult with natural resource agencies early in the project development phase, and to retain future site use options for natural resource management is often justified with the argument that the TPA milestones must be met. This justification is neither acceptable nor appropriate. Hazardous waste cleanups can be accomplished in an efficient and environmentally sound manner. To do so requires that the environmental and natural resource concerns be addressed from the very beginning of project development and that they are recognized as an integral part of the cleanup process.

Thus, it is critical that the TPA milestones be renegotiated to permit adequate time and funding to address environmental issues throughout the entire cleanup process, including environmental site evaluations, planning and implementation of mitigation and restoration, and consultation with natural resource trustees. As successful restoration of a site may take five to ten years or more to accomplish, the milestones must include adequate time to attain effective restoration. Planning for cleanup costs at Hanford must include the funds needed to accomplish environmental goals consistent with the natural resource trusteeship responsibilities of Energy. The Service requests that all parties in the ongoing TPA negotiations seek milestone extensions or adjustments to enable the Hanford cleanup to proceed in a more environmentally responsible manner.

The Service appreciates the opportunity to provide comments on the content of the TPA negotiations. Please contact me if you have any questions or wish to discuss our comments.

Sincerely,

for Nancy J. Gloman

David C. Frederick
State Supervisor

kab/jmc

c: Columbia Basin Ecoregion, Portland (Bill Shake, ARD)
Columbia NWR, Othello (Dave Goeke)
DOI, OEPC, Portland (Regional Environmental Officer)
DOE, Richland (Annette Carlson)

United States Department of the Interior
OFFICE OF THE SECRETARY
Office of Environmental Policy and Compliance
500 NE Multnomah Street, Suite 600
Portland, Oregon 97232-2036

August 14, 1995

ER 95/488

Paul F.X. Dunigan, Jr.
NEPA Compliance Officer
U.S. Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

Dear Mr. Dunigan:

The Department of the Interior (Department) has reviewed the Implementation Plan for the Proposed Hanford Remedial Action Environmental Impact Statement, Benton County, Richland, Washington. The Department does not have any comments to offer.

We appreciate the opportunity to comment.

Sincerely,

Charles S. Polityke
Regional Environmental Officer

9613459.2174

025493

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

DEC 28

Ms. Donna L. Powaukee, Manager
Environmental Restoration/
Waste Management Program
Nez Perce Tribe
P.O. Box 365
Lapwai, Idaho 83540-0365

Dear Ms. Powaukee:

PRELIMINARY DRAFT OF THE HANFORD REMEDIAL ACTION (HRA) ENVIRONMENTAL IMPACT STATEMENT (EIS)

Attached you will find the November 10, 1995, preliminary draft of the HRA EIS. This preliminary draft is currently being reviewed by the U.S. Department of Energy (DOE), Richland Operations Office (RL) and its contractors before official release to the public for public comment. Because this version has not been completely reviewed and approved by DOE, the reader is cautioned not to interpret anything in the preliminary draft as official DOE policy or analysis. Until issued by DOE, this text only reflects the contractor's best interpretation of the directions given by DOE's representatives. Changes might occur as a result of the current internal review, including the title of the EIS to reflect the land use planning emphasis.

For example, this is the third preliminary draft to be internally reviewed by RL. In the July 1, 1994, preliminary draft, errors were discovered in the risk isopleths. These errors were corrected in the September 26, 1994, preliminary draft. This November 10, 1995, preliminary draft was written to further define the alternatives based on the analyses in the September 26, 1994, version. The November 10, 1995, preliminary draft is most likely the last version that will be internally reviewed by DOE before the scheduled release sometime between February to August of 1995. Internal drafts are constantly being revised to include the newest technical information, correct errors, reflect policy direction, update events, and edit text or graphics.

Due to the length and complexity of the subjects that will be covered in the public draft of the HRA EIS, the many concurrent similar planning processes that are being pursued by other governmental bodies, and the unusual length of time since the public scoping meetings were held, DOE has decided to place this copy of the preliminary draft of the HRA EIS in the Richland Public Reading Room. DOE does not see this as a precedence for other ongoing or future EISs but, in this special case believes there may be a benefit to the public in making the preliminary draft available given the many other related external interests.

Subject Code: 5650.8280
Written Response Required? NO
Classes CCN: N/A
OU: N/A
TSD: N/A
ERA: N/A
Non-Project: N

If you should have any questions on the preliminary draft, please contact Mr. Tom Ferns on (509) 372-0649.

Sincerely,

Richard A. Holten, Director
Restoration Projects

RAP:TWF

Attachment

9613459.2175

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

DEC 2 1995

Mr. J. R. Wilkinson
Confederated Tribes of the
Umatilla Indian Reservation
P.O. Box 638
Pendleton, Oregon 97801

Dear Mr. Wilkinson:

PRELIMINARY DRAFT OF THE HANFORD REMEDIAL ACTION (HRA) ENVIRONMENTAL IMPACT STATEMENT (EIS)

Attached you will find the November 10, 1995, preliminary draft of the HRA EIS. This preliminary draft is currently being reviewed by the U.S. Department of Energy (DOE), Richland Operations Office (RL) and its contractors before official release to the public for public comment. Because this version has not been completely reviewed and approved by DOE, the reader is cautioned not to interpret anything in the preliminary draft as official DOE policy or analysis. Until issued by DOE, this text only reflects the contractor's best interpretation of the directions given by DOE's representatives. Changes might occur as a result of the current internal review, including the title of the EIS to reflect the land use planning emphasis.

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Subject Code: 6650.9280
Written Response Required? NO
Closes CCN: N/A
OU: N/A
TSD: N/A
ERA: N/A
Non-Project: N

If you should have any questions on the preliminary draft, please contact Mr. Tom Ferns on (509) 372-0649.

Sincerely,

Richard A. Holten, Director
Restoration Projects

RAP:TWF

Attachment

9613459.2176

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

DEC 20 1995

Mr. Douglas R. Sherwood
Hanford Project Manager
U.S. Environmental Protection Agency
712 Swift Blvd., Suite 5
Richland, Washington 99352

Mr. Mike Wilson
Nuclear Waste Program
State of Washington
Department of Ecology
P. O. Box 47600
Olympia, Washington 9504-7600

Dear Messrs. Sherwood and Wilson:

PRELIMINARY DRAFT OF THE HANFORD REMEDIAL ACTION (HRA) ENVIRONMENTAL IMPACT STATEMENT (EIS)

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Subject Code: 6650.8280
Written Response Required? NO
Closes CCN: N/A
OU: N/A
TSD: N/A
ERA: N/A
Non-Project: N

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If you should have any questions on the preliminary draft, please contact Mr. Tom Ferns on (509) 372-0649.

Sincerely,

Richard A. Holten, Director
Restoration Projects

RAP:TWF

Attachment

9613459.2177

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

DEC 20 1995

Mr. Russell Jim, Manager
Environmental Restoration/
Waste Management Program
Confederated Tribes and Bands
of the Yakama Indian Nation
P. O. Box 151
Toppenish, Washington 98948

Dear Mr. Jim:

PRELIMINARY DRAFT OF THE HANFORD REMEDIAL ACTION (HRA) ENVIRONMENTAL IMPACT STATEMENT (EIS)

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Subject Code: 6650.8280
Written Response Required? NO
Closes CCN: N/A
OU: N/A
TSD: N/A
ERA: N/A
Non-Project: N

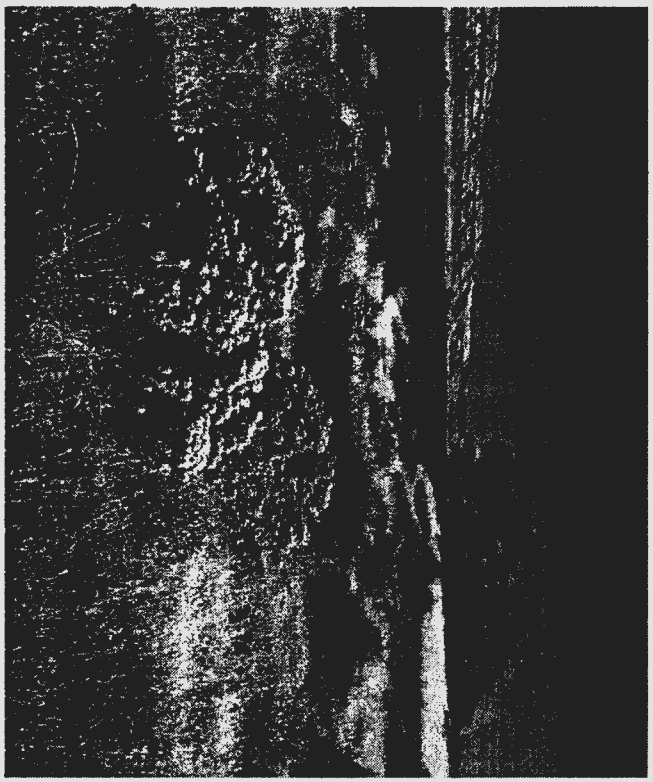
If you should have any questions on the preliminary draft, please contact Mr. Tom Ferns on (509) 372-0649.

Sincerely,

Richard A. Holten, Director
Restoration Projects

RAP:TWF

Attachment



List of Preparers

96139217.8

9613459.2179

7.0 List of Preparers

7.1 Environmental Impact Statement Preparers

U.S. Department of Energy, Richland Operations Office

Thomas W. Ferns, Project Manager

U.S. Department of Energy, Richland Operations Office
M.S., 1985, Land Rehabilitation, Montana State University
B.S., 1980, Interdisciplinary Science, Southern Oregon State College
B.S., 1980, Biology, Southern Oregon State College
Years of Experience: 15

Jason Associates Corporation

William J. Berry, Senior Scientist
Jason Associates Corporation
Ph.D, 1988, Entomology, Iowa State University
M.S., 1983, Biology, University of Notre Dame
B.S., 1981, Biology, University of Notre Dame
Years of Experience: 8

Elizabeth A. Bouchard, Publications Assistant
Jason Associates Corporation
Years of Experience: 10

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B.S., 1995, Physical Science, Washington State University
Years of Experience: 4

Teresa L. Clark, Technical Editor/Integrating Writer
Jason Associates Corporation
Early Childhood Development/Ricks College
Years of Experience: 9

Donald Thomas England Scientific Specialist
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B.S., 1985, Biology/Chemistry, Radford University
Years of Experience: 10

Thomas M. Ivory, Senior Scientist
Jason Associates Corporation
Ph.D., 1973, Environmental Microbiology, University of Utah
M.S., 1967, Environmental Microbiology, University of Utah
B.A., 1965, Biology, University of Utah
Years of Experience: 29

Lynne Roeder-Smith, Public Involvement
Jason Associates Corporation
B.A., 1988, Communications, Washington State University
Years of Experience: 7

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M.S., 1986, Land Rehabilitation, Montana State University
B. S., 1983, Environmental Studies, Bemidji State University
Years of Experience: 10

Regan S. Weeks, Senior Scientist
Jason Associates Corporation
B.S., 1986, Environmental Studies, Huxley College, Western Washington University
Years of Experience: 8

Bechtel Hanford, Inc.

Rudy Prosser, HGIS Database Administrator
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B.S. 1982, Philosophy, University of California San Diego
M.S. 1994, Geography, San Diego State University
Years of Experience: 12

Advanced Sciences, Inc.

Timothy L. Alexander, Noise Specialist
Advanced Sciences, Inc.
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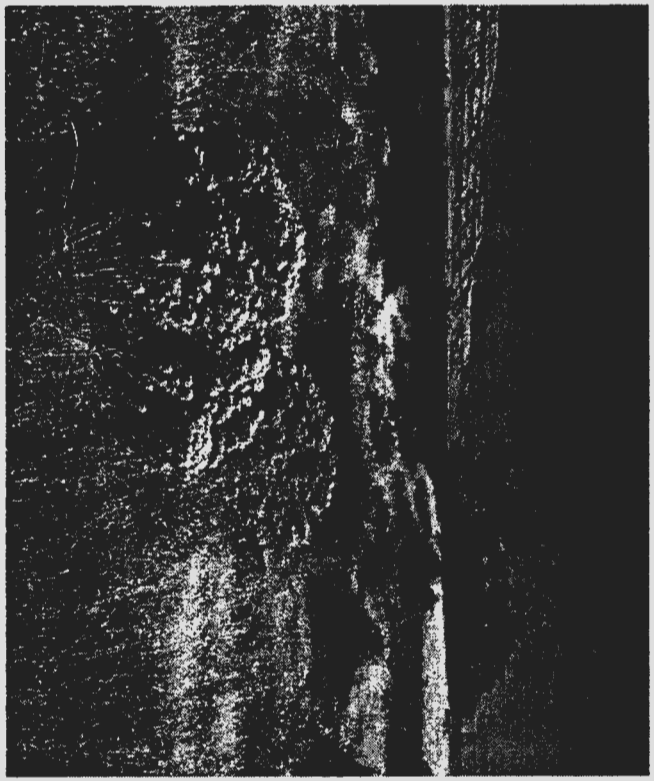

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Federal Facilities Compliance Act of 1992, 42 USC 6901, et seq.

Federal Insecticide, Fungicide, and Rodenticide Act of 1975, 7 USC 136, et seq.

Fish and Wildlife Coordination Act of 1934, 16 USC 661, et seq.

Growth Management Act of 1989, RCW Chapter 36.70A, et seq.

Hazardous and Solid Waste Amendments of 1984, 42 USC 6901, et seq.

Hazardous Waste Management Act of 1976, RCW Chapter 70.105, et seq.

Migratory Bird Treaty Act of 1918, 16 USC 703, et seq.

Model Toxics Control Act of 1989, RCW Chapter 70.105D, et seq.

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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.

NPS, 1988, *National Register of Historic Places,* National Park Service, U.S. Department of the Interior, Washington, D.C.

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, 1993, "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.

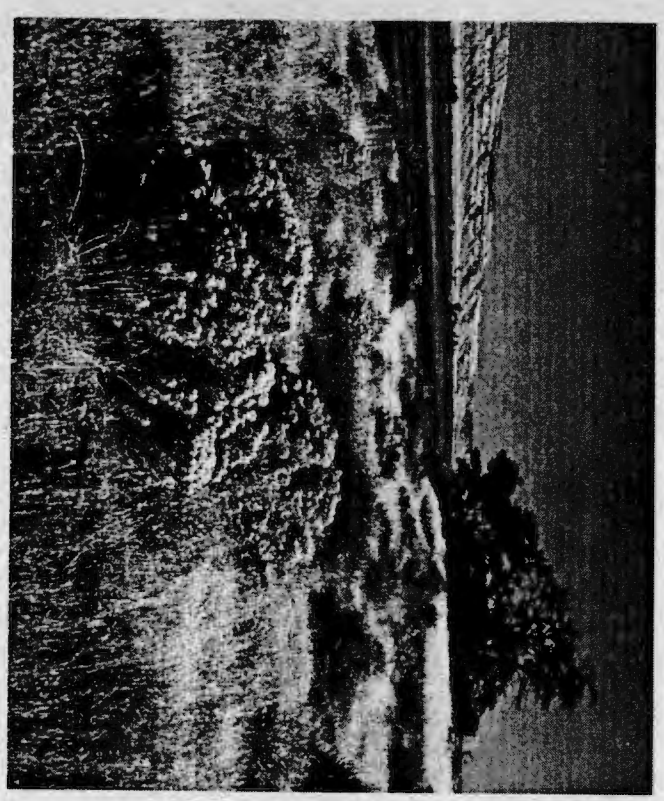
WAC 246-247, 1994, "Radiation Protection--Air Emissions," *Washington Administrative Code*, as amended.

Washington Clean Air Act of 1991, RCW Chapter 70.94, et seq.

Water Pollution Control Act of 1945, as amended, RCW 90.48, 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.



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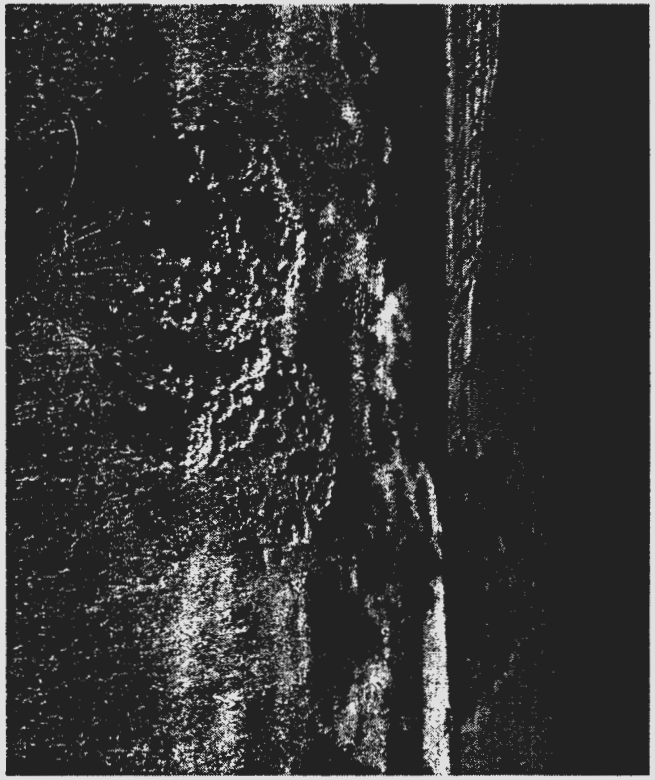

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