DOE/RL-2003-59

Hanford Site Risk-Based End State Vision

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management
Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

United States
Department of Energy
P.O. Box 550
Richland, Washington 99352

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Acronyms

ALE	Fitzner/Eberhardt Arid Lands Ecology Reserve
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLUP	Comprehensive Land-Use Plan
DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
Ecology	Washington State Department of Ecology
EM	Office of Environmental Management
EPA	U.S. Environmental Protection Agency
FFTF	Fast Flux Test Facility
HAMMER	Hazardous Materials Management and Emergency Response
HQ	U.S. Department of Energy Headquarters
NEPA	National Environmental Policy Act
NPL	National Priorities List
ORP	Office of River Protection
PUREX	Plutonium-Uranium Extraction (Plant)
RBES	risk-based end states
RCRA	Resource Conservation and Recovery Act
REDOX	Reduction-Oxidation (Plant)
RL	Richland Operations Office
SAC	System Assessment Capability
USDA	U.S. Department of Agriculture

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The following maps are included as attachments to this document:

1.0 Introduction

The purpose of this document is to present the site-specific risk-based end state (RBES) cleanup vision for the U.S. Department of Energy's (DOE) Hanford Site. This document is the primary tool for communicating Hanford's RBES vision to DOE, the site contractors, the regulators, Tribal Nations, and public stakeholders. This document responds to the requirements of DOE Policy 455.1, *Use of Risk-Based End States*, and was prepared following DOE's *Guidance for Developing a Site-Specific Risk-Based End State Vision*. The purpose of the policy is to focus DOE on conducting cleanup that protects human health and the environment for the planned future use of each defined area on each site. The policy requires DOE to continue to comply with applicable federal, state, community and treaty requirements. It is not a license to do less, but rather to link decision making to a larger perspective.

In September 1999, DOE issued the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (CLUP) (DOE 1999a), which was the basis for developing Hanford's RBES vision presented in this document. The plan evaluated the potential environmental impact associated with implementing a 50-year comprehensive land-use plan for the Hanford Site. DOE's selected alternative anticipates multiple uses of the Hanford Site, including consolidating waste management operations in the Central Plateau, allowing industrial development in the eastern and southern portions of the site, increasing recreational access to the Columbia River, and expanding the Saddle Mountain National Wildlife Refuge to include all of the Wahluke Slope, and the management of the Fitzner/Eberhardt Arid Lands Ecology Reserve (ALE) by the U.S. Fish and Wildlife Service.

In 2002, DOE's Office of Environmental Management (EM) established a set of corporate projects to lead its response to the top-to-bottom review (DOE 2002a). The corporate projects are intended to change the way DOE-EM and, in some cases, DOE does business. One of these corporate projects, "A Cleanup Program Driven by Risk-Based End States Project," resulted in DOE Policy 455.1 being issued in 2003 along with guidance and implementation documents. This policy is consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Resource Conservation and Recovery Act (RCRA), and the Atomic Energy Act of 1954, which either explicitly or implicitly direct the consideration of future land use and risk in making cleanup decisions. This RBES approach attempts to gain a common acceptance of the post-remediation future for Hanford prior to implementing final remediation measures.

During 2003, DOE and the U.S. Fish and Wildlife Service were joint stewards of the Hanford Reach National Monument (Figure 1.1). The U.S. Fish and Wildlife Service administers three major management units of the monument totaling about 66,775 hectares (165,000 acres), including:

1. Fitzner/Eberhardt Arid Land Ecology Reserve – a 312 square kilometer (120 square mile) tract of land in the southwestern portion of the Hanford Site

2. Saddle Mountain Unit – a 130 square kilometer (50 square mile) tract of land on the north-northwest side of the Columbia River, generally south and east of State Highway 24

3. Wahluke Unit – a 225 square kilometer (87 square mile) tract of land located north and east of both the Columbia River and the Saddle Mountain Unit.

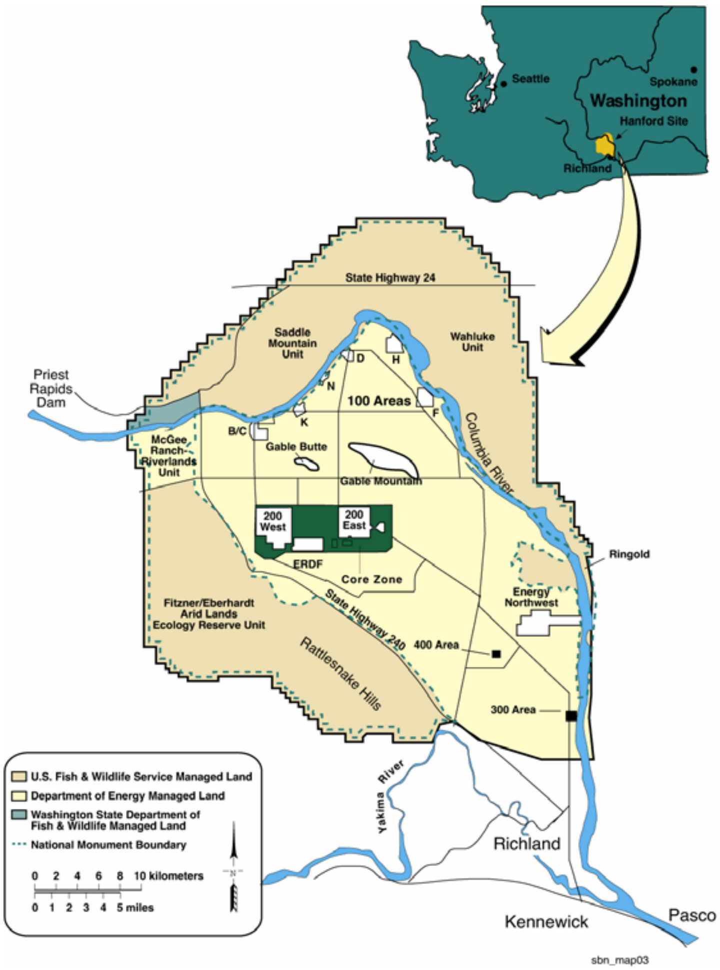

Figure 1.1. The Hanford Site (586 square miles) in Southeastern Washington State

The portion of the monument administered by DOE includes the McGee Ranch/Riverlands Unit (north and west of State Highway 24 and south of the Columbia River), the Columbia River islands in Benton County, the Columbia River Corridor (0.4 kilometer [0.25 mile] inland from the Hanford Reach shoreline) on the Benton County side of the river, and the sand dunes area located along the Hanford side of the Columbia River north of the Columbia Generating Station. Approximately 162 hectares (400 acres) along the north side of the Columbia River, west of the Vernita Bridge and south of State Highway 243, were managed by the Washington Department of Fish and Wildlife under a permit from DOE.

In total, these land areas encompass 67,178 hectares (166,000 acres) and are now part of the Hanford Reach National Monument have served as a safety and security buffer zone for Hanford Site operations since 1943, resulting in an ecosystem that has been relatively untouched for nearly 60 years.

1.1 Organization of the Report

Information in this document has been taken wherever possible from existing documents. This report is organized into three main sections. Chapter 2 provides a regional context for RBES using several regional maps.

Chapter 3 was drawn extensively from the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE 1999a). The chapter describes the RBES on a Hanford Site scale. The chapter includes current state and RBES vision.

Chapter 4 relies heavily on the numerous documents developed to reach decisions on cleanup of the Hanford Site including CERCLA interim action records of decision. The chapter contains the hazard-specific descriptions. The chapter is organized by major areas of the Hanford Site (100 Area, 200 Area, 300 Area, 400 Area, 600 Area, and 1100 Area) and the specific types of hazards that exist in each area (e.g., liquid waste sites, burial grounds, facilities, residual vadose zone contamination, groundwater). Current state and RBES vision conceptual site models are included.

The end-state conceptual site model narrative also includes a description of the mechanisms assumed in the RBES vision that will ensure sustainable protection or safety for at-risk receptors and the uncertainties or risks of failure that could adversely affect these assumptions.

Chapter 5 is a discussion of the variance between the RBES vision and current cleanup plans for the DOE Hanford Site. This document provides an initial discussion of these variances; however, it is anticipated that additional variances will be identified through discussions with regulators, the affected governmental organizations, adjacent landowners, and the general public during the development of the RBES vision.

1.2 Site Mission

From its creation in 1943 until the late 1980s, the Hanford Site was dedicated first to the production of plutonium for national defense and later to management of the resulting waste. The plutonium production activities produced about 2,600 waste sites on the Hanford Site. The severity of contamination at individual waste sites ranges from contaminated tumbleweeds to radioactive and chemical waste in underground tanks. The waste and nuclear material inventory remaining from the plutonium production mission contains about 390 million curies of radioactivity and 362,874 to 544,311 metric tons (400,000 to 600,000 tons) of chemicals (Gephart 2003), as shown in Table 1.1. There are significant unknowns in this inventory, especially for specific radionuclides and their chemical forms.

Table 1.1. Hanford Site Waste and Nuclear Material Inventory

Waste Source	Radioactivity (million curies)	Chemicals	Volume
Tank Waste	195	217, 724 metric tonnes (240,000 tons)	2e+008 liters (53 million gallons)
Solid Waste	6	63,503 metric tonnes (70,000 tons)	707,921 cubic meters (25 million cubic feet)
Soil and Groundwater	2	90,718 to 272,155 metric tonnes (100,000 to 300,000 tons)	9.9e+008 cubic meters (35 billion cubic feet)
Facilities	1	--	5,663,369 cubic meters (200 million cubic feet)
Nuclear Material	185	--	708 cubic meters (25,000 cubic feet)

Major operational areas (Figure 1.1) were created at the Hanford Site to carry out this mission:

- The 100 Areas (on the south shore of the Columbia River) are the sites of nine retired plutonium production reactors, including the dual-purpose N-Reactor. The 100 Areas occupy ~11 square kilometers (4 square miles).

- The 200 West and 200 East Areas are located within the Central Plateau, ~8 and 11 kilometers (~5 and 7 miles), respectively, south of the Columbia River. Historically, these areas have been dedicated to fuel reprocessing and to waste management and disposal activities. The 200 Areas cover ~16 square kilometers (~6 square miles).

- The 300 Area, located just north of the city of Richland, once contained fuel fabrication facilities and is currently the site of nuclear research and development and biological sciences laboratory. This area covers 1.5 square kilometers (0.6 square mile).

- The 400 Area is ~8 kilometers (~5 miles) northwest of the 300 Area. The 400 Area contains the Fast Flux Test Facility, which was used in the testing of breeder reactor systems. Also included in this area is the Fuels and Materials Examination Facility.

- The 600 Area includes all of the Hanford Site not occupied by the 100, 200, 300, and 400 Areas.

- The former 1100 Area (now called Richland North) is located south of the Hanford Site in the northern portion of the city of Richland. This is a support area that includes general stores, transportation maintenance, and the DOE and contractor facilities. The 1100 Area has been remediated and removed from the U.S. Environmental Protection Agency's (EPA's) National Priorities List (NPL). Title of ~324 hectares (~800 acres) has been transferred to the Port of Benton for industrial development.

Non-DOE activities on Hanford Site leased land include commercial power production on the land occupied by the Energy Northwest Washington Nuclear Plant (WNP)-2 plant, as well as the partially completed WNP-1 and WNP-4 plants, and operation of a commercial low-level waste burial site by US Ecology, Inc. Immediately adjacent to the southern boundary of the Hanford Site, Framatome ANP, Richland, Inc. operates a commercial nuclear fuel fabrication facility, and Pacific EcoSolutions operates a low-level waste decontamination, super compaction, and packaging disposal facility. The Laser Interferometer Gravitational-Wave Observatory is located between the 200 and 400 Areas.

Since the closeout of the plutonium production mission, the Hanford Site has transitioned to an environmental restoration and waste management mission. In the past 14 years, efforts have shifted to the development of new waste treatment and disposal technologies, and to characterization and cleanup of nuclear materials and contamination left from historical operations.

Currently, the primary mission includes cleaning up and shrinking the site footprint from ~1,517 square kilometers (~586 square miles) to ~194 square kilometers (~75 square miles) by 2012. The online report *Hanford 2012: Accelerating Cleanup and Shrinking the Site* (DOE 2000a) states that the cleanup mission includes three strategies:

1. Restore the Columbia River corridor by continuing to clean up Hanford Site sources of radiological and chemical contamination that threaten the air, groundwater, or Columbia River. It is expected that most River Corridor projects will be completed by 2012.

2. Transition the Central Plateau (200 East and 200 West Areas) from primarily waste storage areas to waste characterization, treatment, storage, and disposal operations that are expected to take another 40 years.

3. Prepare the Hanford Site for future activities such as long-term stewardship, other DOE and non-DOE federal missions, and other public and private use.

On May 15, 1989, DOE, EPA, and the Washington State Department of Ecology (Ecology) signed a comprehensive agreement for cleaning up the Hanford Site. The *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1998), or Tri-Party Agreement, is an agreement for achieving compliance with the CERCLA remedial action provisions and the RCRA treatment, storage, and disposal unit regulations and corrective action provisions. The Tri-Party Agreement (1) defines and ranks CERCLA and RCRA cleanup commitments, (2) establishes responsibilities, (3) provides a basis for budgeting, and (4) reflects aggressive goals for site remediation, with enforceable milestones to ensure compliance.

1.3 Status of Cleanup Program

This section presents the evolution of Hanford's thinking on risk-based strategies for cleaning up the Hanford Site, from a 1995 study commissioned by Mr. Grumbly to the present day status of the cleanup program.

A Risk-Based Approach to Cleanup. In June 1995, the existing Hanford Site contractors (Pacific Northwest Laboratory, Westinghouse Hanford Company, and Bechtel Hanford, Inc.) produced a document titled *Development of a Risk-Based Approach to Hanford Site Cleanup* (Hesser et al. 1995) in response to a request from Mr. Grumbly, then Assistant Secretary for Environmental Management. Mr. Grumbly asked Hanford to develop a conceptual set of risk-based cleanup strategies that (1) protected the public, the workers, and the environment from unacceptable risks, (2) were technically executable, and (3) fit within an expected annual funding profile of $1.05 billion. A systems engineering approach was used to develop mortgage-based, risk-based, and land-based cleanup strategies that differed in terms of the work to be performed, its sequence, and the resulting end states. The report recommended adoption of a risk-based cleanup strategy. The major decisions identified by the alternatives examined in the report were

- Retrieval and treatment versus in-place disposal of tank waste
- Retrieval and treatment versus in-place disposal of post-1970 transuranic waste
- Treatment and confinement versus restriction of the contaminated groundwater
- Demolition and removal versus entombment of major facilities

Central Plateau Risk Framework. DOE, EPA, and Ecology initiated the development of a Central Plateau Risk Framework in October 2001. The product of this effort provides a basis for making cleanup decisions in the Central Plateau and will be considered as future Tri-Party Agreement milestones are developed. Through a series of technical workshops attended by all the Central Plateau programs, initial agreements were made on the basic assumptions for the risk framework. This framework was then taken to the Hanford Advisory Board, the Tribal Nations, the Oregon Hanford Waste Board, and the Hanford Site Board of Trustees. Salient points of the risk framework include the following items:

- "The Core Zone (200 Areas including B Pond [main pond] and S Ponds) will have an industrial scenario for the foreseeable future (Figure 1.2).

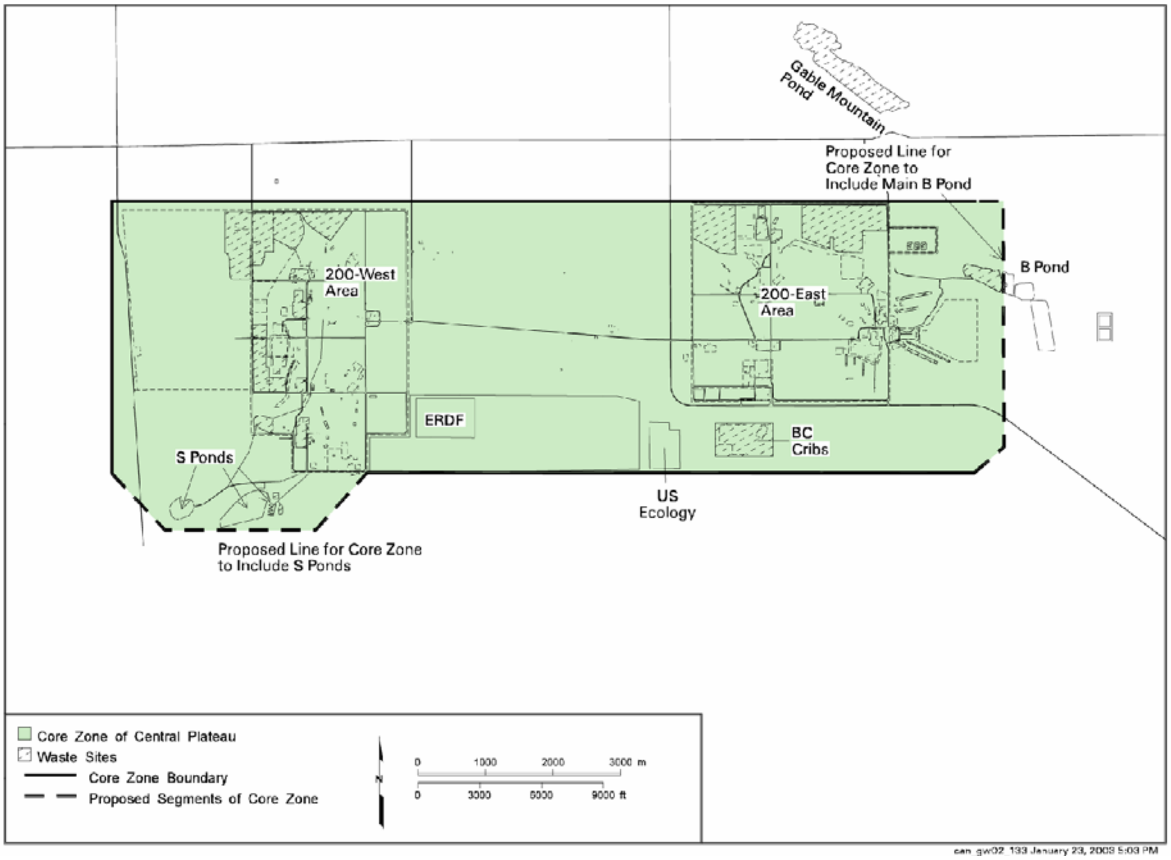

Figure 1.2. Central Plateau Core Zone Map

- The Core Zone will be remediated and closed allowing for other uses consistent with an industrial scenario (environmental industries) that will maintain active human presence in this area, which in turn will enhance the ability to maintain the institutional knowledge of the wastes left in place for future generations. Exposure scenarios used for this zone should include a reasonable maximum exposure to a worker/day user, to possible Native American users, and to intruders. An assumption of industrial land use will be used to set cleanup levels.

- DOE will follow the required regulatory processes for groundwater remediation (including public participation) to establish the points of compliance and remedial action objectives. It is anticipated that groundwater contamination under the Core Zone will preclude beneficial use for the foreseeable future, which is at least the period of waste management and institutional controls (150 years). It is assumed that the tritium and iodine-129 plumes beyond the Core Zone boundary to the Columbia River will exceed the drinking water standards for the period of the next 150 to 300 years (less for the tritium plume). It is expected that other groundwater contaminants will remain below or will be restored to drinking water levels outside the Core Zone.

- Drilling for water use would be limited in the Core Zone. An intruder scenario will be calculated for assessing the risk to human health and the environment.

- Waste sites outside the Core Zone but within the Central Plateau (200-N, Gable Mountain Pond, 100-B/C crib area) will be remediated and closed based on an evaluation of multiple land use scenarios to optimize land use, institutional control cost, and long-term stewardship.

- Other land use scenarios (e.g., residential, recreational) may be used for comparison purposes to support decision-making, especially for
  - the post-active institutional controls period (>150 years)
  - sites near the Core Zone perimeter to analyze opportunities to "shrink the site"
  - early (precedent-setting) closure/remediation decisions

This framework does not deal with the tank retrieval decision."

This risk framework was developed subsequent to the CLUP and is not completely consistent with the land uses envisioned in the CLUP and the likely allowable land uses included in the comprehensive conservation plan being developed for the Hanford Reach National Monument.

In the future, activities at Hanford will be concentrated at the Central Plateau. The associated buffer zone, required for safety purposes, that presently extends to the Columbia River should shrink back to the Central Plateau boundary over time. One hundred and fifty years has been identified as the reasonable time period to switch from active control to passive control outside the Central Plateau. This time period was chosen because the tritium and iodine plumes that currently exist in this region are expected to decay or disperse to below the drinking water standard within 150 years.

Groundwater Institutional Controls. The requirements for engineered barriers and institutional controls are found in the Hanford cleanup decision documents. CERCLA records of decision stipulate the selected cleanup remedy or the closeout process once cleanup is completed for a particular site, which may include the implementation of engineered barriers and institutional controls. The requirements for institutional controls under CERCLA response actions are listed in *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions* (FHI 2002a), along with descriptions of their implementation and maintenance.

Institutional controls are used to augment the engineered components associated with the cleanup of waste to minimize the potential for human exposure to contamination and are primarily administrative in nature. Approximately 259 square kilometers (100 square miles) of Hanford groundwater has been affected (e.g., drinking water standards are exceeded) because of past waste management practices. A significant portion of the remainder of the site continues to serve as a buffer zone for safety and emergency response purposes, and to protect human health and the environment from remaining hazards. DOE will control access and use of the Core Zone and the buffer zone for the duration of the cleanup, including restrictions on the drilling of new groundwater wells in the existing plumes or their paths. It is expected that institutional controls will be enforced until the remedial action objectives have been obtained. In the event that DOE transfers property with groundwater use restrictions to another entity, the appropriate use restrictions are attached to the real estate transaction to ensure that specific institutional controls will remain in place.

Groundwater use on the Hanford Site is generally restricted, except for the purposes of monitoring and treatment, as approved by EPA or Ecology. Groundwater use is also controlled through excavation permits and the land-use process. A limited number of wells are currently in operation for purposes other than research or testing, including those that supply drinking water at the Fast Flux Test Facility (FFTF) in the 400 Area, the Hanford Patrol Training Center, the Yakima Barricade, and Energy Northwest. Other wells provide backup fire protection, emergency cooling water, and aquatic studies (FHI 2002a).

Drinking water systems are operated in accordance with the Washington State Department of Health *Washington Administrative Code*. In addition, new wells are registered with Ecology. The control measures used to protect groundwater for drinking water systems are described in the *Hanford Site Wellhead Protection Plan* (WASTREN 1995).

Top-to-Bottom Review. In February 2002, the Top-to-Bottom Review Team presented their report, *A Review of the Environmental Management Program* (DOE 2002a) to Jessie Roberson, the new Assistant Secretary for DOE-EM. The review issued four major findings:

- The manner in which DOE-EM developed, solicited, selected, and managed many contracts was not focused on accelerating risk reduction and applying innovative approaches to doing the work.
- DOE-EM's cleanup strategy was not based on comprehensive, coherent, technically supported risk prioritization.
- DOE-EM's internal business processes were not structured to support accelerated risk reduction or to address its current challenges of uncontrolled cost and schedule growth.
- The scope of the DOE-EM program included activities that were not focused on or supportive of an accelerated, risk-based cleanup and closure mission.

To address these weaknesses, the team recommended an aggressive course of action to change DOE-EM's approach to its cleanup and closure mandate. All the recommended changes were designed to focus the program on one result – reducing risk to public health, workers, and the environment on an accelerated basis.

Hanford Performance Management Plan. In August 2002, DOE, Richland Operations Office (RL) submitted the *Performance Management Plan for the Accelerated Cleanup of the Hanford Site* (Hanford Performance Management Plan) to DOE Headquarters (HQ; DOE 2002b) in response to the Top-To-Bottom Review. The plan lays out DOE-RL's goals for accelerated completion of the DOE-EM mission at Hanford and to high-quality, comprehensive cleanup that protects public health and the environment. The six strategic initiatives outlined in the plan call for DOE to:

1. Restore the Columbia River corridor by 2012 – completing remediation of 50 burial grounds, 551 waste sites, 261 excess facilities, and seven plutonium production reactors, thereby reducing risk to the river and shrinking the Hanford Site by about 85%.

2. Take several near-term actions to ensure the tank waste program ends by 2035, including increasing the capacity of the planned Waste Treatment Plant; demonstrating tank closure and starting to close tanks within five years; and demonstrating alternative treatment and immobilization solutions for lower-risk tank waste.

3. Accelerate the stabilization and shipment offsite of nuclear materials – including cleaning up K Basins spent nuclear fuel, sludge, debris, and water 10 months early; stabilizing and securely storing remaining plutonium nine years sooner; demolishing the Plutonium Finishing Plant 7 years earlier; and evaluating the benefits of moving Hanford's water-stored cesium and strontium capsules to a secure dry storage facility before shipping them directly (non-vitrified) to the national geologic repository.

4. Address waste issues by accelerating treatment and disposal of mixed low-level waste, retrieving and shipping transuranic waste offsite years ahead of current plans, and coordinating remaining waste site remediation with tank closure.

5. Use Hanford's massive decommissioned chemical separations buildings as waste disposal facilities, and accelerate the disposition of the Central Plateau's 900 excess facilities and more than 800 non-tank-farm waste sites by using regional and other grouping strategies.

6. Protect groundwater resources by removing or isolating contaminant sources on the Central Plateau, remediating other contamination sources, dramatically reducing the conditions that have the potential to drive contaminants into the groundwater, treating groundwater, and integrating monitoring requirements.

Hanford's Long-Term Stewardship Program. DOE is committed to protecting human health and the environment and to meeting its long-term, post-cleanup obligations in a safe and cost-effective manner. Hanford's long-term stewardship's vision statement is

> *"The vitality of human, biological, natural, and cultural resources is sustained over multiple generations."*

The long-term stewardship's mission statement serves as the charter for the program:

> *"The mission of the LTS Program is to provide for continuous human and environmental protection, and the conservation and consideration of use of the biological, natural, and cultural resources, following the completion of the cleanup mission. This will be accomplished through the following functions:*
>
> 1. *Managing post-cleanup residual risks*
> 2. *Managing Site resources*
> 3. *Managing stewardship information*
> 4. *Using science and technology*
> 5. *Providing post-cleanup infrastructure*
> 6. *Integrating long-term stewardship responsibilities"*

Cleanup Progress to Date. DOE, Ecology, and EPA have worked hard to bring a well-defined and manageable focus to Hanford cleanup: restoring the lands along the Columbia River Corridor and transitioning the Central Plateau to a modern waste management operation. Substantial progress has been made toward reducing risk and achieving the cleanup outcomes identified in the Tri-Party Agreement documents. Substantive integration between the DOE Office of River Protection (ORP) and DOE-RL of performance and risk assessment methods, information and results has been noticeably improved. Arrangements to coordinate individual project performance assessments with DOE Order required cumulative risk assessment efforts has been facilitated by the co-location of key contractor personnel and joint direction by DOE-ORP and DOE-RL staff.

Major underground radioactive tank waste safety issues have been resolved and all tanks have been removed from the Congressional watch list. Also, 98% of the pumpable liquids remaining has been removed from the single-shell tanks included in the Interim Stabilization Consent Decree (over 11.4 million liters [3 million gallons]). The Plutonium-Uranium Extraction (PUREX) Plant and B Plant chemical processing plants were the first in the DOE complex to be deactivated to a low-cost maintenance state. Spent nuclear fuel is being taken out of wet storage and moved away from the Columbia River to safe, dry storage on the Central Plateau. Plutonium is being stabilized and packaged for safe, secure, long-term storage and disposition. Construction of the Waste Treatment Plant for tank waste treatment and immobilization has begun. Additionally, work is progressing on the evaluation and potential deployment of supplemental treatment methods to support completion of Tri-Party Agreement milestones for accelerating the pace of retrieval and disposal of tank waste.

DOE-ORP has aggressively pursued a tank farm corrective action program to quantify the extent and the risk-based impacts of past leaks in the tank farms. This soil-leak characterization program is the basis for long-term predictions of tank residual performance that will be used for risk-based closure of the tank farms. Risk has been incorporated into the selection of tank retrieval sequences and communicated to Ecology.

DOE is actively addressing contaminated groundwater plumes. Reactor complexes are being dismantled and reactor cores cocooned for interim safe storage. All unpermitted discharges to the soil have stopped. More than 3.6 million metric tons (4 million tons) of contaminated soil have been moved away from the Columbia River shoreline and into the Environmental Restoration Disposal Facility near the center of the Hanford Site. Over 1 million curies of radioactivity have been removed from contaminated facilities near the city of Richland, and nearly 1,000 metric tons (1,102 tons) of excess uranium has moved offsite. Over 1,100 drums of transuranic waste have been sent to the Waste Isolation Pilot Plant for disposal. All of this progress has been made while transforming the site safety environment to be among the best in the DOE complex.

1.4 Risk Conceptual Model

Looney and Falta (2000) describe a conceptual model as a detailed technical description of the system that answers the question, "How do we believe the system actually operates?" Conceptual models are evolving hypotheses that identify the important features, events, and processes controlling fluid flow and contaminant transport at a specific field site and in the context of a specific problem. Figure 1.3 presents a high level, simplified conceptual model for the release of contaminants from Hanford's facilities, transport of the contaminants through the environment, and the potential impact of those contaminants on living systems.

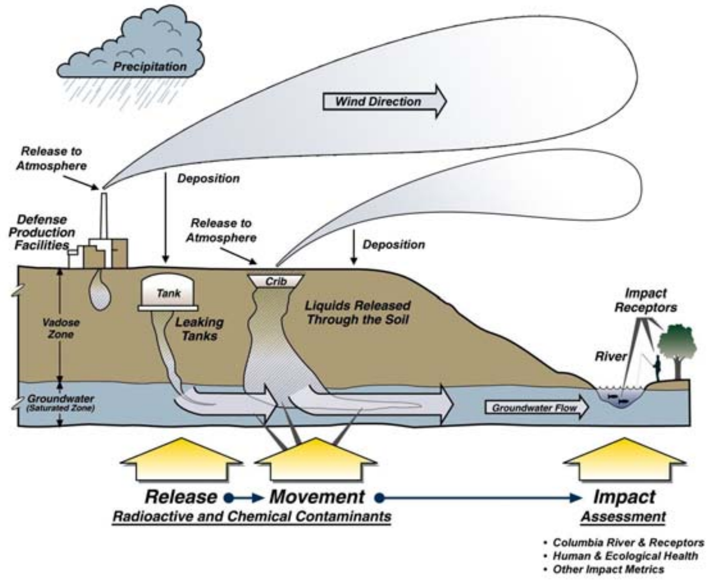

Figure 1.3. A Simplified Conceptual Model for the Release of Contaminants from Hanford's Facilities, Transport through the Environment, and Potential Impact

This information is presented schematically in a conceptual model for risk assessment in Figure 1.4. This conceptual illustration portrays a linear flow of information. In general, contaminants in a waste site inventory may be released to the atmospheric, vadose zone, and Columbia River pathways. In the past, releases have occurred directly to the groundwater through reverse wells and to the Columbia River from the single-pass reactors. During chemical separation plant operation, release occurred to the atmosphere. The atmosphere, groundwater, Columbia River and riparian zone provide opportunities for humans and other living things to be exposed to the contaminants leading to a potential health risk or other impact. A conceptual model for each element of this model is presented in the following paragraphs.

Inventory Conceptual Model. The vast majority of the radioactive waste inventory at the Hanford Site was created during the production of plutonium for atomic weapons. A conceptual model of the Hanford Site during the production operations is shown in Figure 1.5. There were three distinct steps in the production process: fuel fabrication, fuel irradiation, and chemical separation. Other processes were carried out on sites that contributed to waste inventory, such as uranium recovery from the tanks and final processing of plutonium carried out at the Plutonium Finishing Plant. During the first decades at the Hanford Site, it was common to locate waste disposal sites relatively close to waste-generating facilities.

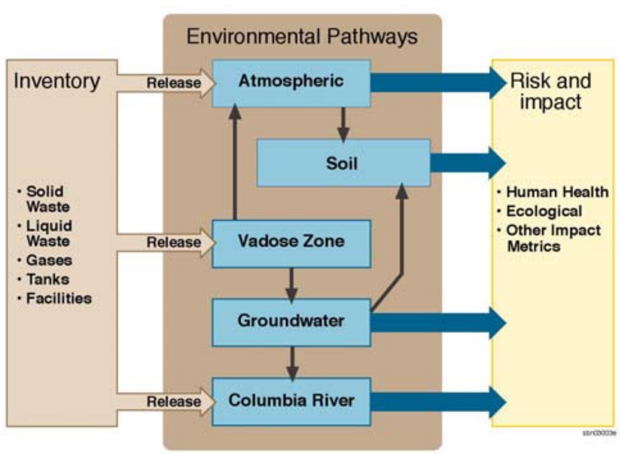

Figure 1.4. Conceptual Model for Risk Assessment

This practice resulted in numerous and varied disposal sites. The most dangerous radioactive waste was stored in large single-shell tanks in the 200 Areas (Agnew 1997; Kupfer et al. 1997). Large volumes of solid waste (e.g., contaminated tools and protective

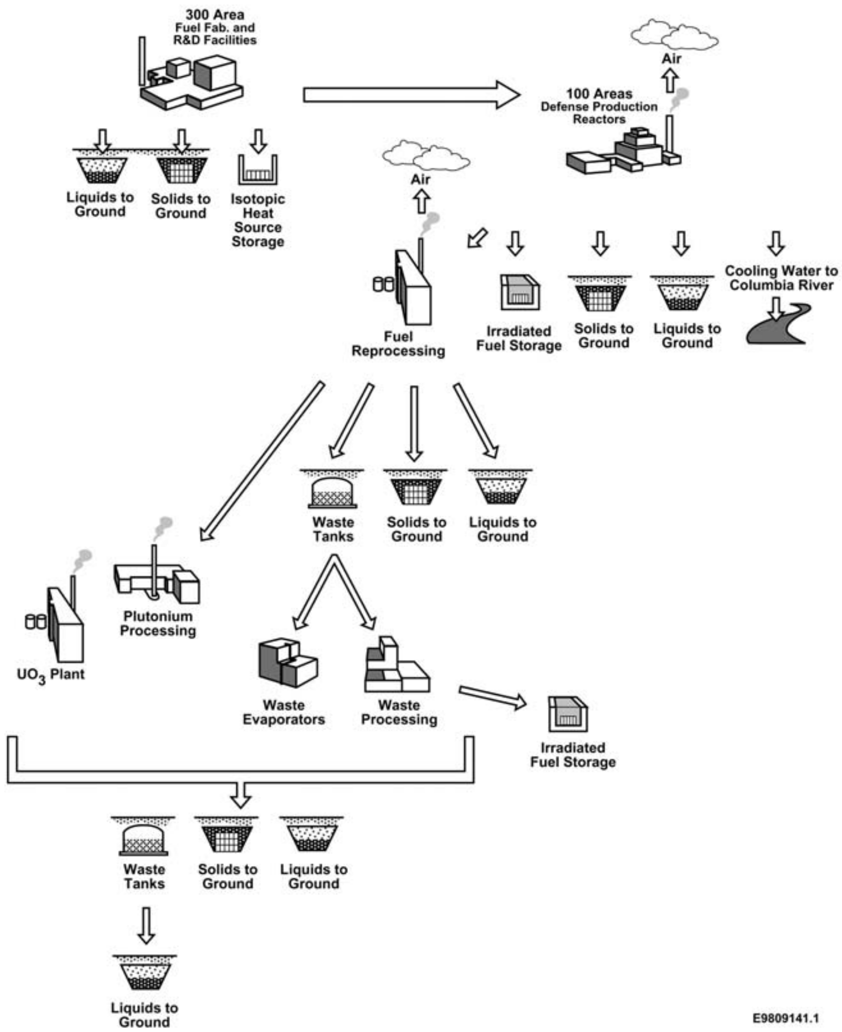

Figure 1.5. Hanford Plutonium Production Process and Waste Disposal Conceptual Model

clothing) were disposed in burial grounds, and large volumes of relatively low-level radioactive liquid waste were discharged to shallow subsurface cribs, French drains, injection (or reverse) wells, and specific retention trenches. More recently, all fuel fabrication and reactor operations ended and cleanup of past-practice units began in the 300 and 100 Areas. Low-level waste from ongoing operations is disposed in burial grounds in the 200 West and 200 East Areas. Most liquid discharges of radioactive waste have been discontinued, an exception being tritium disposal to the State-Approved Land Disposal Site, which receives treated water from the 200 Area Effluent Treatment Facility.

To determine an inventory estimate at a moment in time (e.g., now or at site closure), one needs to amend the conceptual model shown in the figure to include two aspects. First, the quantities of radionuclides and chemicals imported and exported from the Hanford Site are introduced or extracted at several points in the operation (e.g., materials fed into the fuel fabrication process, chemicals fed into the reactor operation and chemical separation processes, and uranium and other special nuclear materials left the Hanford Site). Second, the figure presents the production mission, and needs to be overlaid with the current cleanup mission. Decisions regarding the remediation, decontamination and decommissioning, and disposal actions will impact virtually all facilities and wastes depicted in the conceptual model. These cleanup actions will define the end-state configuration (i.e., both location and stability or form) of the waste.

Waste Form Release Conceptual Model. Waste containment facilities have a number of features that influence the rate at which contaminants can be released from waste. Those features are illustrated in Figure 1.6. The waste may be placed in a trench or reside in a tank. The trench, tank, or other engineered structure may have features that serve as barriers preventing infiltrating water from making contact with and transporting contaminants from the waste to the vadose zone. Waste inside an engineered structure (e.g., trench) may also be contained in a waste package (e.g., a metal drum or high-integrity concrete container). The drum or concrete container acts as an additional barrier preventing transport of the contaminants from the waste. Major containment materials for Hanford waste are concrete, steel, and bituminous layers and coatings. The stability and permeability of containment materials change over time. Time affects which features dominate the water or contaminant migration in containment materials. Surface covers on an engineered system and liners (geomembrane and geosynthetic) and leachate collection systems further restrict infiltrating water from transporting contaminants to the vadose zone. Surface covers are particularly important because migration of infiltrating pore water may be limited as long as the cover maintains its integrity.

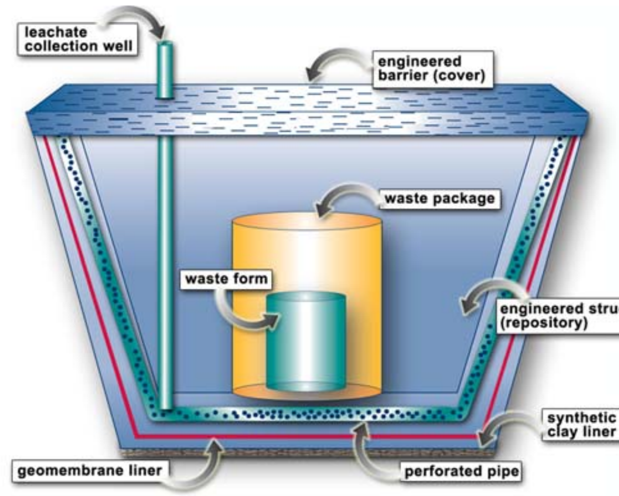

Figure 1.6. Basic Features of a Waste Containment Facility

Individual waste sites may have one or more of the features shown in Figure 1.6. However, it is unlikely that a waste site will have all of the features in the conceptual model and many of Hanford's early waste sites were constructed without engineered barriers. However, they are being reviewed under the Tri-Party Agreement to assure long-term stabilization, which could include future engineered barriers.

A number of key processes govern how much contaminant at any given time is released from the waste to the infiltrating water. One process is the affinity of contaminants to be retained by the waste (e.g., sorption to soil or waste material). Another process is the ability of waste to dissolve, and in some cases, to form new precipitates allowing some contaminants to be released to the infiltrating water while others remain trapped in the precipitated solids. Release from the waste may also be limited by the solubility of the contaminant in the infiltrating water.

Water infiltrating an engineered system may contact and react with fill materials (e.g., soil, basalt, or grout), containment materials in various states of degradation, and different types of waste. Reaction with these materials will change the water chemistry and physical and hydraulic properties over time. The water composition, pH, and redox state at any given time will influence the extent to which these processes influence contaminant release from the waste.

Vadose Zone Conceptual Model. Vadose zone contamination is primarily the result of liquid waste being released to ponds, ditches, and cribs, leakage from retention basins, and, to a lesser degree, the accidental release of contaminants through low-volume spills and dry waste burial grounds. Billions of liters of wastewater have created large contamination plumes within the vadose zone, many of which have already been remediated in the 100 Areas.

The primary forces for contaminant transport are the source/release events and recharge events. The dominant transport pathway is downward through the vadose zone sediment. Stratigraphic layering, variations in the hydraulic properties, and the presence of impeding features (e.g., caliche layers) can locally alter and redirect the movement of contaminants laterally. Discordant features (either natural or manmade – for example fractures, unsealed boreholes) can provide preferential pathways capable of concentrating or contributing to phenomena such as fingering and funnel flow. Wilson et al. (1995) describes flow within the vadose zone as dynamic and characterized by periods of unsaturated flow at varying degrees of partial saturation punctuated by episodes of preferential, saturated flow in response to hydrologic events or releases of liquids.

The movement of contaminants in the vadose zone is affected by their sorption in the far field and sometimes by complex dissolution/precipitation reactions between the waste liquids of extreme pH and the slightly alkaline sediment in the near-field. The significance of sorption is that it delays downward movement of the contaminant and allows degradation processes (e.g., radioactive decay) to occur and for some contaminants, rather irreversible incorporation into the sediment. The sorptive capacity of vadose zone sediment is fairly high; however, the amount of sorption is a function of many factors including mineral surface area and type, contaminant type (speciation) and concentration, overall solution chemistry and concentration, and reaction rates for the control adsorption or precipitation, dissolution, and hydrolysis reactions. Some contaminants do not sorb at all and are moved along with the bulk solution.

Contaminants that exist in the gas phase (e.g., carbon tetrachloride) are subject to atmospheric venting. Contaminants near the soil surface are subject to animal and plant uptake. Contaminants that are consumed by microbes are subject to degradation into other compounds that may or may not pose a risk to humans and the environment. Specific topics of interest to the Hanford Site include the following:

- subsurface contamination (i.e., characteristics of past disposal and leak age, including chemistries, volume, and distribution)

- surface hydrologic features and processes (e.g., winter rain and snow melt, water line leaks, infiltration, deep drainage, and evaporation rates)

- subsurface geologic and hydraulic features and processes (e.g., stratigraphy, structures, physical properties, geochemistry, and microbiology of the sediments above the water table) (DOE 1999b).

Atmospheric Transport Conceptual Model. Contaminants can be released to the atmosphere at ground level through volatilization of contaminants in the vadose zone or releases from Hanford subsurface disposal sites and at elevated points through releases from Hanford processing plant stacks. The distance and direction of transport of contaminants through the atmosphere is affected by the wind speed and direction (at the surface and at the release height). Ambient air temperature affects how the plume rises as it is transported through the atmosphere. The temperature of the effluent can also affect plume-rise. Dispersion of the contaminant plume is determined by the thickness of the atmospheric mixing-layer and the atmospheric stability class. Contaminants are considered to be one of three types for the evaluation of deposition in numerical models: noble gas, iodine, or particle. Contaminants that do not deposit on the ground but are available for inhalation are treated as noble gases; iodine and particles are both deposited on the ground, but have different deposition characteristics. The deposition of contaminants is controlled by atmospheric conditions and surface roughness. Precipitation (rain and snow fall) results in wet deposition of contaminants. In numerical applications, any portion of contaminant that is deposited on the ground is removed from the atmospheric plume to maintain a mass balance.

Groundwater Conceptual and Implementation Model. The state-of-knowledge concerning characterization, modeling, and monitoring of the groundwater system, described in DOE (1999b), provides the primary basis for the groundwater conceptual model discussed. The key components needed for contaminant flow and transport through the groundwater element are schematically depicted in Figure 1.7. The groundwater conceptual model is an interpretation or working description of the characteristics and dynamics of the physical hydrogeologic system, and it consolidates Hanford Site data (e.g., geologic, hydraulic, transport, and contaminant) into a set of assumptions and concepts that can be quantitatively evaluated.

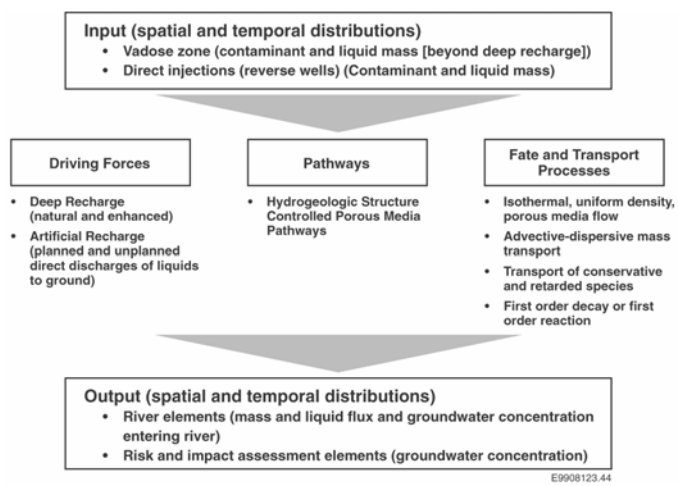

Figure 1.7. Some Primary Conceptual Model Components for Flow and Transport of Contaminants through Groundwater

The groundwater flow system affects the potential for contaminants to migrate from the Hanford Site through the groundwater pathway. To understand this system, the geology and hydrology of the site must be determined because they control the movement of contaminants in groundwater. This information provides the basis for analysis of groundwater flow and contaminant plume migration which is central to many risk assessments used in decision support at Hanford.

The current conceptual model of the unconfined aquifer system has identified up to nine major hydrogeologic units (Thorne and Chamness 1992, Thorne and Newcomer 1992, and Thorne et al. 1993, 1994) within the sediments above the underlying basalt bedrock. Although nine hydrogeologic units were defined, only seven are found below the water table under present day and anticipated future conditions. The Hanford formation combined with the pre-Missoula gravel deposits were designated as a major hydrogeologic unit. Within the Ringold Formation, six different major hydrogeologic units have been identified including three predominantly coarse grained sediment and three predominantly fine-grained sediment with low permeability. The early Palouse soil and Plio-Pleistocene deposits form two other hydrogeologic units but these units are largely above the existing water table and are not considered important units within the unconfined aquifer system. The Holocene alluvium, colluvium, and/or eolian sediments are also well above the water table and are not considered important to the unconfined aquifer system.

Several key processes important to evaluating contaminant fate and transport in groundwater include advection and dispersion, first order radioactive decay, chemical interactions with the water and sediment, and contaminant density. A broader range of chemical processes including the effects of multi-phase behavior, density, and alternative degradation (that is, abiotic and biotic degradation) processes may be important to consider in evaluating the historical and future behavior of an another constituent of interest, carbon tetrachloride, in vicinity of source areas in 200 West Area. Recent vadose modeling of historical carbon tetrachloride transport have been initiated and will examine the effects of these broader range of chemical processes to evaluate their importance in plume development and transport in groundwater near source areas. Another factor that may be important to evaluating contaminant behavior for certain source areas is thermal effects. These effects are being considered in close proximity to tank farms with detailed vadose zone modeling but because of the modulating effect of the thick vadose zone in these areas, the thermal impact of these types of waste sources on contaminant behavior in groundwater is not expected to be significant or important.

Columbia River Conceptual Model. The Columbia River is the largest North American River to discharge into the Pacific Ocean. The river originates in Canada and flows south 1,953 kilometers (1,212 miles) to the Pacific Ocean. The watershed drains a total of 670,000 square kilometers (258,620 square miles) and receives waters from seven states and one Canadian province. Key contributors to the flow are runoff from the Cascade Mountains in Washington and Oregon and from the western slopes of the Rocky Mountains in Idaho, Montana, and British Columbia. Average annual flows below Priest Rapids and The Dalles dams are ~3,360 cubic meters (~120,000 cubic feet) per second and 5,376 cubic meters (192,000 cubic feet) per second, respectively. Numerous dams within the United States and Canada regulate flow on the main stem of the Columbia River. Priest Rapids Dam is the nearest dam upstream of the Hanford Site, and McNary Dam is the nearest downstream (Figure 1.8). The dams on the lower Columbia River greatly increase the water travel times from the upper reaches of the river to the mouth, subsequently reducing the sediment loads discharged downstream. The increased travel times also allow for greater radionuclide deposition and decay.

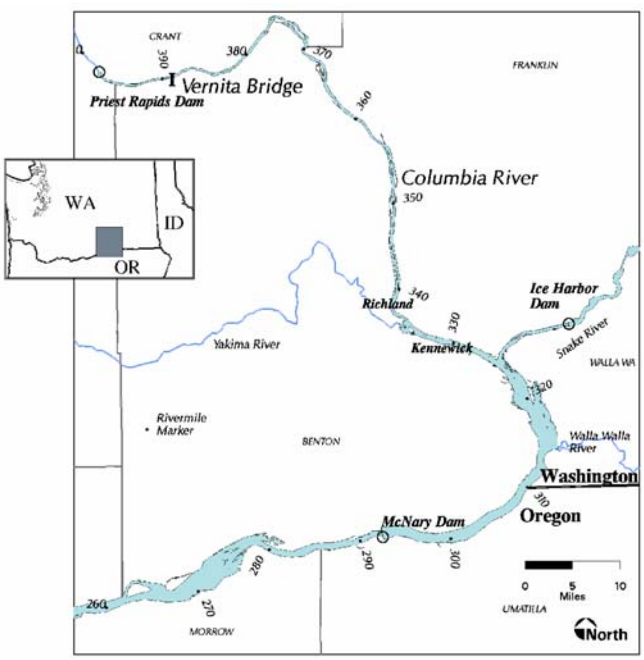

Figure 1.8. Columbia River Showing the Area Between Priest Rapids Dam and McNary Dam

The Snake, Yakima, and Walla Walla Rivers all contribute suspended sediment to the Columbia River; contributions from the Snake River are the most significant. Since construction of McNary Dam (completed in 1953), much of the sediment load has been trapped behind the dam. However, at McNary Dam and other Columbia River dams, some of the trapped sediment is re-suspended and transported downstream by seasonal high discharges. As expected, much of this material is re-deposited behind dams located farther downstream. Sediment accumulates faster on the Oregon shore than on the Washington shore because sediment input from the Snake and Walla Walla Rivers stay near the shore on the Oregon side.

Sediment monitoring samples taken for the Hanford Surface Environmental Surveillance Project indicated cobble and coarse and fine sand bed sediment at sampling locations along the Hanford Site

(Blanton et al. 1995). Silt and clay sediment was observed at the McNary Dam sampling site. The conceptual model used in the initial assessment included the environmental pathways and transport processes that affect contaminant transport in surface water systems. These pathways and processes are illustrated in Figure 1.9.

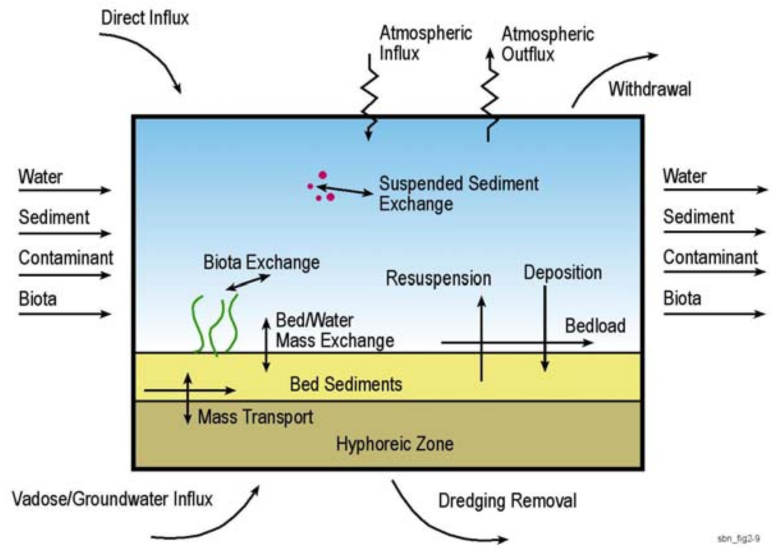

Figure 1.9. Schematic of the Transport and Fate Processes in the River Conceptual Model

Several sources cause uncertainty in the mathematical representation of the conceptual model. These include the choice of temporal and spatial scales, initial and boundary conditions, model parameters, and the physical processes themselves. Examples of uncertainty in physical processes are fluid turbulence and cohesive sediment transport. Uncertainty also arises when selecting parameters such as channel roughness coefficients, porosity, and sediment-contaminant interaction coefficients as well as the influx of contaminants through the interface with groundwater.

Human Health Conceptual Model. The conceptual human health model (Figure 1.10) includes exposure pathways of ingestion, inhalation, dermal/contact, and direct radiation exposure from all abiotic and biotic media.

The Human Health Risk conceptual model shares many features with the Ecological Impacts conceptual model. Concentrations of contaminants in Columbia River water, groundwater, seep/spring water, soils, and sediments are the starting points. Irrigation is included from water sources to soils, which is a human-induced transport mechanism that results in the introduction of contaminated non-riparian agricultural soils. The process of irrigation also adds a process to the contamination of plants; that of foliar deposition and retention. A currently unmodeled exposure mechanism is the potential for future human disruption of the waste disposal systems, which would contaminate surface soils in the vicinity of the waste sites.

As a result of the accumulation processes in farm products that are parallel to those of the Ecological model, humans may be exposed to contaminants in physical media and food products. Farm animal products such as milk, meat, or eggs may be contaminated by input from feed and water sources. Another process that differentiates the human from the ecological exposures is that of the human food distribution systems. People ship crops around the country and pipe water from place to place. During this transfer, other processes that modify the contaminant concentrations occur, such as water purification and food preparation. Ultimately, people eat, drink, inhale or are otherwise exposed to the contaminants. As a result, individual health effects may occur. Relative exposures to these sources depend on individual

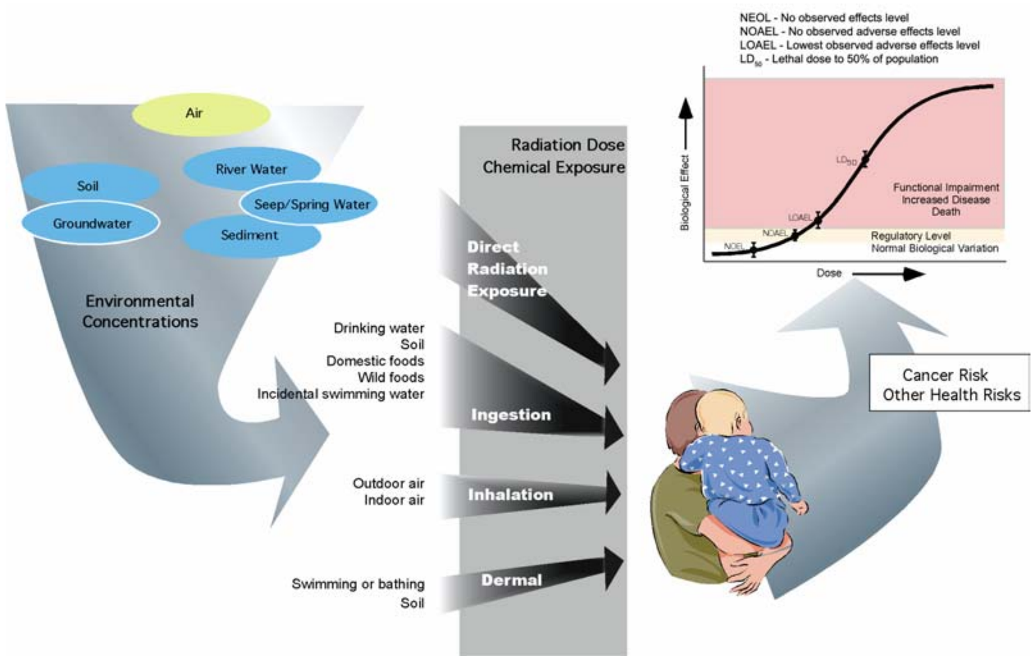

Figure 1.10. Conceptual Human Health Model

lifestyles or exposure scenarios. Exposure scenarios include those of a resident farmer using groundwater from upland areas or river sources, several Native American lifestyles, river recreational users, and Richland residents.

There may be interactions between chemicals, or between radiation dose and chemical intake, but the effects of radiation exposure and toxic chemical exposure are evaluated separately. Human health risks are evaluated and summed across exposures.

The human health model may be run multiple times to evaluate various individual Impact Scenarios. The Impact Scenarios are the combinations of exposure mode and duration that define specific time/location/pathway/activity combinations that have been requested by the analyst. The Human Risk module is designed to allow multiple evaluations of this nature, in order to answer the types of "what if" questions that often arise in discussions of risk.

Ecological Conceptual Model. The conceptual model for assessing ecological risk/impact has two parts: quantifying exposure to contaminants and translating exposure into effect. Organisms in the Hanford environment are or can be exposed in one or more habitats: within the Columbia River, in the riparian zone along the river, and in the upland habitat. Plants and animals in the Columbia River may be exposed to contaminants in surface water, sediment, or pore water (Figure 1.11). Contaminants enter these media by direct discharge (no longer occurring), through influx of contaminated groundwater to the river, or as background from upstream sources. A very small portion of the total contaminant influx has been and will be via atmospheric deposition; the bulk of the exposure arises from groundwater influx. Consequently, the primary zones of exposure in the river are associated with contaminant plumes entering from the 100 and 300 Areas, and the large, broad plumes from the 200 Areas that intercept the Columbia River from the Hanford town site to the northern end of the 300 Area.

As shown in the Figure 1.11, organisms using the Columbia River are primarily exposed in the zone where groundwater intercepts the river, i.e., the exposure is to pore water (mixed groundwater and river water) and sediments in chemical equilibrium with the pore water. Because of the large river flows relative to groundwater influx, concentrations reach background levels within a few centimeters of the river bottom at these influx areas.

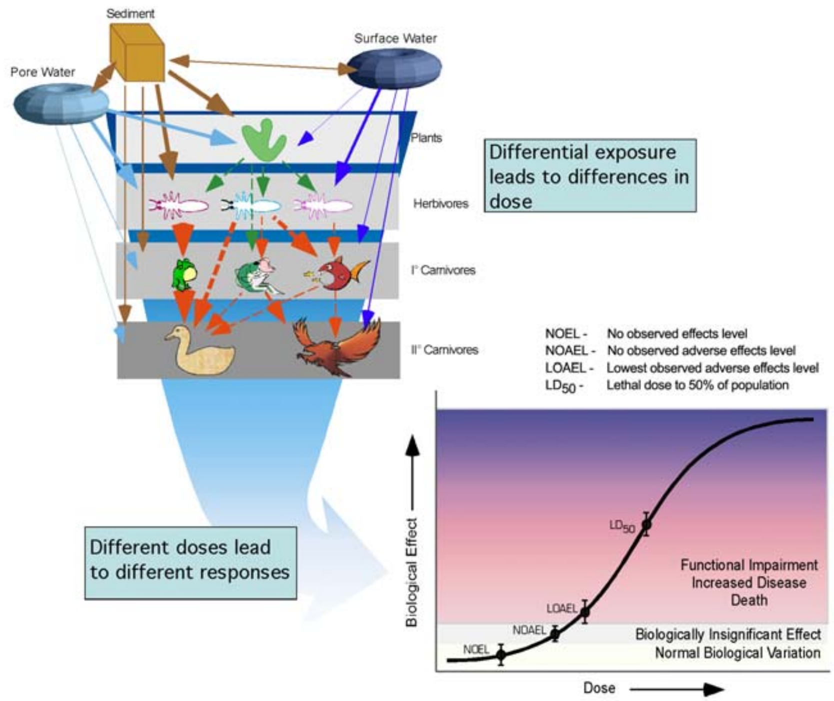

Figure 1.11. Ecological Conceptual Model

Once contaminants enter the biological environment, they may be transported through the food chain. For example, contaminants in groundwater may enter aquatic plants and accumulate in edible tissues. Herbivores (e.g., snails, carp) consume this plant material, along with any contaminants deposited on the plant surface as particulate matter. They may also ingest sediment directly (e.g., clams), and also consume river water that contain diluted contaminants. The tissues of herbivores will then reflect their accumulated exposure to contaminants. Omnivores and carnivores will thus consume prey that have integrated the various contaminants they have encountered through their lifetime. A conceptual food chain is shown in the figure above, which also indicates relative exposure of the various trophic components to sediment, pore water, and surface water.

Organisms in the riparian zone are exposed to contaminants either in the shallow groundwater (through animal burrowing or plant root penetration) or in the river and its associated sediments. Contaminants in soils may also be transported to leaves and stems through vapor or particulate deposition resulting from wind erosion or rainsplash. Terrestrial (i.e., air-respiring) animals may be exposed to contaminants via ingestion of contaminated food or water, dermal exposure to contaminated soil or water, and/or inhalation of airborne contaminants.

Finally, organisms in the upland areas may be exposed to contaminants in groundwater via deep-rooted plants, such as trees, asparagus, and sagebrush, whose roots penetrate as much as 15 meters (49 feet) below the ground surface. This pathway is only available where the groundwater is relatively shallow, i.e., along the Columbia River margins, at the southern portion of Gable Mountain, and at the Hanford town site area. Otherwise, groundwater is too deep to be accessed by plants.

Contaminant exposure may have one of three consequences depending on the duration and level of exposure: no effect, an adaptive response, or an adverse effect. No effects result when exposure levels are below the threshold of significant physiological response. At higher exposure levels, some contaminants may induce an adaptive response in the exposed organism. Adaptive responses include behavioral changes (e.g., avoiding some threshold of contaminants), biochemical/physiological changes (e.g., induction of enzymatic pathways to detoxify contaminants or repair deoxyribonucleic acid [DNA]), or structural changes (e.g., proliferation of metal exchange sites on gills). Adverse effects arise when the exposure exceeds the organism's capacity to deal adaptively with the chemical or radionuclide.

Radiological effects are a function of the energy deposited in the receiving biological tissues and the relative biological effectiveness of the radiation. Chemical effects arise from specific actions on the structural, genetic, and enzymatic components in the exposed organism. Effects of Hanford-derived contaminants include narcosis (e.g., carbon tetrachloride), neural toxicity (e.g., mercury), and enzymatic disruption (e.g., copper). In combination, contaminants effects may be independent, additive, synergistic, or suppressive. The conceptual model accounts for multiple contaminants by grouping those with similar modes of action and treating them as additive unless research data are available that suggest otherwise. For the purposes of screening analyses, de minimus levels are set by DOE's population-protection radiation exposure standards for ionizing radiation effects and by lowest observed effects levels obtained from regulatory agencies and the literature for chemical effects (Figure 1.11).

Effects on individuals can alter populations and communities if the effect is severe enough and includes a sufficient fraction of the population. Higher-order effects include such responses as decreased population sizes, decreased population growth rates, increased rates of tumors, or evolutionary (genetic) changes. The key consideration here is that higher order effects do not appear without effects occurring at the individual level of organization. Thus, toxic effects of contaminants on certain populations (e.g., benthic insect larvae) can affect other, less-exposed ecosystem components (such as juvenile salmon) through alterations in prey base or habitat. These indirect effects are evaluated as part of the approach to risk-based standards.

2.0 Regional Context Risk-Based End State Description

This chapter provides information on the physical features and land use for the region surrounding the Hanford Site. Maps (Figures 2.1a, 2.1b, 2.1c, 2.2a, and 2.2b) showing the current conditions and the RBES Vision conditions are included in each section.

2.1 Physical and Surface Interface

The Hanford Site lies within the semi-arid Pasco Basin of the Columbia Plateau in southeast Washington State. The Columbia Plateau is a broad plain situated between the Cascade Range to the west and the Rocky Mountains to the east. This plateau was formed by a thick sequence of Miocene-Age tholeiitic basalt flows, called the Columbia River Basalt Group, which emanated from fissures in north central and northeastern Oregon, eastern Washington, and western Idaho (Swanson et al. 1979). In the central and western sections of the Columbia Plateau, where the Hanford Site is located, the Columbia River Basalt Group is underlain by continental sedimentary rocks from earlier in the Tertiary Period.

Four major geologic processes, occurring over millions of years, formed the soil, rocks, and geologic features of the area. The area was flooded with numerous basaltic lava flows between 17 and 6 million years ago, followed by tectonic forces that folded the basalt. In this landscape, the ancestral Columbia River meandered across the area leaving behind layers of sediment called the Ringold Formation. About 12,000 years ago the area was inundated by a series of Ice Age floods (including the Missoula Floods), which deposited more sediment in what is referred to informally as the Hanford formation. Major man made and natural features of the region for the current and Risk Based End State Vision are shown on Figures 2.1a and 2.1b. Few changes are expected with the exception of the footprint of the Hanford Site.

Hanford is a dry area, known for its sandy soil, basalt ridges, and shrub-steppe vegetation. Precipitation in the area averages less than 15.8 centimeters (6.2 inches) per year. Surface water enters the Pasco Basin from several other basins that include the Yakima River Basin, Horse Heaven Basin, Walla Walla River Basin, Palouse/Snake Basin, and the Big Bend Basin. The major rivers in the area are the Columbia, Snake, Yakima, and Walla Walla Rivers. Figure 2.1c shows the major drainage basins in the region contributing to the Columbia River.

2.2 Human and Ecological Land Use

Historically, Tribal Nations used the Columbia River extensively for fishing, hunting, gathering, and pasturing of livestock. By the turn of the century, settlers had moved into the region and developed irrigated farms. Grand Coulee Dam was built on the Columbia River in the 1940s, and the Columbia Irrigation Project brought more water for farming and the population increased in Franklin County, across the Columbia River from Hanford.

Currently, land use within the vicinity of the Hanford Site includes urban and industrial development, wildlife protection areas, recreation, irrigated and dryland farming, and grazing. According to the 1992 Census of Agriculture, Benton, Franklin, and Grant counties had a total of 9,586 square kilometers (3,745 square miles) of land in farms, of which 6,670 square kilometers (2,606 square miles) were in cropland. Approximately 46% of cropland was irrigated in 1992, and ~40% of cropland in 1992 was used as pastureland. According to the 1992 census, the total market value of agricultural products in the three counties was $935 million, including $758 million for crops and $177 million for livestock. In 1994, wheat represented the largest single crop (in terms of area) planted in Benton and Franklin counties. The total area planted in the two counties was 975 square kilometers (376 square miles) and 120 square kilometers (46.4 square miles) for winter and spring wheat, respectively. Other major crops such as alfalfa, apples, asparagus, cherries, corn, grapes, and potatoes are also produced in Benton and Franklin counties. In 1994, the Conservation Reserve Program of the U.S. Department of Agriculture (USDA)[1] included 102.8 square kilometers (39.7 square miles) in Benton County, 93.6 square kilometers (36.1 square miles) in Franklin County, and 101.1 square kilometers (39 square miles) in Grant County.[2]

In 1992, the Columbia Basin Project, a major irrigation project north of the Tri-Cities, produced gross crop returns of $552 million, representing 12.5% of all crops grown in Washington State. Also, in that year, 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%).

Land use in the region surrounding the Hanford Site is not expected to change drastically during the upcoming decades. It is assumed that the region will continue to be dedicated to agricultural and that populations may increase mainly around the current urban areas. Current and Risk Based End State Vision regional human and ecological land use are shown in Figures 2.2a and b.

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1 Agricultural lands at risk for soil erosion set aside to enhance wildlife.

2 Personal communication with R Hamilton, Conservation Program Specialist with the U.S. Department of Agriculture, Farm Service Agency, in Spokane, Washington, October 1997.

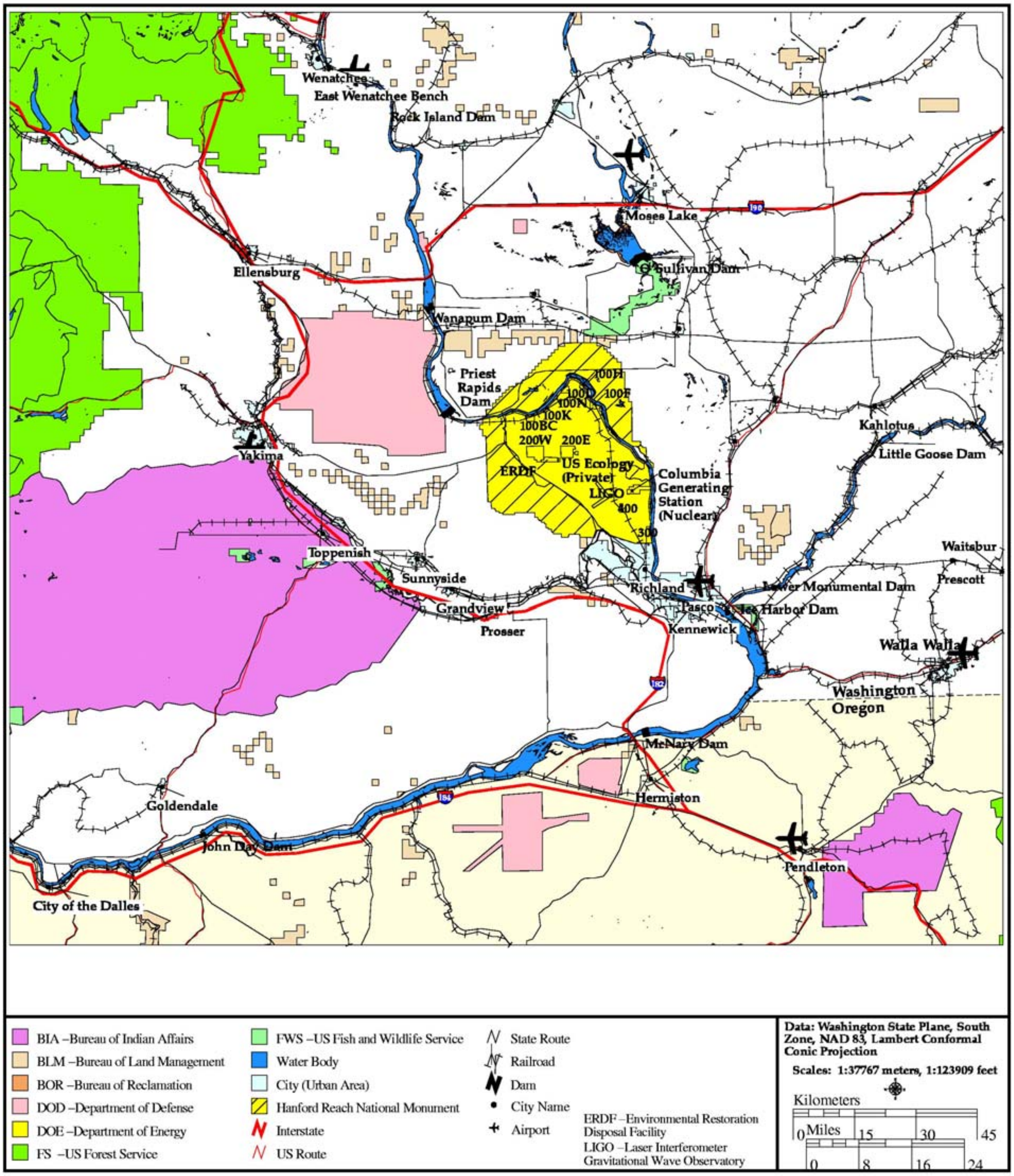

Figure 2.1a. Regional Physical and Surface Interface – Current State

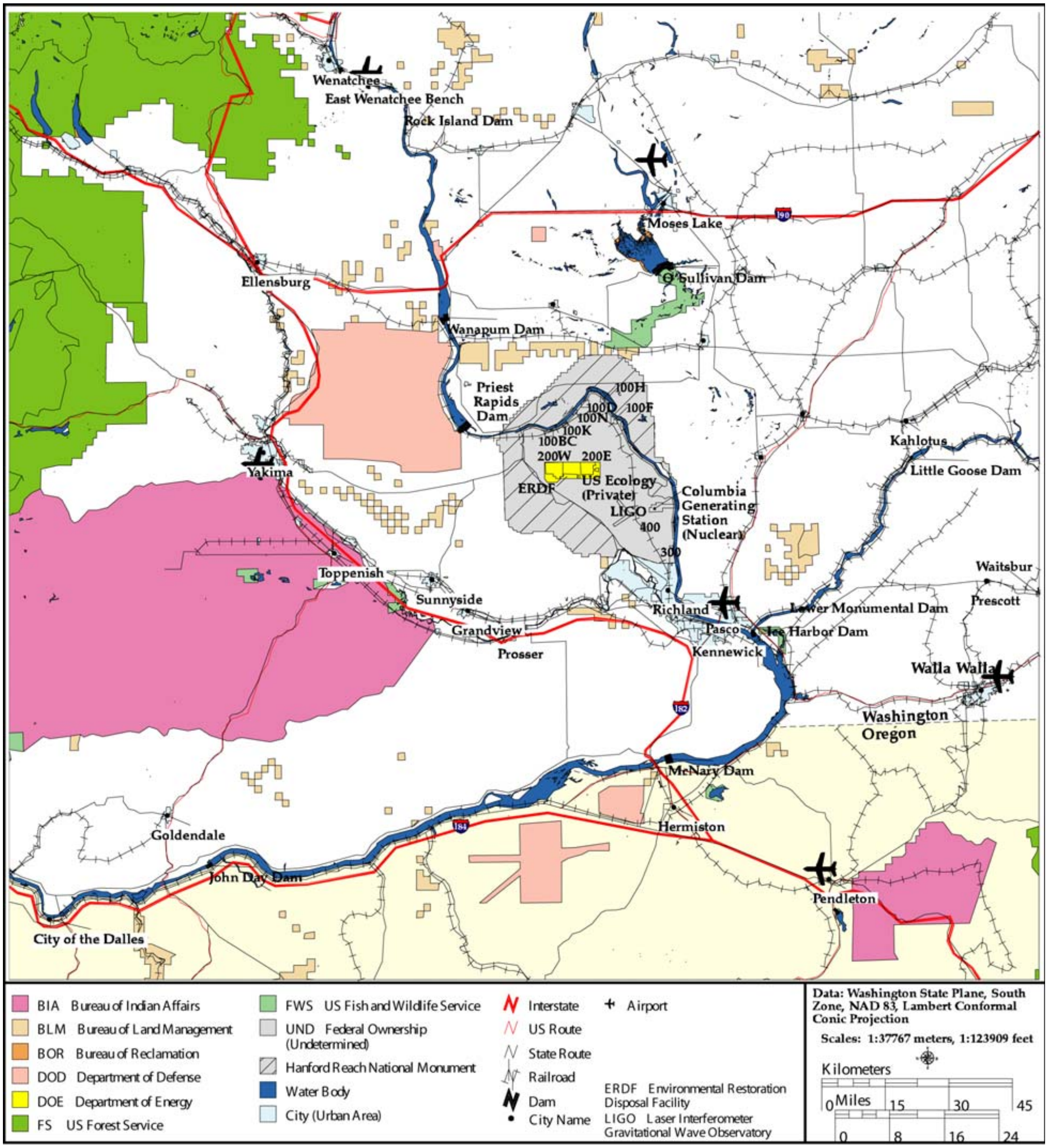

Figure 2.1b. Regional Physical and Surface Interface – RBES Vision

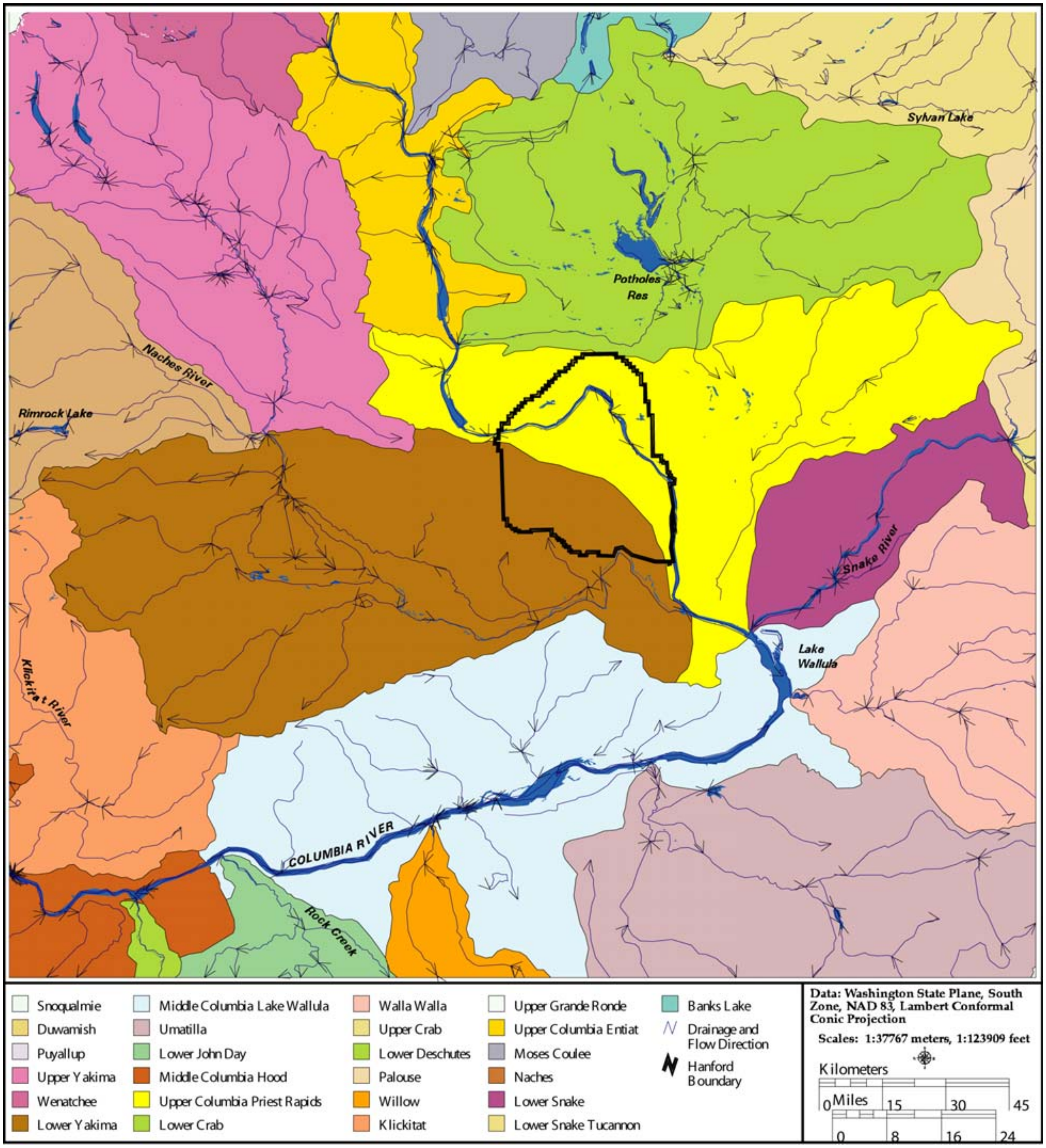

Figure 2.1c. Columbia River Watershed

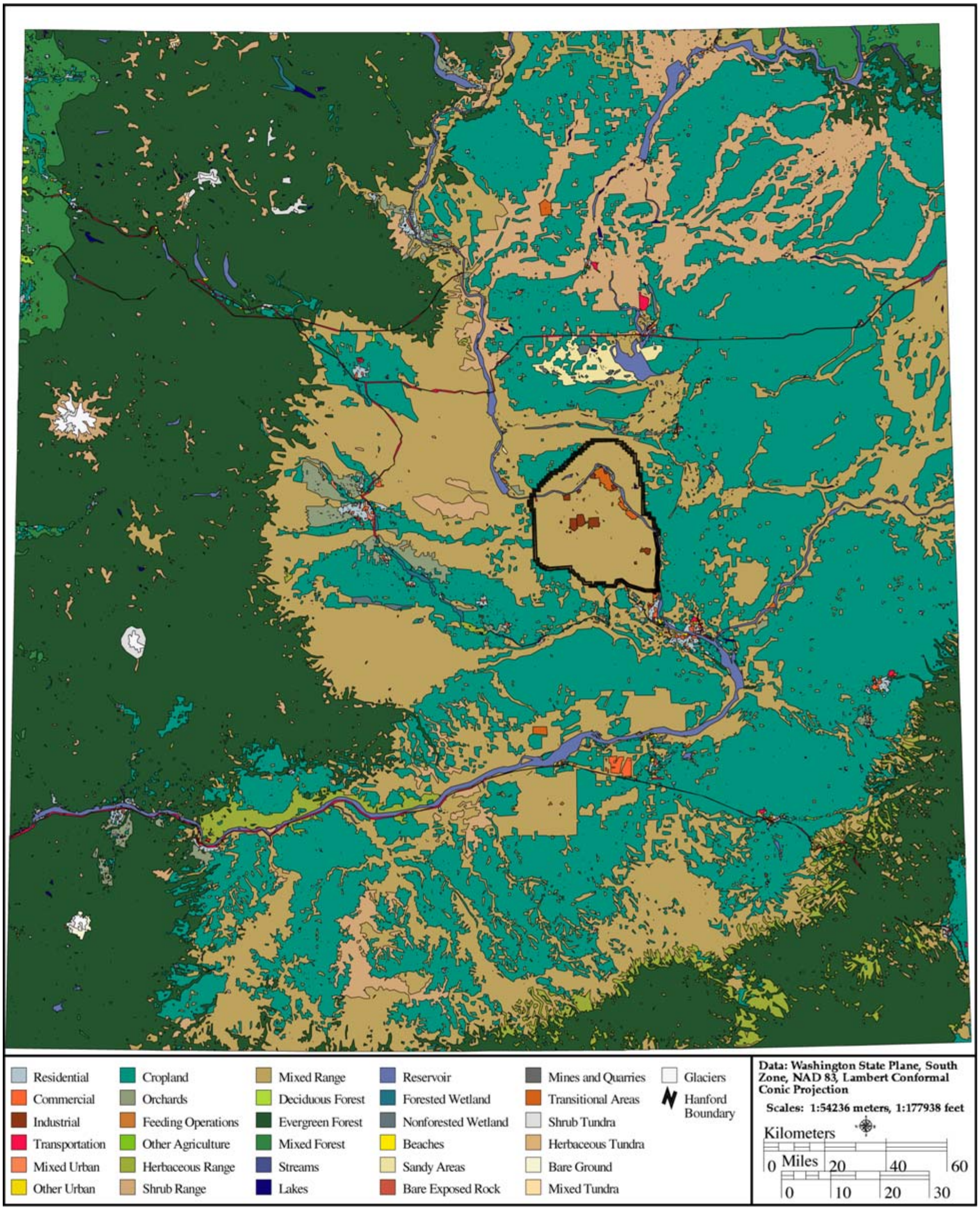

Figure 2.2a. Regional Human and Ecological Land Use – Current State

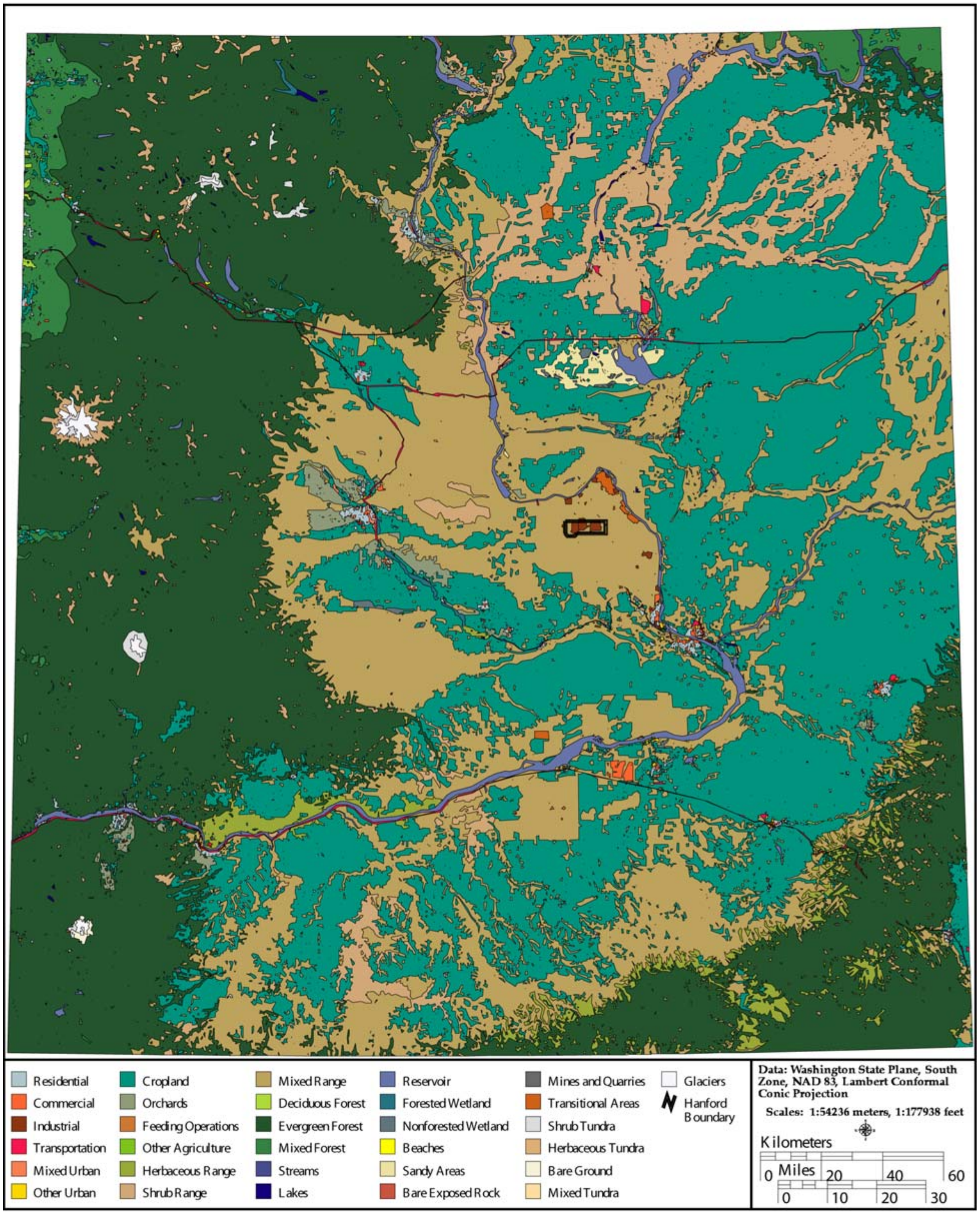

Figure 2.2b. Regional Human and Ecological Land Use – RBES Vision

3.0 Site-Specific Risk-Based End State Description

This section describes the end state of the Hanford Site in terms of physical and surface interfaces, human and ecological land use, legal ownership, and demographics. The information is based on DOE's selected alternative from the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE 1999a). DOE's selected alternative anticipates multiple uses of the Hanford Site, including anticipated future DOE missions, non-DOE federal missions, and other public and private-sector land uses. DOE's selected alternative includes the following elements:

- *Cleanup Mission* – consolidate waste management operations on 50.1 square kilometers (20 square miles) in the Central Plateau of the Hanford Site
- *Economic Development Mission* – allow industrial development in the eastern and southern portions of Hanford and increase recreational access to the Columbia River
- *Natural Resource Trustee Mission* – expand the existing Saddle Mountain National Wildlife Refuge to include all of the Wahluke Slope, consistent with the 1994 Hanford Reach environmental impact statement (DOI 1994) and 1996 Hanford Reach record of decision (DOI 1996); place the ALE Reserve under U.S. Fish and Wildlife Service management by permit so it may be included in the overlay wildlife refuge.

Based on the extensive public comments received, the following changes were also included in the selected alternative:

- All conservation (mining and grazing) was changed to conservation (mining).
- The National Wildlife Refuge designation was extended to include the ALE Reserve, the Riverlands, and McGee Ranch; and all river islands not in Benton County. The selected alternative clarifies that the refuge will be an overlay wildlife refuge, and that DOE retains the right to mine a portion of ALE for cover materials.
- A railroad right-of-way through the Riverlands portion of the proposed Refuge was given status as a preexisting condition and was included in the U.S. Fish and Wildlife Service permit to manage the Refuge.
- The White Bluffs town site was added to the selected alternative map as low-intensity recreation to serve as the White Bluffs Memorial.
- The low-intensity recreation comfort stations along the river, which could eventually serve as anchor points for a river trail from Richland to the Vernita Bridge, were moved to ensure that they have both river and road access.
- A high-intensity recreation triangle was added to the selected alternative map near Horn Rapids Park on the Yakima River.

3.1 Physical and Surface Interface

The Hanford Site lies within the semi-arid Pasco Basin of the Columbia Plateau in southeastern Washington State. The site occupies an area of ~1,517 square kilometers (~586 square miles) north of the confluence of the Yakima River with the Columbia River. Within the geographic boundary of the site, there are 36.42 square kilometers (14.1 square miles) of Columbia River surface water, and one section (2.6 square kilometers [1 square mile]) of land owned by the state of Washington.

The Hanford Site is about 50 kilometers (30 miles) north to south and 40 kilometers (24 miles) east to west. The Columbia River flows through the northern part of the site and, turning south, forms part of the 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, and the Saddle Mountains form the Site's northern boundary. Two small east-west ridges, Gable Butte and Gable Mountain, rise above the plateau of the central part of the site. Adjoining lands to the west, north, and east are principally agricultural and range land. The cities of Richland, Kennewick, and Pasco (also referred to as the Tri-Cities) constitute the nearest population center and are located immediately south-east of the Hanford Site. A description of the Hanford Site can be found in the annual environmental report (Poston et al. 2003). Details about Hanford Site groundwater can be found in the annual monitoring report (Hartman et al. 2003).

Figure 3.1a shows the current physical and surface interface on the Hanford Site. Figure 3.1b shows the RBES vision for the site.

As discussed in Section 2.1, the Hanford Site lies in the Columbia Plateau. This plateau was formed by a thick sequence of Micene-Age tholeiitic basalt flows called the Columbia River Basalt Group. In addition to the Columbia River Basalt Group, stratigraphic units underlying the Hanford Site include, in ascending order:

- **Ringold Formation** – a heterogeneous mix of variably cemented and compacted gravel, sand, silt, and clay deposited by the ancestral Columbia and Snake Rivers. The system that deposited the sediment was a braided stream channel with the two rivers joining in the area of the present White Bluffs.

- **Plio-Pleistocene unit and Early Palouse soil** – a sequence of sidestream alluvial deposits and buried soil horizons with significant caliche in some areas. The unit overlies the Ringold Formation and is found only in the western part of the Hanford Site.

- **Hanford Formation and Pre-Missoula gravels** – a series of coarse-grained sediments, ranging from sand to cobble and boulder size gravel deposited from a series of cataclysmic floods during the Pleistocene Age. The floods occurred when ice dams broke, releasing water from Lake Missoula, a large glacial lake that formed in the Clark Fork River Valley. Pre-Missoula (flood) gravels underlie the Hanford formation gravel deposits in the central part of the Hanford Site. The pre-Missoula deposits are difficult to distinguish from the Hanford gravels, so they are usually grouped together.

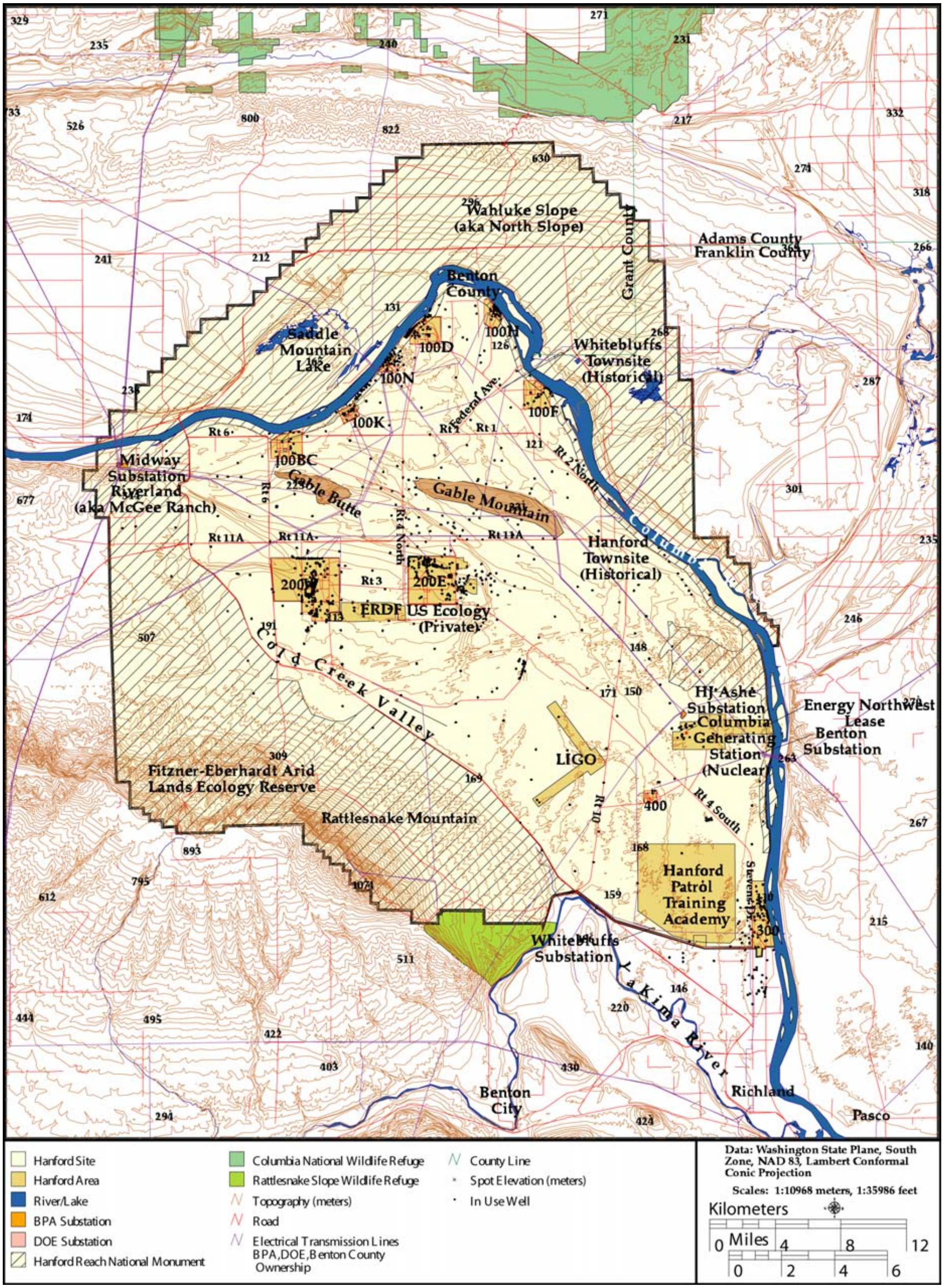

Figure 3.1a. Site Physical and Surface Interface – Current State

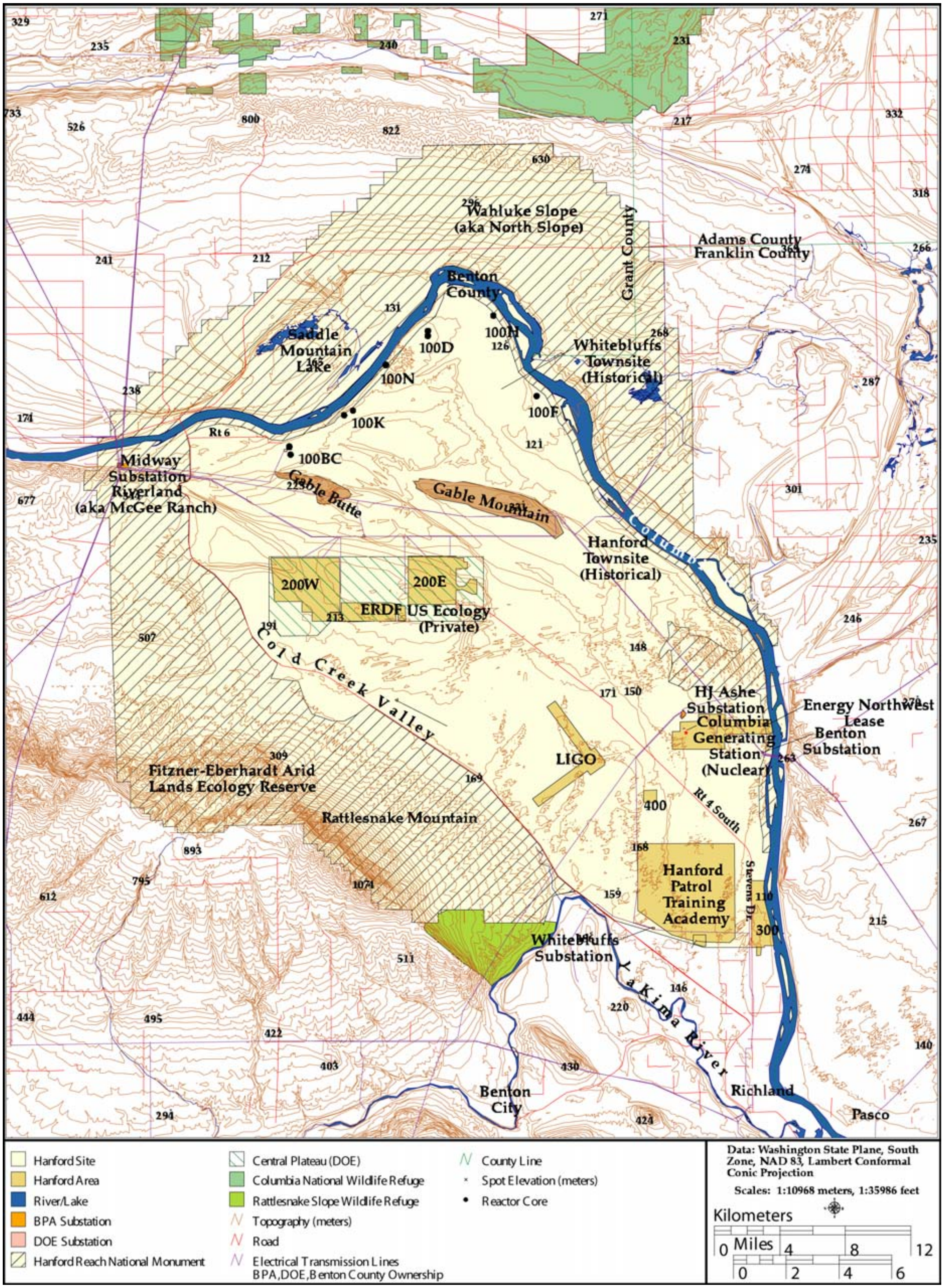

Figure 3.1b Site Physical and Surface Interface – RBES Vision

- **Holocene surficial deposits** – a discontinuous veneer of alluvium, colluvium, and/or eolian sediment. In the 200 West Area and southern part of the 200 East Area, these deposits consist dominantly of laterally discontinuous sheets of wind-blown silt and fine-grained sand. They are generally found above the water table.

Groundwater within these sediments is present under both unconfined and confined aquifer conditions. The unconfined aquifer is contained in the unconsolidated to semiconsolidated Ringold and Hanford formations that overlie the basalt bedrock. In some areas, low permeability mud layers within the Ringold formation form aquitards that create locally confined hydraulic conditions within the aquifer system.

The water table lies within the Hanford formation over most of the eastern and northern parts of the Hanford Site (Figure 3.1c). The Hanford formation lies entirely above the water table in the western part of the site and in some other localized areas. Within these areas, the water table is generally found in hydrogeologic units associated with the Ringold Formation. Also shown in Figure 3.1c are areas on the Hanford Site where the surface basalt bedrock features crops out above the water table in the vicinity of Gable Butte and Gable Mountain. Another basalt bedrock feature associated with the a subsurface extension of the Yakima Ridge found to be above the water table is also shown in the southwest part of the Hanford Site.

Figure 3.1d shows a geologic cross section of the Hanford Site and the location of the water table between Cold Creek Valley and the Columbia River. This cross section represents A-A' on the map in Figure 3.1c and shows that the saturated sediment of the Hanford formation represents a small portion of the total saturated sediments above basalt when compared to the total saturated thickness of the Ringold Formation.

The major stratigraphic and the corresponding hydrogeologic units contained within the Hanford and Ringold formations, provided in Figure 3.1e, show key differences in sediment characteristics among the major units. The geologic column on the right defines the lithostratigraphic units, based on mapping and physical properties of the sediment, modified from Lindsey (1995). The hydrogeologic column on the left defines hydrostratigraphic units based on hydraulic properties (Thorne et al. 1993).

A sequence of basalt-confined aquifers is present within the Columbia River Basalt Group beneath the Hanford Site. These aquifers are composed of sedimentary interbeds and the relatively permeable tops of basalt flows. The dense interior sections of the basalt flows form confining layers. The most recent basalt flow underlying the Hanford Site is the Elephant Mountain Member of the Saddle Mountains Basalt. However, the younger Ice Harbor Member is found in the southern part of the site (DOE 1988). The Rattlesnake Ridge interbed is the uppermost laterally extensive hydrogeologic unit of these sedimentary interbeds and this unit represents the uppermost confined aquifer unit.

The local unconfined aquifer flow system is bounded by Yakima River and basalt ridges on the south and west and by the Columbia River on the north and east. The Columbia River represents a point of regional discharge for the unconfined aquifer system. Groundwater in the unconfined aquifer generally flows from upland areas in the west and southwest parts of the Hanford Site either north through the gap between Gable Butte and Gable Mountain or east toward the Columbia River where it eventually discharges into the Columbia River. Groundwater in the basalt-confined aquifers also generally flows

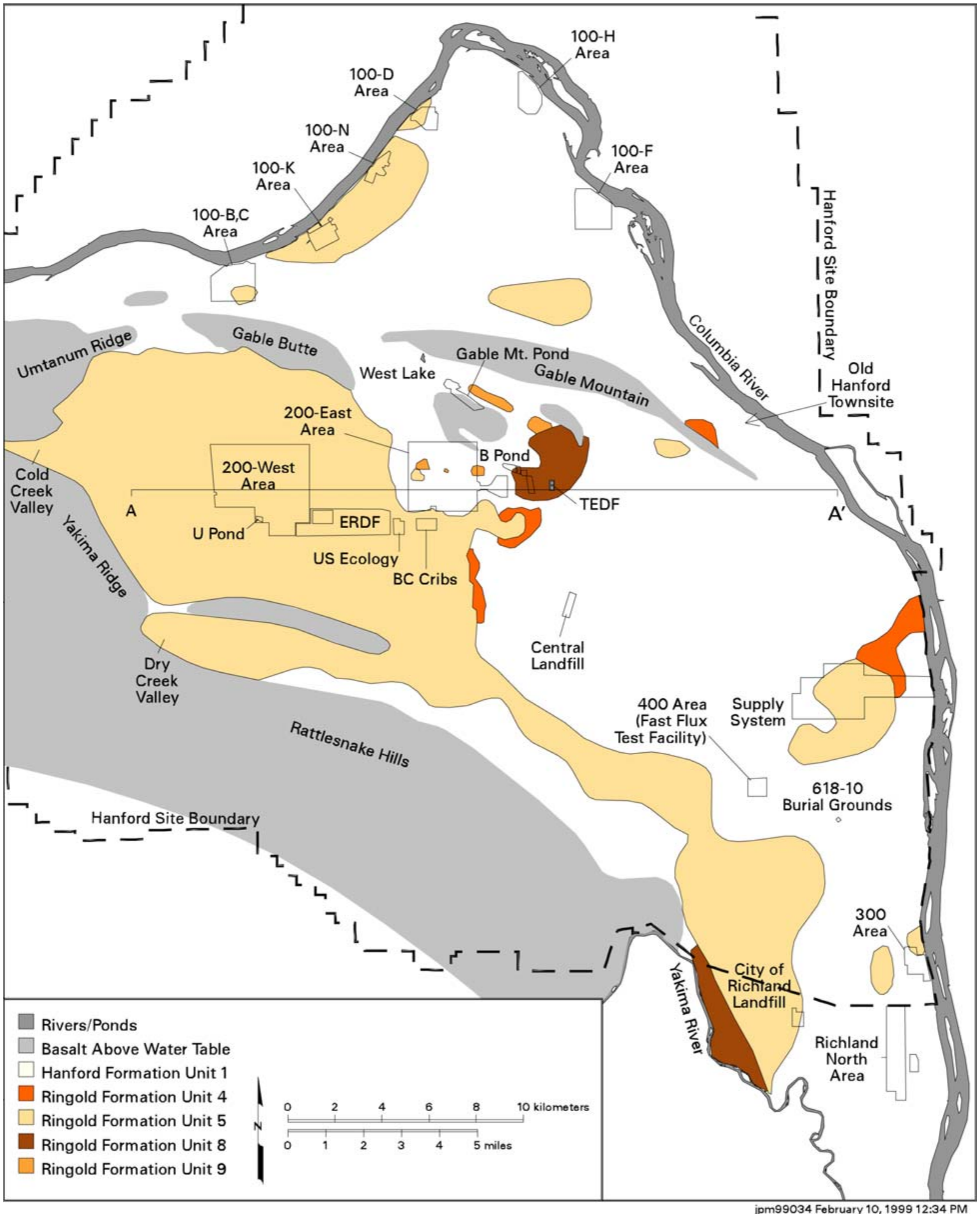

Figure 3.1c. Major Hydrogeologic Units at the Water Table in March 1999

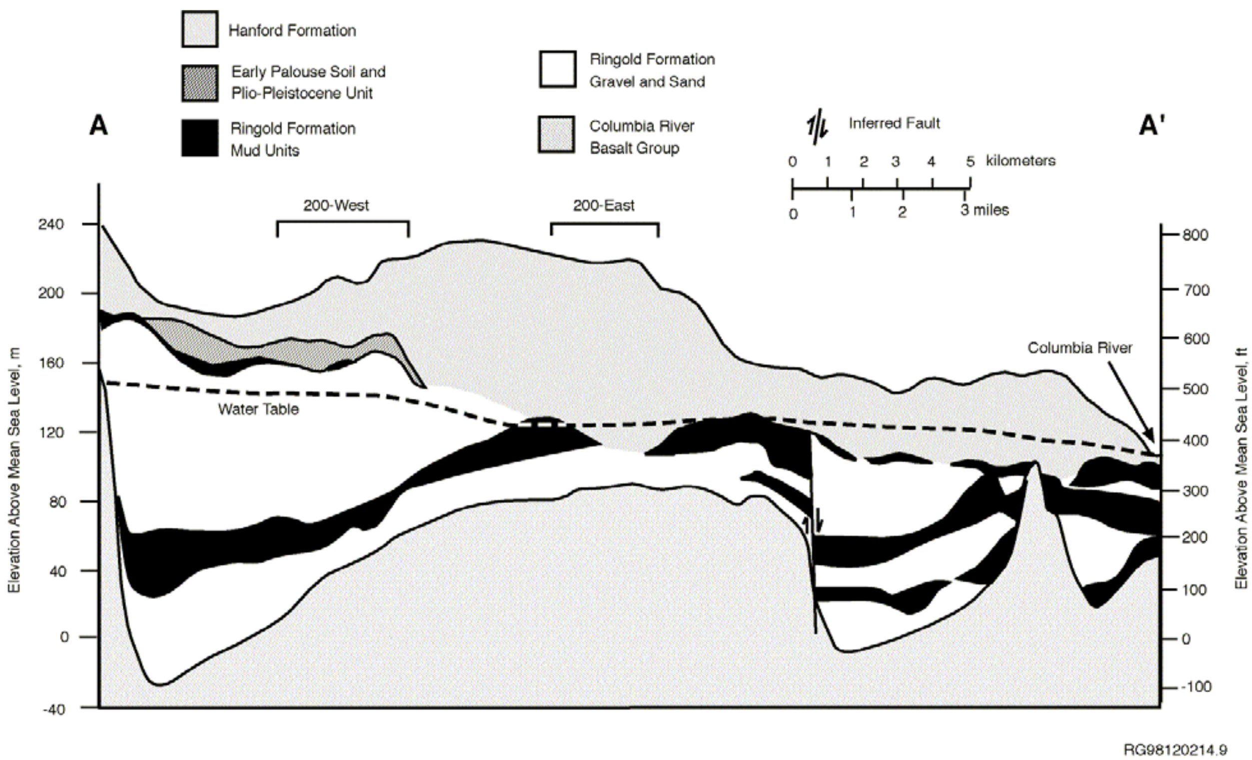

Figure 3.1d. West-East Cross Section Showing Major Hydrogeologic Units at the Hanford Site and the Water Table in 1999

from elevated regions at the edge of the Pasco Basin toward the Columbia River (Spane and Webber 1995). However, the discharge zone locations are also influenced by geologic structures that increase the vertical permeability of the confining basalt layers.

The amount of groundwater within the unconfined and confined aquifers discharging to the Columbia River and the lower reaches of the Yakima River is a function of the local hydraulic gradient between the groundwater elevation adjacent to the river and the river stage elevation. This hydraulic gradient is highly variable because the river stage is affected by releases from upstream dams. Estimates made using the site-wide model indicate that groundwater discharging to the Columbia River from the Hanford side of the river would be less than one-tenth of one percent of the average annual flow in the river of about 2,832 cubic meters (100,000 cubic feet) per second.

Existing plumes of tritium and iodine-129 migrating east from 200 East Area discharge into the Columbia River near the Hanford town site. Plumes of tritium and technetium-99 also migrating north through the gap between Gable Mountain and Gable Butte have reached the river in the 100-B/C Area. Plumes of various constituents also discharge into the river in vicinity in all of the 100 Areas and the 300 Area.

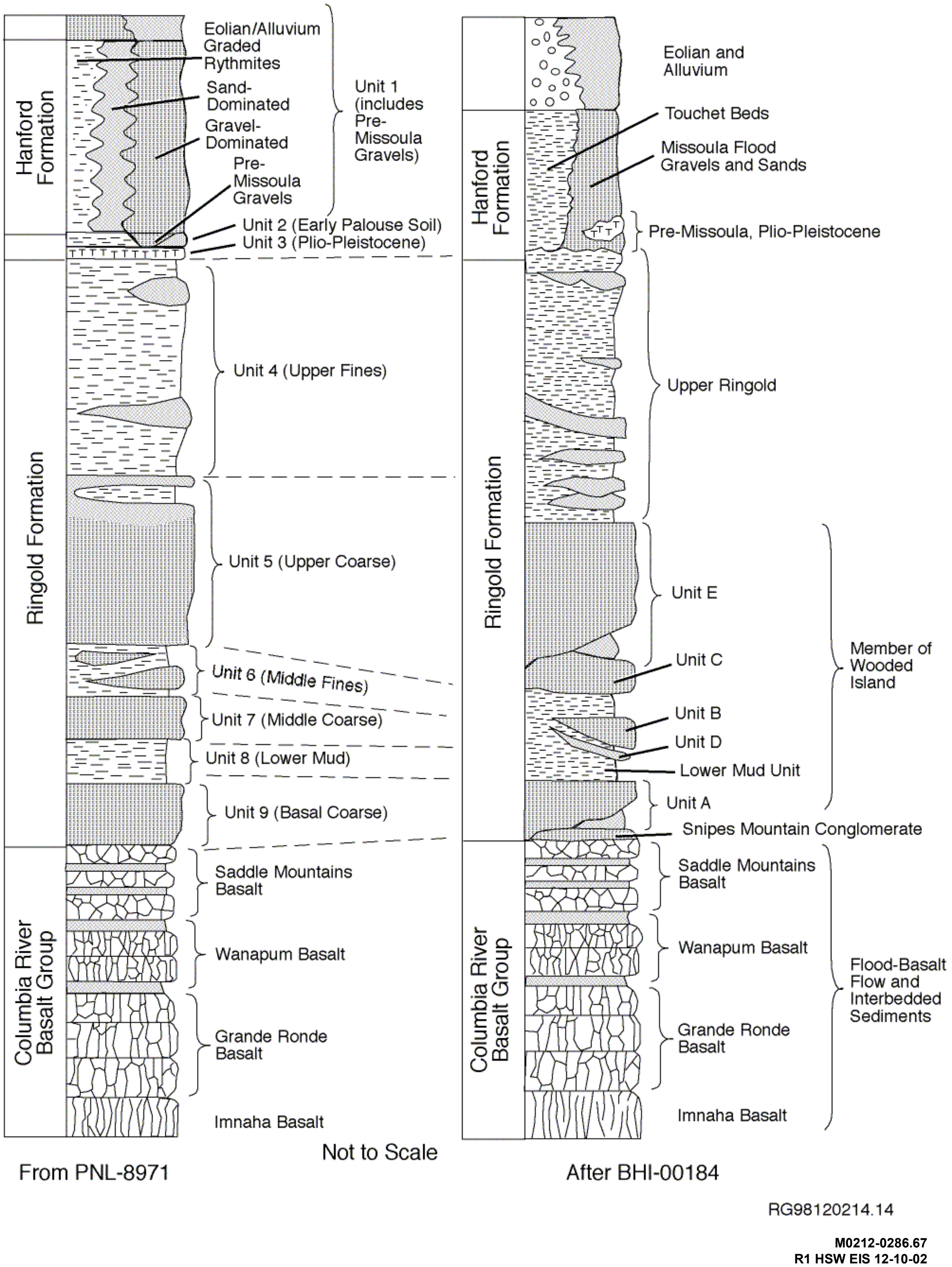

Figure 3.1e. Comparison of Generalized Hydrogeologic and Geologic Stratigraphy (from Thorne et al. 1993 and after Lindsey 1995)

Recharge to the unconfined aquifer system occurs from several sources including

- infiltration of precipitation falling across the Hanford Site.
- infiltration of runoff from elevated regions along the western and southwest boundary of the Hanford Site
- infiltration of spring water and upwelling of groundwater that originates from the basalt-confined aquifer system
- artificial recharge in vicinity of onsite wastewater facilities, offsite irrigation, and nearby municipal city of Richland water supply systems.

Recharge from infiltration of precipitation is highly variable, both spatially and temporally, and ranges from near zero to greater than 100 millimeters per year, depending on climate, vegetation, and soil texture (Gee et al. 1992; Fayer and Walters 1995). Recharge from precipitation is highest in coarse-textured soil with little or no vegetation, which is the case for most of the industrial areas on the Hanford Site. A recharge distribution applied in the site-wide model, described in Cole et al. (1997, 2001) and shown in Figure 3.1f, is based on distributions of soil and vegetation types.

The majority of runoff from elevated regions along the western and southwest boundary of the Hanford Site infiltrate into the unconfined aquifer system within Cold Creek and Dry Creek Valleys and along the base of Rattlesnake Hills along the west and southwest boundaries of the Hanford Site.

The aquifer also receives recharge from upper reaches of the Yakima River where the stage is above the regional water table.

Intercommunication between the unconfined aquifer and the uppermost basalt-confined aquifer occurs from several leakage processes. The major sources of leakage include

- areally distributed leakage through the uppermost basalt confining layer (that is, the Elephant Mountain Member of the Saddle Mountains Basalt
- leakage at an erosional windows through the uppermost confining unit near Gable Mountain/Gable Butte and near B Pond
- leakage along two thrust fault zones north of Gable Mountain and Gable Butte and north of the Yakima Ridge.

Since the start of Hanford Site operations in the mid-1940s, the unconfined aquifer system has also been significantly impacted by artificial recharge from onsite wastewater disposal facilities has been several times greater than the estimated recharge from natural sources. This caused an increase in the water-table elevation over most of the Hanford Site and the formation of groundwater mounds beneath major wastewater disposal facilities. The regional rise in water table was at its highest historical levels in the early to mid-1980s when the mounds in 200 East and 200 West Areas were about 10 and 22 meters (33 and 66 feet) higher than estimated pre-Hanford water-table conditions, respectively.

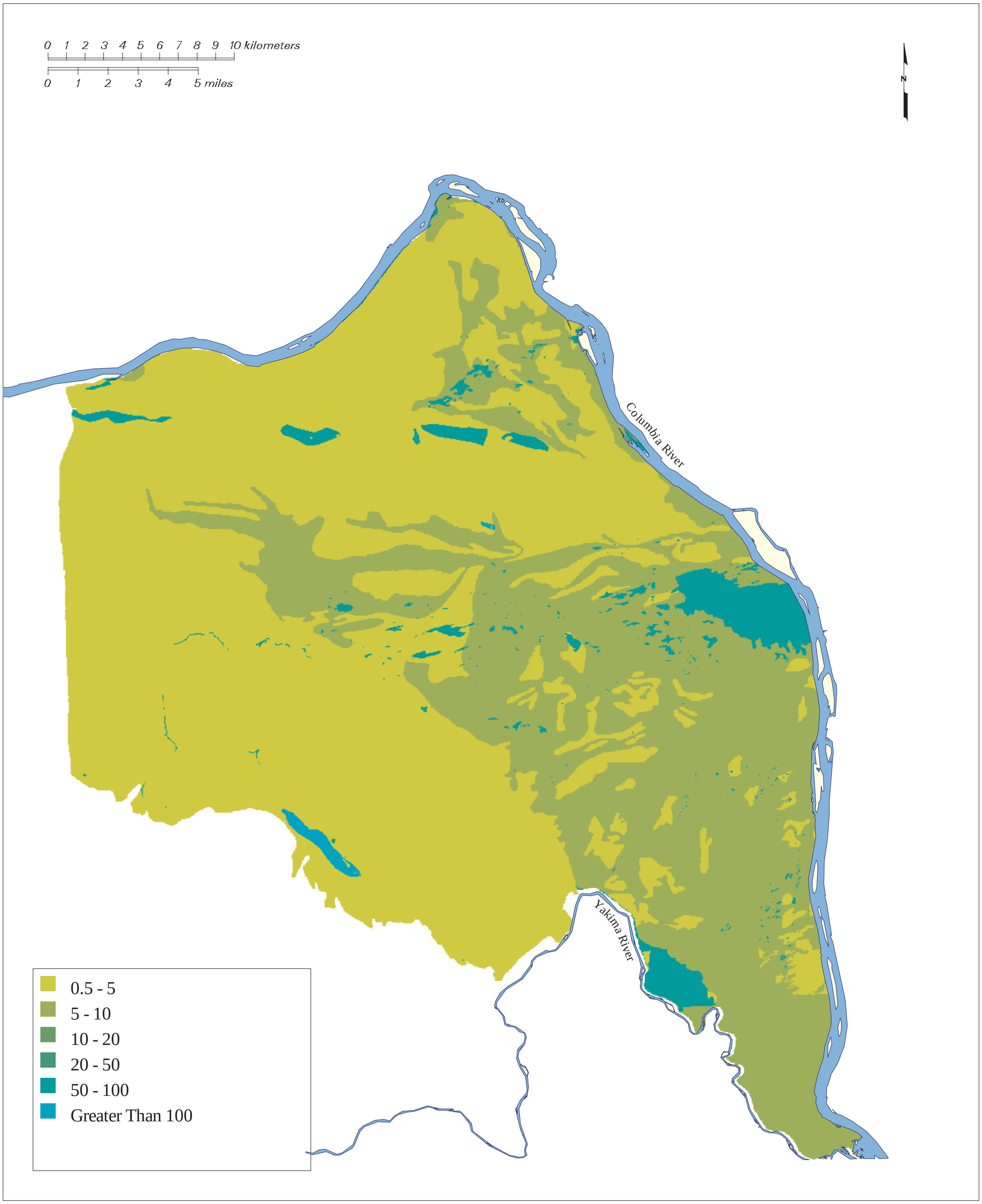

Figure 3.1f. Estimates (in millimeters) of Recharge for 1979 Conditions (Fayer and Walters 1995)

Beginning in 1988, production activities on the Hanford Site closed, which resulted in a decrease of wastewater disposal and subsequent decreases in water-table elevation over much of the site. Remnants of the groundwater mounds that formed during the historical periods of highest wastewater discharge are still evident in vicinity of major discharge facilities near the 200 East and 200 West Areas.

The unconfined aquifer system has also been impacted locally by other sources of artificial recharge as a result of irrigation in the upper Cold Creek Valley in the western part of the site, in agricultural areas south of the Hanford Site, and in the vicinity of the recharge basin/withdrawal well system used by the city of Richland for municipal water supply.

These past and current hydraulic impacts on the unconfined aquifer system are predicted to subside in the future and the aquifer system is expected return to more natural flow conditions over the next 300 to 400 hundred years. Previous modeling analysis by Cole et al. (1997) suggest that as water levels drop in the vicinity of central areas in the Hanford Site where the surface basalt features associated with Gable Butte and Gable Mountain crop out above the water table, the saturated thickness of the unconfined aquifer will decrease and the aquifer may actually dry out in certain areas. This thinning/drying of the aquifer is predicted to occur in the area just north of the 200 East Area between Gable Butte and the outcrop south of Gable Mountain, and a potential exists for this northern area of the unconfined aquifer to become hydrologically separated from the area south of Gable Mountain and Gable Butte.

3.2 Human and Ecological Land Use

Land uses at the Hanford Site have changed dramatically over the past 100 years. By the turn of the century, settlers had moved into the area, developing irrigated farmland and practicing extensive grazing. In 1943, the federal government acquired the Hanford Site for production of nuclear materials to be used in development of the atomic bomb.

3.2.1 Land Use Adjoining the Hanford Site

Land use adjoining the Hanford Site includes a low-level radioactive waste decontamination, super-compaction, plasma gasification and vitrification unit (operated by Pacific EcoSolutions) and a commercial nuclear fuel fabrication facility (operated by Framatome ANP).

3.2.2 Hanford Site Land Use

Land-use categories at the Hanford Site include reactor operations, waste operations, administrative support, operations support, sensitive areas, and undeveloped areas (Figure 3.2a). Remedial activities are currently focused within or near the disturbed areas. Much of the Hanford Site is undeveloped, providing a safety and security buffer for the smaller areas used for operations. Public access to most facility areas is restricted.

In 2000, the Hanford National Monument Proclamation became the dominant reservation for many of the Wahluke Slope, Columbia River Corridor, McGee/Riverlands, and ALE lands. These laws are still being managed by DOE and its permittees under agreements that follow. DOE is in the process of transitioning the administrative ownership and prime management of monument lands to the U.S. Fish and Wildlife Service.

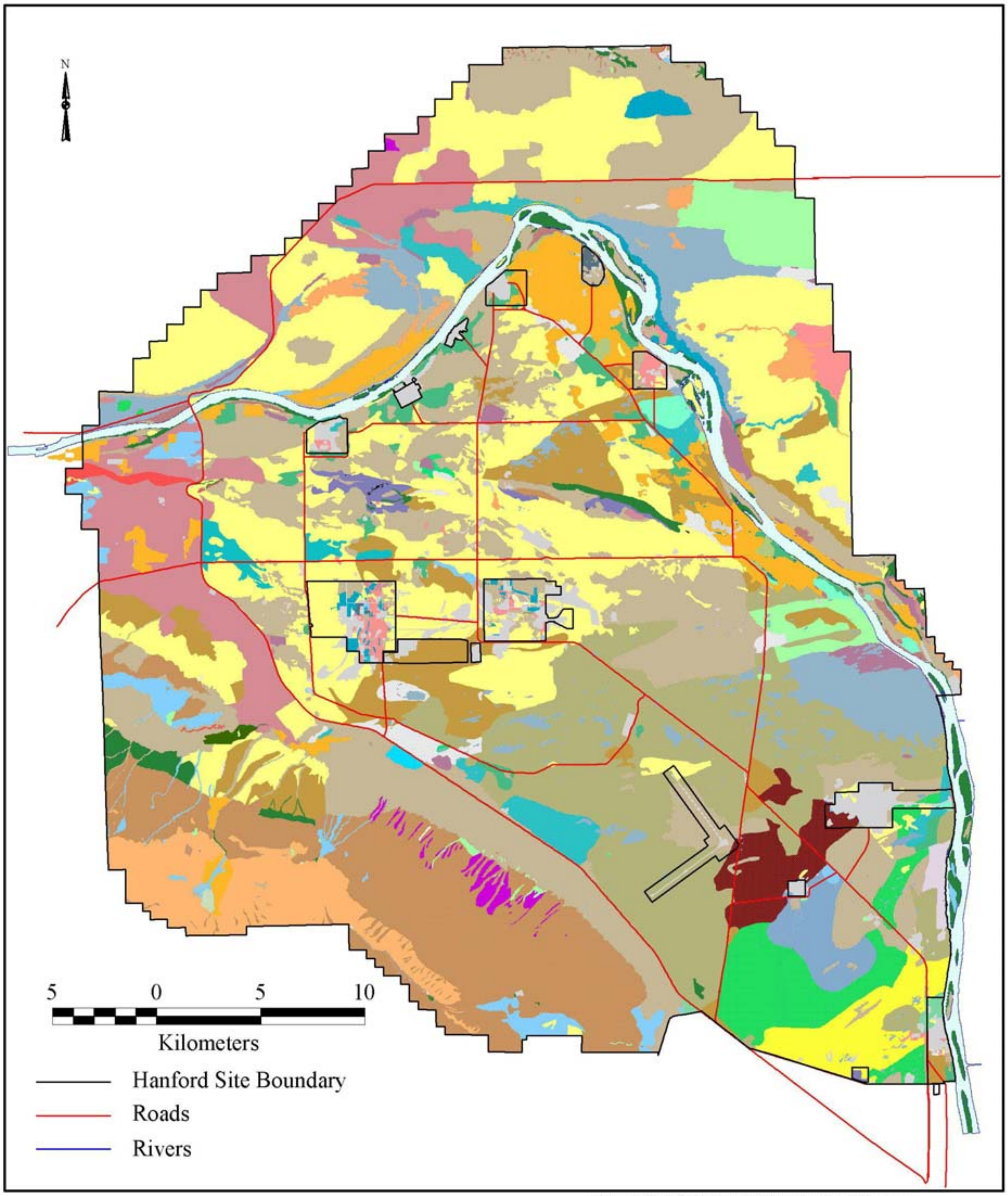

Figure 3.2a. Site Human and Ecological Land Use – Current State Distribution of Vegetation Types and Land Use Areas on the Hanford Site Prior to the *24 Command Fire* of 2000 (Neitzel 2002a). Legend on following page.

Figure 3.2a. (contd) Legend for Figure 3.2a

Wahluke Slope. The area north of the Columbia River encompasses ~357 square kilometers (~138 square miles) of relatively undisturbed or recovering shrub-steppe habitat. The northwest portion of the area is managed by the U.S. Fish and Wildlife Service under a permit issued by DOE in 1971 as the Saddle Mountain National Wildlife Refuge. The permit conditions require that the refuge remain closed to the public as a protective perimeter surrounding Hanford operations. The closure has benefited migratory birds, such as curlews, loggerhead shrikes, and waterfowl.

Until recently, in the northeast portion of the Wahluke Slope, the Washington Department of Fish and Wildlife operated the Wahluke State Wildlife Recreation Area, which was established in 1971. In April 1999, the Washington Department of Fish and Wildlife and the U.S. Fish and Wildlife Service notified DOE of their intent to modify their management responsibilities on the Wahluke Slope under the 1971 agreement, leaving only a small portion (~324 hectares [~800 acres]) northwest of the Vernita Bridge under Washington Department of Fish and Wildlife permit. The U.S. Fish and Wildlife Service informed DOE that it intends to allow essentially the same uses permitted by the state of Washington under the Washington Department of Fish and Wildlife's management of the Wahluke Slope. Therefore, transfer of management of the Wahluke Slope from the Washington Department of Fish and Wildlife to the U.S. Fish and Wildlife Service involves only a change in the agency managing the property and does not involve any change in the management activities for the Wahluke Slope. Management of the entire Wahluke Slope by the U.S. Fish and Wildlife Service as an overlay wildlife refuge is consistent with the 1996 U.S. Department of Interior (DOI) record of decision for the Hanford Reach environmental impact statement (DOI 1996). The record of decision recommended the Wahluke Slope be designated a wildlife refuge and the Hanford Reach a Wild and Scenic River, and that the wildlife refuge be managed by the U.S. Fish and Wildlife Service.

The Washington Department of Fish and Wildlife had leased a total of ~43 hectares (~107 acres) of the Wahluke State Wildlife Recreation Area for sharecropping. The purpose of these agricultural leases is to produce food and cover for wildlife and manage the land for continued multi-purpose recreation. In addition, the Washington Department of Fish and Wildlife issued a grazing permit for ~3,756 hectares (~9,280 acres), allowing up to 750 animal-unit-months to graze the parcel. This grazing lease was allowed to expire on December 31, 1998. But under State Environmental Protection Act regulations, for up to 10 years after the expiration of the lease, the Washington Department of Fish and Wildlife can reinstate the grazing lease without public review.

The Wahluke Wildlife Recreation Area is open to the public for recreational uses during daylight hours. According to data published in the *Hanford Reach of the Columbia River, Comprehensive River Conservation Study and Environmental Impact Statement Final - June 1994* (National Park Service 1994), the Wahluke State Wildlife Recreation Area has more than 40,000 visits per year by recreationalists. Most recreational visits are related to sport fishing in the Columbia River.

The Wahluke Slope once contained small, non-radioactively contaminated sites (e.g., military and farmstead landfills). In February 1996, a no further action record of decision was signed documenting that previous removal actions done in 1993 and 1994 removed all contaminants to below the Washington Administrative Code (WAC), WAC 173-340 Washington Model Toxics Control Act (MTCA) and that these areas do not pose a threat to human health or the environment. DOE is not planning to alter the current land uses of the Wahluke Slope and is specifically prohibited from causing any adverse impact on the values for which the area is under consideration for Wild and Scenic River (DOI 1996).

Columbia River Corridor. Portions of the 111.6 square kilometers (43.1 square miles) of the Columbia River Corridor, which is adjacent to and runs through the Hanford Site, is used by the public and tribes for boating, water skiing, fishing, and hunting of upland game birds and migratory waterfowl. While public access is allowed on certain islands, access to other islands and adjacent areas is restricted because of unique habitats and the presence of cultural resources.

The 100 Area NPL site occupies ~68 square kilometers (~26 square miles) along the southern shoreline of the Columbia River Corridor. The area contains all of the facilities in the 100 Areas, including nine retired plutonium production reactors, associated facilities, and structures. The primary land uses are CERCLA remedial actions, reactor decommissioning, and undeveloped areas used by wildlife. Future use restrictions will be placed as appropriate on the CERCLA sites, such as institutional controls on activities that potentially extend beyond 4.6 meters (15 feet) below ground surface.

The area known as the Hanford Reach includes an average of a 402-meter (1,320-foot) strip of federally-owned land on either side of the Columbia River. The Hanford Reach is the last unimpounded, non-tidal segment of the Columbia River in the United States. In 1988, Congress passed Public Law 100-605, *Study: Hanford Reach, Washington*, which required the Secretary of the Interior to prepare an environmental impact study (in consultation with the Secretary of Energy) to evaluate the outstanding features of the Hanford Reach and its immediate environment.

Alternatives for preserving the outstanding 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 final *Hanford Reach of the Columbia River, Comprehensive River Conservation Study and Environmental Impact Statement Final - June 1994* (National Park Service 1994). The record of decision issued as a result of this document recommended that the Hanford Reach be designated a recreational river, as defined by the National Wild and Scenic Rivers Act of 1968. The record of decision also recommended that the remainder of the Wahluke Slope be established as a National Fish and Wildlife Refuge. Finally, the record of decision recommended that the ~728 hectares (~1,800 acres) of private land located in the Hanford Reach Study Area be included in the recreational river boundary but not the refuge boundary.

On June 9, 2000, the President signed a proclamation creating the Hanford Reach National Monument (65 FR 37253). The monument encompasses 793 square kilometers (306 square miles) of lands already owned by the federal government that were planned for preservation or conservation in the land-use plan (DOE 1999a). No changes have occurred to related land uses since the monument designation.

The U.S. Fish and Wildlife Service is writing a comprehensive conservation plan environmental impact statement for all lands within the monument (with DOE-RL as a cooperating agency), which should be completed in 3 years.

DOE-RL is working on a phased approach to transfer most of the monument land to DOI by September 2005. DOE-HQ agrees with DOE-RL and will provide support and direction as needed. Current plans under consideration include the following:

- Transfer most ALE monument land to DOI by September 2004
- Transfer most McGee/Riverland and Wahluke Slope lands by 2005

Central Plateau. The 200 East and 200 West Areas occupy ~51 square kilometers (~19.5 square miles) in the Central Plateau of the Hanford Site. Facilities located in the Central Plateau were built to process irradiated fuel from the production reactors. The operation of these facilities resulted in the storage, disposal, and unplanned release of radioactive and non-radioactive waste. The primary land uses are waste operations and operations support. The CLUP indicates that deed or land-use restrictions for activities that potentially may extend beyond 4.6 meters (15 feet) below ground surface are expected for CERCLA and RCRA remediation areas in the Central Plateau geographic study area under the rural residential scenario and down to 3.6 meters (12 feet) in an ecological scenario. In addition, it is anticipated that the Central Plateau will remain a waste management area for the foreseeable future.

In 1964, a 410-hectare (1,000-acre) tract was leased to Washington State to promote nuclear-related development. A commercial low-level radioactive waste disposal facility, run by US Ecology, Inc., currently operates on 41 hectares (100 acres) of the leasehold. The rest of the leasehold was not used by the state, and this portion of the leasehold recently reverted to DOE. DOE constructed the Environmental Restoration Disposal Facility on this tract.

The Environmental Restoration Disposal Facility is operated on the Central Plateau to provide disposal capacity for environmental remediation waste (e.g., low-level, mixed low-level, and dangerous wastes) generated during remediation of the 100, 200, and 300 Areas of the Hanford Site. The facility is currently about 65 hectares (160 acres) and can be expanded up to 414 hectares (1,023 acres), as additional waste disposal capacity is required.

All Other Areas. The All Other Areas geographic area is 689 square kilometers (266 square miles) and contains the 300, 400, 600, and 1100 Areas; Energy Northwest facilities; and a section of land currently owned by the state of Washington.

The 300 Area is located just north of the city of Richland and covers 1.5 square kilometers (0.6 square mile). The 300 Area is the site of former reactor fuel fabrication facilities and is also the principal location of nuclear research and development facilities serving the Hanford Site. The Environmental Molecular Sciences Laboratory and associated research programs provide research capability to advance technologies in support of DOE's mission of environmental remediation and waste management.

The 400 Area, located southeast of the 200 East Area, is the site of the Fast Flux Test Facility (FFTF). FFTF is a 400-megawatt thermal, liquid metal (sodium-cooled) nuclear research test reactor that was constructed in the late 1970s and operated from 1982 to 1992. Although not designed nor operated as a breeder reactor, FFTF operated during these years as a national research facility for the Liquid Metal Fast Breeder Reactor Program to test advanced nuclear fuels, materials, components, systems, nuclear operating and maintenance procedures, and active and passive safety technologies. The reactor was also used to produce a large number of different isotopes for medical and industrial users, generate tritium for the United States fusion research program, and conduct cooperative, international research.

FFTF has been permanently shutdown and is currently being deactivated including removal and washing of fuel and draining of liquid sodium coolant. In May 2003, DOE, EPA, and Ecology signed into agreement the FFTF series of Tri-Party Agreement milestones to govern the deactivation activities currently underway. A small-business solicitation was published in September 2003 seeking offers to achieve a safe and accelerated closure of FFTF by 2012, while reducing risk to the public and workers, streamlining essential operations, minimizing costs, and introducing new and innovative approaches for the deactivation and decommissioning of FFTF facilities. FFTF site tours and one-on-one sessions with interested potential bidders were held in early October 2003. It is anticipated that a contract will be awarded by June 30, 2004.

The 1100 Area, located just north of Richland, served as the central warehousing, vehicle maintenance, and transportation operations center for the Hanford Site. A deed restriction has been filed with Benton County for the Horn Rapids Landfill, which restricts future land uses in the vicinity of the landfill because of asbestos disposal there. The Horn Rapids Landfill was included in the 1100 Area CERCLA cleanup, although it is located on the Hanford Site to the north of Horn Rapids Road; it remains in federal ownership. Also, DOE transferred ~318 hectares (~786 acres) of the former 1100 Area to the Port of Benton. DOE prepared an environmental assessment (DOE 1998) that resulted in a finding of no significant impact on August 27, 1998, for the transfer of this portion of the 1100 Area and the southern rail connection to the Port of Benton. The Port officially took ownership and control of the 1100 Area (consisting of 318 hectares [786 acres], 26 buildings, and 26 kilometers [16 miles] of railroad track) on October 1, 1998. This portion of the 1100 Area is no longer under DOE control.

Together with the Washington State Department of Transportation and Legislature Transportation Committee, the Port of Benton is currently funding a major study ($600,000) to determine the feasibility of reconnecting the Hanford main rail line to Ellensburg, Washington (as it was in the 1970s), as an alternative route for Yakima Valley rail traffic flowing between the Puget Sound and the Tri-Cities. The current Yakima Valley route passes directly through all the cities in the Valley, including the cities of Yakima and Kennewick, which have plans to develop their downtown areas to be more people friendly. Specifically, the Port has expressed a desire to use the Hanford rail system and extend the current system upriver where there is currently only an abandoned railroad grade.

Additional land uses in all other geographic areas include the following:

- The Hazardous Materials Management and Emergency Response (HAMMER) Volpentest Training and Education Center, which is used to train hazardous materials response personnel. The HAMMER Volpentest Training and Education Center is located north of the 1100 Area and covers ~32 hectares (~80 acres).

- Land was leased to Energy Northwest to construct three commercial power reactors in the 1970s. One plant, WNP-2, was completed and is currently operating. Activities on the other two plants were terminated and the plants will not be completed.

- In 1980, the Federal government sold a 259-hectare (640 acre) section of land south of the 200 East Area, near State Route 240, to the state of Washington for the purpose of non-radioactive hazardous waste disposal. This parcel is uncontaminated (although the underlying groundwater is contaminated) and undeveloped. The deed requires that if it were used for any purpose other than hazardous waste disposal, ownership would revert to the Federal government.

- The Laser Interferometer Gravitational-Wave Observatory, built by the National Science Foundation on the Hanford Site, detects cosmic gravitational waves for scientific research. The facility consists of two underground optical tube arms, each 4 kilometers (2.5 miles) long, arrayed in an "L" shape. The facility is sensitive to vibrations in the vicinity, which can be expected to constrain nearby land uses.

Fitzner/Eberhardt Arid Lands Ecology (ALE) Reserve. The Fitzner/Eberhardt Arid Lands Ecology Reserve (also designated as the Rattlesnake Hills Research Natural Area, or the ALE Reserve) encompasses 308.7 square kilometers (119.2 square miles) in the southwestern portion of the Hanford Site and is managed as a habitat and wildlife reserve and environmental research center. A "research natural area" is a classification used 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 ALE Reserve remains the largest research natural area in the state of Washington.

The mineral rights to a 518-hectare (1,280-acre) area on the ALE Reserve are owned by a private company. There are also two ongoing research and development projects under way on the ALE Reserve: gravity experiments in underground Nike bunkers located in the southern portion of the Reserve, and online science education, teacher training, and astronomy research in the observatory on the top of Rattlesnake Mountain. Both are long-term projects using existing facilities.

Because public access to the ALE Reserve has been restricted since 1943, the shrub-steppe habitat is virtually undisturbed and is part of a much larger Hanford tract of shrub-steppe vegetation. This geographic area contained a number of small contaminated sites that were remediated in 1994 and 1995 and have been re-vegetated. There are two landfills on the ALE Reserve, at least one of which was used for disposal of a non-radioactive hazardous waste. Although remediated, one of the landfills may still contain hazardous materials.

DOE granted a permit and entered into an agreement with U.S. Fish and Wildlife Service to manage the ALE Reserve consistent with the existing ALE Facility Management Plan. The U.S. Fish and Wildlife Service is preparing a comprehensive conservation plan pursuant to the National Wildlife Refuge System Improvement Act of 1997 to identify refuge management actions and to bring the ALE Reserve into the national wildlife refuge system.

3.2.3 Selected Land-Use Alternative

In developing the selected alternative, DOE took into account its role as the long-term caretaker for the Hanford Site for at least the next 50 years. Information considered by DOE includes:

- All surface waste sites, including those remediated
- Groundwater contaminants and flow direction
- Cultural and biological resources
- Exclusive-use zones and emergency planning zones associated with DOE and other Hanford activities (e.g., Energy Northwest's nuclear power reactor; US Ecology, Inc.'s low-level waste disposal site; Laser Interferometer Gravitational-Wave Observatory)

DOE believes that the selected alternative would fulfill the statutory mission and responsibilities of the agency and give adequate consideration to economic, environmental, technical, and other factors.

DOE's selected alternative would establish policies and implementing procedures that would place Hanford's land-use planning decisions in a regional context.

DOE's selected alternative is illustrated in Figure 3.2b and represents a multiple-use theme of industrial-exclusive, industrial, research and development, high-intensity recreation, low-intensity recreation, conservation (mining), and preservation land uses that have been identified by the public, cooperating agencies, and consulting tribal governments as being important to the region:

- DOE, as a federal agency, has a responsibility to protect tribal interests.

- DOE has a responsibility to consult with and recognize the interests of the cooperating agencies. DOE continues to support DOI's proposal to expand the Saddle Mountain National Wildlife Refuge to include all of the Wahluke Slope, consistent with the 2000 Hanford National Monument (65 FR 37253), 1994 Hanford Reach environmental impact statement (DOI 1994), and 1996 Hanford Reach record of decision (DOI 1996). DOE will support economic transition and potential industrial development by the city of Richland or the Port of Benton by encouraging the use of existing utility infrastructure on the Hanford Site as appropriate.

- The public will continue to support protection of cultural and natural resources on the Hanford Site, especially on the Wahluke Slope, the Columbia River Corridor, the McGee Ranch, and the ALE Reserve.

- Mining of onsite geologic materials will be needed to construct surface barriers as required by Hanford Site remediation activities.

Remediation of the Hanford Site will continue and, where necessary, the institutional controls currently in place or selected as part of remedial actions will continue to be required at some level for as long as necessary or for at least the next 50 years. Institutional controls are transferable and can be shared with other governmental agencies.

Plutonium production reactor blocks will remain in the 100 Areas throughout the planning period and will be considered a pre-existing, nonconforming use.

Vadose zone contamination will persist in all other areas, the Central Plateau, and 100 Area. Contaminated groundwater will remain unremediated in all other areas, the Central Plateau, and 100 Area.

The public will support preservation of the Manhattan Project's historical legacy and development of a high-intensity recreation area, consistent with the B Reactor Museum proposal.

- The public will support access to the Columbia River for recreational activities and public restrictions consistent with the protection of cultural and biological resources.

- Areas will be set aside specifically for research and development projects. Sufficient area will be retained to support current and expected DOE facility safety authorization basis.

- An adequate land base and utility infrastructure will be maintained to support possible industrial development associated with future DOE missions.

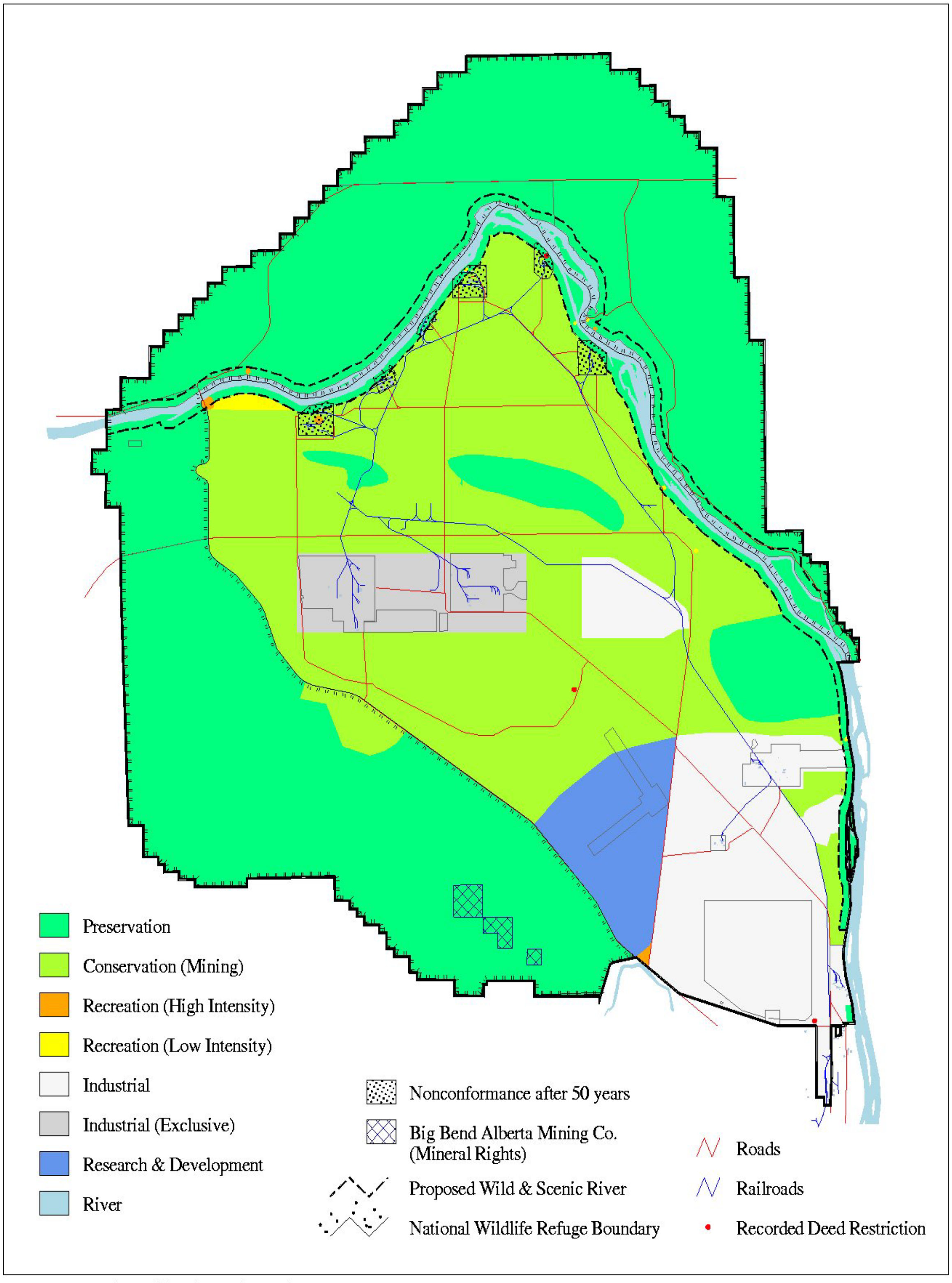

Figure 3.2b. Site Human and Ecological Land Use – RBES (DOE's Selected Land-Use Alternative from DOE 1999a)

The following paragraphs discuss the RBES vision for specific areas of the Hanford Site.

Wahluke Slope. DOE's selected alternative allowed expansion of the existing Saddle Mountain National Wildlife Refuge as an overlay wildlife refuge to include all of the Wahluke Slope consolidating management of the Wahluke Slope under the U.S. Fish and Wildlife Service, consistent with the Hanford Reach record of decision (DOI 1996). An overlay refuge is one where the land belongs to one or more Federal agency, but it is managed by the U.S. Fish and Wildlife Service. DOE granted a permit and entered into an agreement with U.S. Fish and Wildlife Service to manage most of the Wahluke Slope.

The entire Wahluke Slope was designated preservation, with the exceptions near the Columbia River. The major reason for designating this area as preservation is to protect sensitive areas or species of concern (e.g., wetlands, sand dunes, steep slopes, or the White Bluffs) from impacts associated with intensive land-disturbing activities.

A comprehensive conservation plan for the Wahluke Slope is being developed by U.S. Fish and Wildlife Service in accordance with the National Wildlife Refuge System Improvement Act of 1997. This act provides significant guidance for management and public use of refuges allowing for wildlife-dependent recreation uses such as hunting, fishing, wildlife observation and photography, and environmental education and interpretation. The U.S. Fish and Wildlife Service is consulting with DOE during the development of this plan to ensure necessary and appropriate buffer zones for ongoing and potential future missions at the Hanford Site.

Columbia River Corridor. The Columbia River Corridor has historically contained reactors and associated buildings to support Hanford's former defense production and energy research missions. Nevertheless, remediation planning documents, public statements of advisory groups, and such planning documents as the environmental impact statement for reactor decommissioning (DOE 1992a) have determined that remediation and restoration of the Columbia River Corridor would return the corridor to a non-developed, natural condition. Restrictions on certain activities at many remediated waste sites may continue to be necessary to prevent the mobilization of contaminants, the most likely example of such restrictions being on activities that discharge water to the soil or excavate below 4.6 meters (15 feet). Although the surplus reactor record of decision (DOE 1989) calls for the reactor buildings to be demolished and the reactor blocks to be moved to the Central Plateau, this action might not take place until 2068. As a result, the reactor buildings could remain in the Columbia River Corridor throughout the 50-year-plus planning period addressed by the environmental impact statement (64 FR 61615) and would be considered a pre-existing non-conformance into the future.

The Columbia River Corridor would include high-intensity recreation, low-intensity recreation, conservation (mining), and preservation land-use designations. The river islands and a 0.4-kilometer (0.25-mile) buffer zone would be designated as preservation to protect cultural and ecological resources. Those islands not in Benton County would be included in the refuge.

The Hanford CLUP (DOE 1999a, pg. 3-21) indicates that four sites, away from existing contamination, would be designated high-intensity recreation to support visitor-serving activities and facilities development. The B Reactor would be considered for a museum and the surrounding area could be available for museum-support facilities. The high-intensity recreation area near Vernita Bridge (where the current Washington State rest stop is located) would be expanded across State Highway 240 and to the south to include a boat ramp and other visitor facilities. Two areas on the Wahluke Slope would be designated as high-intensity recreation for potential exclusive tribal fishing (DOE 1999a).

The plan also indicates that six areas would be designated for low-intensity recreation. The area west of the B Reactor would be used as a corridor between the high-intensity recreation areas associated with the B Reactor and the Vernita Bridge rest stop and boat ramp. A second area near the D/DR Reactors site would be used for visitor services along a proposed recreational trail. The third and fourth areas, the White Bluffs boat launch, and its counterpart on the Wahluke Slope, are located between the H and F Reactors and would be used for primitive boat launch facilities. A fifth area, near the old Hanford High School, would accommodate visitor facilities and access to the former town site and provide visitor services for hiking and biking trails that could be developed along the Hanford Reach. A sixth site, just north of Energy Northwest, would also provide visitor services for recreational trails (e.g., hiking and biking) along the Hanford Reach. On the Wahluke Slope side of the Columbia River, the White Bluffs boat launch would remain managed as is, with a low-intensity recreation designation. A low-intensity recreation designation for the water surface of the Columbia River would be consistent with current management practices and the wishes of many stakeholders in the region.

The remainder of land within the Columbia River Corridor outside the 0.4-kilometer (0.25-mile) buffer zone would be designated for conservation (mining). Mining would be permitted only in support of governmental missions or to further the biological function of wetlands (i.e., conversion of a gravel pit to a wetland by excavating to groundwater). A conservation (mining) designation would allow DOE to provide protection to sensitive cultural and biological resource areas, while allowing access to geologic resources. Activities that use or effect groundwater would continue to be restricted.

A preservation land-use designation for the Columbia River islands would be consistent with the Hanford Reach record of decision (DOI 1996) and would provide additional protection to sensitive cultural areas, wetlands, floodplains, Upper Columbia Run steelhead, and bald eagles from impacts associated with intensive land-disturbing activities. Remediation activities would continue in the 100 Areas (i.e., 100-B/C, 100-KE, 100-KW, 100-N, 100-D, 100-DR, 100-H, and 100-F Areas), and would be considered a pre-existing, non-conforming use in the preservation land-use designation.

DOE is considering whether each of these designations is appropriate under the designation of the Hanford Reach as a National Monument. For land which under the control of the U.S. Fish and Wildlife Service future uses will be dealt with through the Comprehensive Conservation Plan.

Central Plateau. The Central Plateau (200 Areas) geographic area would be designated for industrial-exclusive use. An industrial-exclusive land-use designation would allow for continued waste management operations within the Central Plateau geographic area. This designation would also allow expansion of existing facilities or development of new compatible facilities. Designating the Central Plateau as industrial-exclusive would be consistent with the Future Site Uses Working Group's recommendations, current DOE management practice, other governments' recommendations, and many public stakeholder values throughout the region.

Tank Farm Specific End States. DOE and its predecessor agencies, dating back to the Manhattan Project, created a variety of radioactive and chemical waste as by-products of producing fissile materials for defense purposes. Today, ~2e+008 liters (~53 million gallons) of liquid, sludge, and saltcake waste containing ~195 million curies of radioactive material are stored in 149 single-shell tanks and 28 double-shell tanks. Those tanks are distributed among 18 tank farms within the 200 East and 200 West Areas on the Hanford Central Plateau. DOE-ORP was created to execute cleanup of the Hanford tank farms. Its responsibilities include retrieving wastes from the tanks in accordance with the Hanford Federal Facilities Agreement and Consent Order (Tri-Party Agreement; Ecology et al. 1998), treating and dispositioning the waste to authorized disposal locations, executing targeted remediation actions when necessary if soil and/or ancillary equipment contamination levels so warrant, and closing the tank farms in a manner that will protect human health and the environment for extremely long times (hundreds or thousands of years) into the future.

DOE-ORP's cleanup approach integrates its commitments under the Tri-Party Agreement with its responsibilities under the Atomic Energy Act of 1954, the National Environmental Policy Act (NEPA), and applicable DOE Orders and environmental regulations that flow from those acts. While the Tri-Party Agreement cleanup and closure requirements are relatively prescriptive, the Tri-Party Agreement and the regulations it encompasses do include moderate levels of flexibility to deploy risk-based solutions for cleanup and closure actions. Examples include Appendix H to the Tri-Party Agreement (Ecology et al. 1998), which provides for alternative retrieval levels if the 99% goal cannot be reasonably attained. Under Appendix H, a balance can be struck between long-term risk, risk to workers, technical practicality, and cost to arrive at alternate levels. Similarly, while Tri-Party Agreement's RCRA roots tend to focus on achieving clean closures, provisions exist that can lead to landfill closures based on similar tradeoffs considered under Appendix H. The result is that while some cleanup actions will be taken to meet prescriptive objectives, exercising the flexibilities within Tri-Party Agreement will result in protective conditions existing at the completion of cleanup and closure with risk analyses being a factor in determining the final end states. The tank farm end states are within the final closure of the Hanford Site and groundwater protection that are regulated under the CERCLA using risk-based principles.

The end state envisioned by DOE-ORP for the tank farms is that the bulk of the radionuclides will be disposed of offsite as high-level waste, and the bulk of the contaminated chemical waste equipment (e.g., pumps, piping, and tanks) will be disposed of onsite in a protective manner that complies with Tri-Party Agreement and appropriate laws, regulations, and DOE Orders. Further details regarding the end state are as follows:

1. Waste will be retrieved at, near, or beyond the goals established by Tri-Party Agreement barring currently unforeseen obstacles. This should result in ~99% of the waste volume being retrieved and treated.

2. High-level waste, containing >90% of the current total tank radioactive material inventory, will be vitrified and, following several years of interim onsite storage, disposed of at the national high-level waste and spent nuclear fuel repository.

3. Transuranic waste retrieved from the tanks will be treated, packaged, and characterized in a manner that should enable disposal off-site at the Waste Isolation Pilot Plant Transuranic geologic repository (pending current NEPA actions on SA-4, waste certification, and the supplemental Waste Isolation Pilot Project environmental impact statement).

4. Low-activity waste and secondary low-level mixed waste will be treated and put into stabilized forms that enable disposal onsite within the Hanford Central Plateau in DOE authorized and Washington Department of Ecology permitted (RCRA) mixed waste disposal facilities (pending NEPA and supplemental low-activity waste treatment test results).

5. Residual materials that cannot be removed from the tanks will be stabilized with grout formulations and/or other materials engineered to isolate and contain any radioactive and hazardous constituents associated with the residuals. The tank void space (above the stabilized residual level) will be back-filled with natural and/or engineered materials selected to both contribute to the defense-in-depth containment and isolation of the wastes and to stabilize the tank against structural failure, e.g., dome collapse.

6. Above grade structures within the tank farms will be decommissioned and brought to grade level. Contaminated rubble and other materials will be disposed of in RCRA and/or CERCLA compliant facilities. Ancillary equipment, pits, and piping will have any liquids removed to the extent it is possible to do so and be backfilled to fill major void spaces prior to final closure (pending the single-shell tank closure plan and single-shell closure environmental impact statement).

7. Engineered barriers (modified RCRA, Hanford barrier, hybrid barrier) will be placed over the tank farms to divert precipitation from contacting residual wastes in the tanks, ancillary equipment, and the soil column underlying the tank farms. The surface barriers will also provide protection against plants, animals, and certain forms of possible human intrusion, e.g., shallow excavations.

8. Tanks and tank farms will be landfill closed under the Tri-Party Agreement, which integrates the RCRA and CERCLA processes and provides for RBES analyses. Active and passive institutional controls (guards; fences; permanent surface and embedded markers; government held land, water, and mineral rights; extensive public records delineating the location and content of the closed tank farms) will be used to reduce the risk of inadvertent intrusion, e.g., major excavation or drilling to obtain groundwater for irrigation or potable purposes. Monitoring systems will be put into place and maintained for an indefinite period of time in the future (hundreds of years) to measure parameters that affect contaminant transport and determine whether any waste migration may be occurring. Specific approaches will be determined nearer the time when final closure of the Hanford Site occurs using appropriate information/technology available at that time.

All Other Areas. Within all other geographic areas, the selected alternative would include industrial, research and development, high-intensity recreation, low-intensity recreation, conservation, and preservation land-use designations. The majority of all other areas would be designated conservation (mining).

Gable Mountain, Gable Butte, the area west of State Highway 240 from the Columbia River across Umtanum Ridge to the ALE Reserve, and the active sand dunes areas would be designated for Preservation, which would provide additional protection of these sensitive areas. The extant railroad grade across the Riverlands area would be considered an active permitted infrastructure.

Fitzner/Eberhardt Arid Lands Ecology (ALE) Reserve. Nearly all of the ALE Reserve geographic area would be designated as Preservation. This designation would be consistent with current management practices of the Rattlesnake Hills Research Natural Area and the U.S. Fish and Wildlife Service permit. A portion of the ALE Reserve would be managed as conservation (mining) during the remediation of the

Hanford Site as a trade-off developed during the cooperating agencies discussions for preservation of a wildlife corridor through the McGee Ranch and after public comment, the inclusion of the McGee Ranch within the Refuge designation. The wildlife corridor through the McGee Ranch/Umtanum Ridge area had been identified by DOE as the preferred quarry site for basalt rock and silty soil materials that could be required for large waste-management area covers (RCRA caps or the Hanford Barrier) in the Central Plateau. In addition to the wildlife corridor function, the mature shrub-steppe vegetation structure in the McGee Ranch area has greater wildlife value than the cheat grass in the ALE Reserve quarry site.

3.3 Site Context Legal Ownership

The Hanford Site land holdings consist of three different real property classifications (Figure 3.3a):

1. Lands acquired in fee by DOE or its predecessor agencies

2. Bureau of Land Management public domain lands withdrawn from the public domain for use as part of the Hanford Site

3. Lands the Bureau of Reclamation has withdrawn from the public domain or acquired in fee as part of the Columbia Basin Project.

In addition, Figure 3.3a-a shows the ownership of land on a regional basis, beyond the boundary of the Hanford Site.

The Bureau of Reclamation agreed to transfer custody, possession, and use of certain acquired and withdrawn lands situated within the control zone of the Hanford Works to the U.S. Atomic Energy Commission on February 27, 1957. These lands consisted of a checkerboard pattern of alternating square-mile sections on the Wahluke Slope.

The alternating square-mile sections that would eventually revert to the Bureau of Land Management or Bureau of Reclamation are an important consideration that complicates land-use planning.

Under the Risk Based End State Land Management/Ownership vision for Hanford has all land except the Central Plateau (200Area Core Zone and buffer zone) has been transferred to another entity (federal, state, local government or private). The Long Term Stewardship (LTS) program will be managed by a DOE program secretarial office, other than EM, that is to be defined in the future. DOE will maintain liability for any residual waste left on site and institutional controls unless, as part of a transfer agreement, the receiver has agreed to assume future liability.

More specifically, the Hanford Reach National Monument has been transferred to the U.S. Fish and Wildlife, the 300 Area has been transferred to local government for industrial redevelopment and the WNP 1, 2 and 4 site has been transferred to Energy Northwest. Other Hanford land will be transferred to other entity as opportunities arise. All land will be managed consistent with the DOE comprehensive Land Use Plan EIS. Figure 3.3b shows land ownership after cleanup is complete.

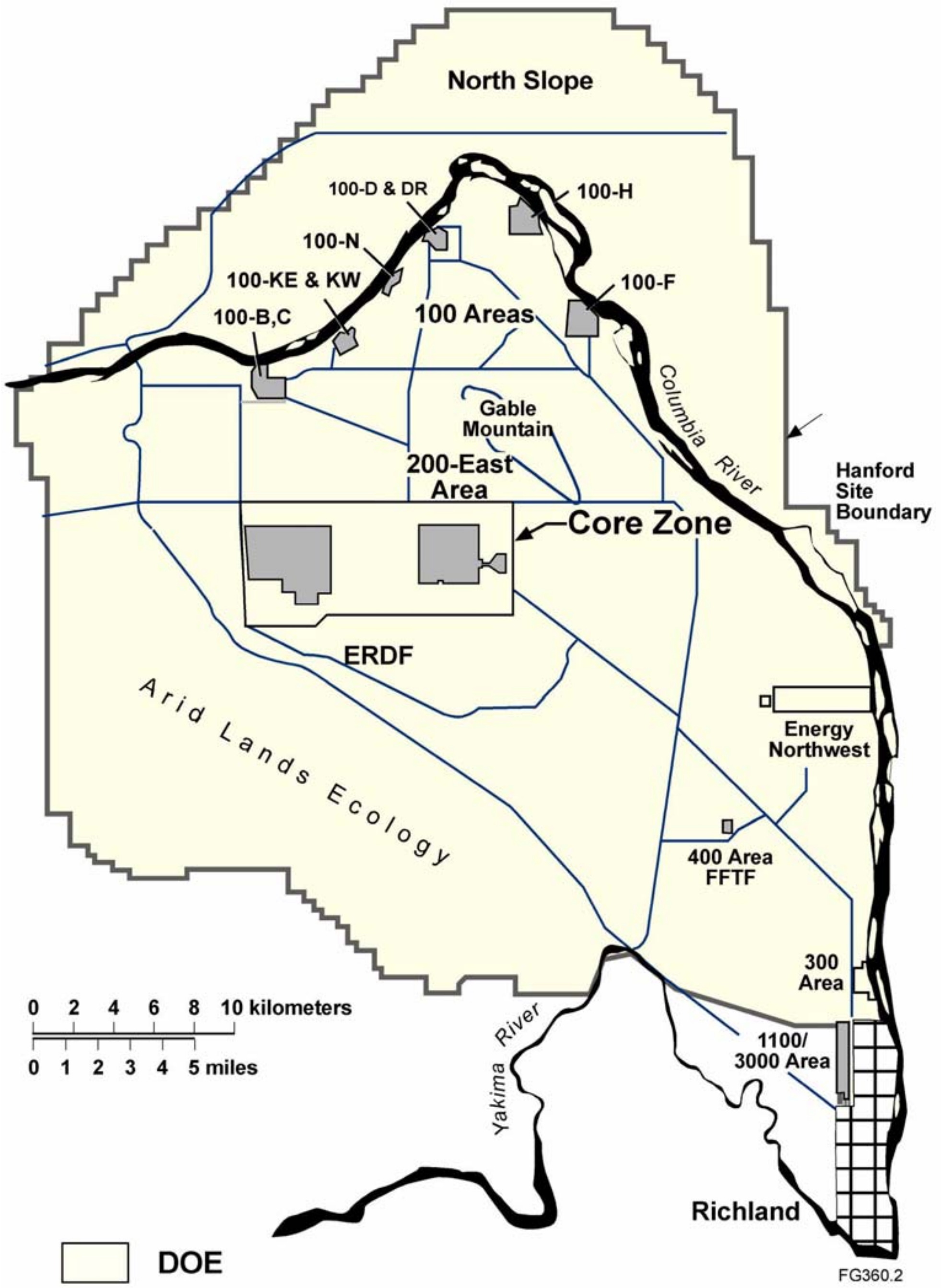

Figure 3.3a. Site Context Legal Ownership – Current State

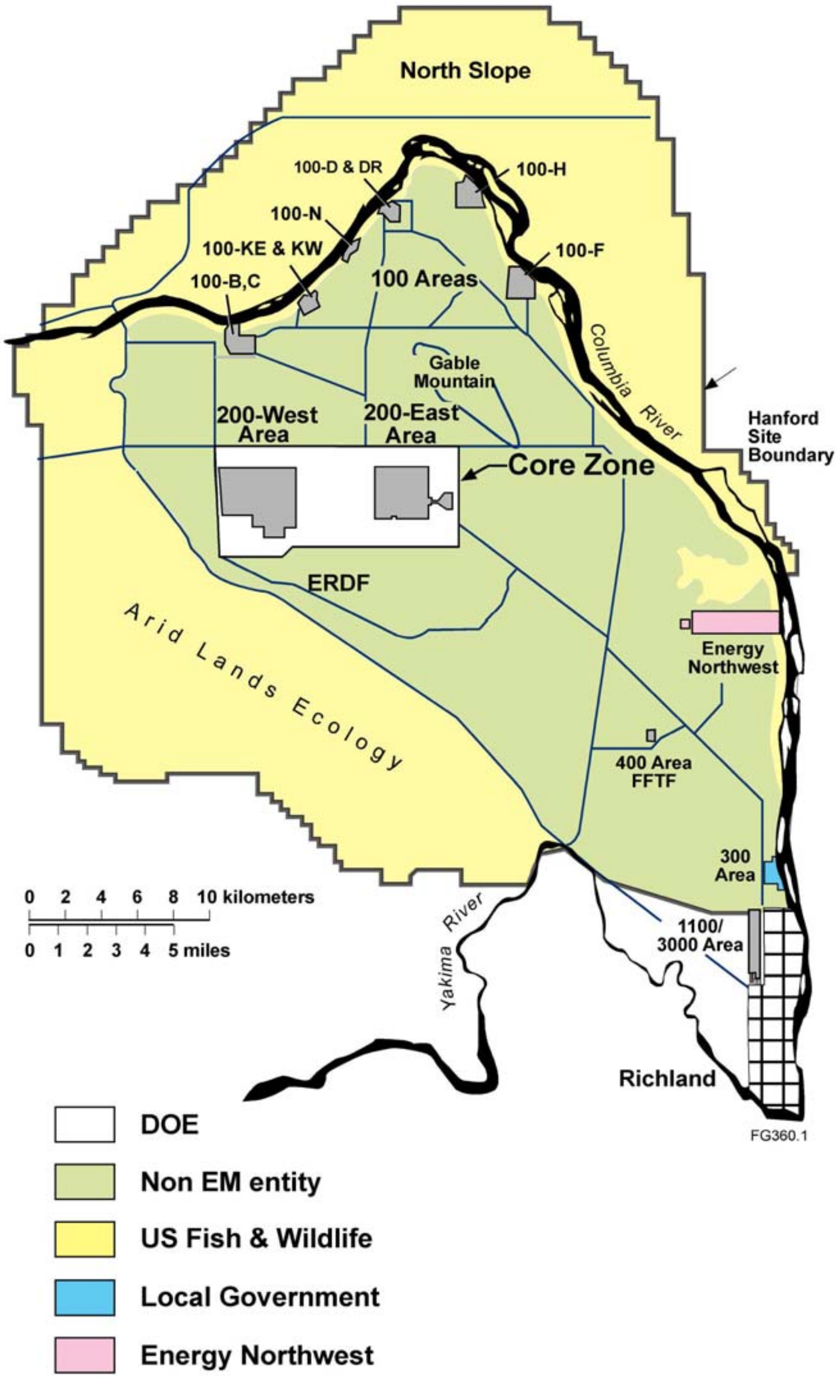

Figure 3.3b. Site Context Legal Ownership – RBES Vision

3.4 Site Context Demographics

An estimated total of 147,600 people lived in Benton County and 51,300 lived in Franklin County during 2002, for a total of 198,900, which is up almost 4% from 2000 (OFM 2002). According to the 2000 Census, population totals for Benton and Franklin counties were 142,475 and 49,347, respectively (Census 2003). Both Benton and Franklin counties grew at a faster pace than Washington as a whole in the 1990s. The population of Benton County grew 26.6%, up from 112,560 in 1990. The population of Franklin County grew 31.7%, up from 37,473 in 1990 (Census 2003).

The distribution of the Tri-Cities population by city is as follows: Richland 40,150; Pasco 34,630; and Kennewick 56,280. The combined populations of Benton City, Prosser, and West Richland totaled 16,560 during 2001. The unincorporated population of Benton County was 34,610. In Franklin County, incorporated areas other than Pasco had a total population of 3,755. The unincorporated population of Franklin County was 12,915 (OFM 2002).

The 2000 population figures by race and Hispanic origin indicate that in Benton and Franklin counties, Asians represent a lower proportion, and individuals of Hispanic origin represent a higher proportion of the population than in the state of Washington as a whole. Benton and Franklin counties exhibit distributions as indicated by the data in Table 3.1.

During 2002, Benton and Franklin counties accounted for 3.3% of Washington's population. The population demographics of Benton and Franklin counties are quite similar to those found within Washington. In general, the population of Benton and Franklin counties is somewhat younger than that of Washington. The 0-to-14-year-old age group accounts for 25.4% of the total bi-county population as compared to 20.9% for Washington. The population in Benton and Franklin counties under the age of 35 is 53.3%, compared to 48.9% for Washington State. During 2002, the 65-year-old and older age group constituted 10% of the population of Benton and Franklin counties compared to 11.2% for Washington (OFM 2003). Table 3.1 represents population estimates and percentages by race and Hispanic origin for Benton, Franklin, Grant, Adams, and Yakima counties, and the 80-kilometer (50-mile) radius of the Hanford Site.

Figure 3.4a shows the current site demographics; Figure 3.4b shows the RBES vision of site demographics.

3.5 Hanford Current/Risk-Based End State Descriptions

The purpose of this section is to clearly describe the current cleanup plans reflected in the Integrated Hanford Baseline and describe the Risk Based End State (RBES) Vision cleanup for each area that is protective of human health and the environment for the land uses identified in the Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS) Record of Decision [DOE 1999a] (CLUP). See Section 3.2.3 and Figure 3.2b of this document for a discussion of the current land uses and the anticipated future land uses. The RBES Vision document is not a decision document. Rather it forms the basis to reevaluate our current cleanup activities and strategic approaches to determine if it is appropriate to change site baseline documents and renegotiate agreements. If current or planned cleanup goals or strategies are deemed appropriate to proceed, the changes will be proposed and reviewed for approval as required by law, regulation or current agreements.

Table 3.1. Population Estimates and Percentages by Race and Hispanic Origin within each County in Washington State and the 80-Kilometer (50-mile) Radius of Hanford (2000 Census - Census 2003)

Subject	Washington State	Percent	Benton/Franklin/Grant/ Adams/Yakima	Percent	Benton County	Franklin County	Grant County	Adams County	Yakima County	80-km (50-mi) Radius of Hanford[a]
Total Population	5,894,121	100	505,529	100	142,475	49,347	74,698	16,428	222,581	482,300
Single Race	5,680,602	96.4	489,206	96.8	138,646	47,302	72,451	15,977	214,830	482,280
White	4,821,823	81.8	367,283	72.7	122,879	30,553	57,174	10,672	146,005	347,047
Black or African American	190,267	3.2	5,494	1.1	1,319	1,230	742	46	2,157	5,507
American Indian/Alaska Native	93,301	1.6	12,468	2.5	1,165	362	863	112	9,966	10,288
Asian	322,335	5.5	6,809	1.3	3,134	800	652	99	2,124	6,681
Native Hawaiian/Pacific Islander	23,953	0.4	482	0.1	163	57	53	6	203	479
Other Race	228,923	3.9	96,670	19.1	9,986	14,300	12,967	5,042	54,375	96,625
Two or More Races	213,519	3.6	16,323	3.2	3,829	2,045	2,247	451	7,751	15,654
Hispanic Origin (of any race)[b]	441,509	7.5	150,951	29.9	17,806	23,032	22,476	7,732	79,905	149,588

(a) Includes a portion of Oregon.
(b) Hispanic origin is not a racial category. It may be viewed as the ancestry, nationality group, lineage, or country of birth of the person or person's parents or ancestors before arrival in the United States. Persons of Hispanic origin may be of any race and are counted in the racial categories shown.

3.5.1 Groundwater Baseline and Risk-Based End State Descriptions

The current and RBES Vision are the same for groundwater. The current cleanup plans are reflected in the groundwater RODs for Interim Action and Hanford's Groundwater Management Plan (DOE/RL-2002-68, March 2003). Current and RBES Vision will use established CERCLA processes to determine active and passive remedial measures to achieve groundwater cleanup goals, and where appropriate, define alternate concentration limits and technical practicability waivers. Under current and RBES Vision scenarios groundwater use for consumption and irrigation will be restricted through institutional controls where it is determined to be technically impracticable to achieve aquifer restoration to its highest beneficial use.

Other than key facility surface source terms, the primary pathway for Hanford contaminants to reach the *reasonably maximally exposed (RME) individual* and the environment for current, future and RBES scenarios is through the groundwater pathway. The locations where such exposure might occur will vary for current, future and RBES scenarios.

Existing groundwater plumes have been evaluated by DOE, EPA, and Ecology for risk to the environment and to the public. Goals for Hanford groundwater cleanup have been defined in Hanford's Groundwater Management Plan and include protection of the groundwater from further degradation, remediation of existing groundwater plumes to reduce risk and restore groundwater resources, and monitoring the groundwater conditions to support cleanup and management decisions. In general, DOE will strive to contain the groundwater contamination from the 200 Areas to the Central Plateau to the extent practicable.

Remediation of existing groundwater plumes is performed to protect the Columbia River and to meet CERCLA goals to restore the aquifer to its highest beneficial use if practicable within a reasonable time. CERCLA also provides processes to develop alternate concentration limits and technical impracticability waivers if attainment of drinking water standards may not be relevant and appropriate or practicable. The Environmental Protection Agency (EPA), Washington State Department of Ecology (Ecology) and the Department of Energy (DOE) have recently reaffirmed that groundwater cleanup at Hanford will be performed under the authority of CERCLA. There have been no final RODs written for Hanford groundwater cleanup. There are, however, five RODs for Interim Action. Four of these RODs call for active remediation to address hexavalent chromium that exceeds ambient water quality criteria at 100-H/D&K; strontium-90 that exceeds drinking water standards at 100-N; uranium and technetium-99 at the 200-UP-01 Operable Unit; and, carbon tetrachloride underlying the 200 West Area. These systems utilize pump-and-treat technologies, vapor extraction and there is one geochemical reactive barrier to address chromium. There is a Record of Decision for Interim Action for natural attenuation and continued monitoring for the uranium plume at the 300 Area that is being reassessed on the basis of effectiveness. One pump-and-treat system, located in the 200 East Area was terminated on the basis of a demonstration of minimal risk and technical impracticability. In addition, there are three plumes from the 200 Area that will likely not require active remedial measures. These plumes are the tritium, nitrate and iodine-129 plumes. They pose no risk to human health because there is no consumption from them and the environmental risk is minimal. The plumes will attenuate in a reasonable time frame (less than 150 years). Tritium has a reasonably short half-life (12.5 years) and will decay and reduce the concentrations; iodine-129 has a much longer half-life and concentrations are expected to decline through dispersion and diffusion. Dispersion and diffusion are also expected to reduce nitrate concentrations.

Active remedial measures are underway for the carbon tetrachloride plume underlying the 200 West Area and for a plume containing technetium-99 and uranium in the 200-UP-01 Operable Unit within the 200 West Area. The remedial actions for carbon tetrachloride in 200 West Area have removed eighty-six metric tons of the contaminant. However, further characterization is needed to design more effective technologies. The pump-and-treat system for technetium-99 and uranium in the 200-UP-01 Operable Unit may reach remedial action objectives in a reasonable time-frame. It is unlikely that aquifer restoration can be fully achieved in the 200 Area Core Zone.

The 100 and 300 Area groundwater contaminant plumes will be assessed through a planned risk assessment covering the River Corridor. Environmental risk from chromium, uranium and strontium-90 plumes currently reaching the Columbia River may drive cleanup actions rather than attainment of drinking water standards. The remedial actions addressing chromium in the 100 H, D, and K Areas appear to be successful in meeting their remedial action goals and will be terminated in a reasonable time-frame. The pump-and-treat system for strontium-90 at 100-N has failed as a viable remedial action and other technologies are being evaluated including geochemical sequestration and bioremediation. The 300 Area uranium plume is not attenuating as envisioned in the RODs for Interim Action and a focused feasibility study has been initiated to evaluate remedial alternatives. Acceleration of the removal of irradiated lithium-aluminum materials that are suspected to be the source of tritium from the few burial grounds where they are suspected to be buried will also decrease the risk of further contamination of groundwater.

The RBES Vision identifies proposed variances from the baseline for Hanford cleanup (see Chapter 5). These proposed variances are not expected to result in additional contribution of contaminants to the underlying groundwater in concentrations that would degrade the aquifer. Therefore, these actions should not affect groundwater cleanup plans. In February, 2004 the Tri Parties concurred on the *Hanford Site Groundwater Strategy: Protection, Monitoring and Remediation*, (DOE/RL-2002-59, February 2004). The RBES Vision for ground water is intended to be consistent with this Strategy.

3.5.2 River Corridor - Background, Baseline and Risk-Based End State Descriptions

The geographic area referred to as the river corridor consists of over 544 square kilometers (210 square miles) of the Hanford Site adjacent to the Columbia River. The area includes a one-quarter mile strip of land along the entire length of the Columbia River shore within the Hanford Site that is included in the Hanford Reach National Monument. The river corridor is divided into three major sub-areas: (1) the 100 Area, comprised of deactivated plutonium production reactors and support facilities; (2) the 300 Area, comprised of former reactor fuel fabrication, research, and support facilities; and (3) the vacant land between the 100 and 300 Areas, extending from the Columbia River to the Central Plateau in the middle of the site.

The 100 Area

The 100 Area lies on the south bank of the Columbia River and consists of six noncontiguous reactor areas (100-B/C, 100-D, 100-F, 100-H, 100-K, and 100-N). Nine nuclear reactors are located in these areas (B, C, D, DR, F, H, KE, KW, and N). They are large, graphite moderated, plutonium production reactors that used slightly enriched uranium metal as fuel. The first eight reactors, which were constructed between 1943 and 1955, used Columbia River water in a single-pass process for cooling the reactor core. Water was either discharged back to the river or diverted to onshore liquid waste disposal sites, such as cribs or trenches. This discharged cooling water contaminated the soil and groundwater with CERCLA hazardous substances. The N Reactor differed from the other eight reactors because it had the dual purpose of producing electricity as well as special nuclear material. The process of using the heat to generate electricity required the reactor coolant to be recirculated rather than single-pass, as was the case for the other eight reactors. This recirculation process, however, caused much higher concentrations of radionuclides to accumulate in the reactor coolant system. Moreover, N Reactor operated over a longer period of time than most of the other reactors. Therefore, the soil receiving discharges from the reactor has a much higher concentration of contaminants. Soil contamination in the 100 Area, in general, is related to the process water discharge, leaking pipelines and burial grounds. The 100 Area contains a total of 550 waste sites of which 45 are burial grounds. One hundred and ninety-two have been remediated as of September 2003. This remediation does not include any burial grounds. The average depth of burial grounds is approximately 6.1 meters (20 feet). Over 3.6 million tons (over 200,000 truckloads) have been excavated from the 100 Area at a cost of over $300 million. The transportation risk of this campaign was 2E-2 fatalities. No fatalities have occurred as a result of the 100 and 300 area cleanup campaigns to date, however there have been 53 near miss incidents conducting this work. In addition, there was one significant transportation incident and 40 events involving movement of material and equipment.

In 1998, C Reactor was placed into interim safe storage. B Reactor is listed in the National Register of Historic Places. Reactor fuel from the final runs of N Reactor has been stored in the fuel storage basins in the K Area. The source term from the K Basin's fuel is 55 million curies of radioactivity, approximately 54.8 million curies in fuel and 200,000 curies in the sludge, water and debris. The fuel is being stabilized and repackaged into a safe storage configuration and is being stored in the Canister Storage Building awaiting final disposal at a geological repository. Approximately 383 containers will be needed to contain all of the fuel. Seventy-nine containers remain to be filled as of February 7, 2004. Completion of fuel removal is scheduled for July 2004. Approximately 50 cubic meters of sludge remain in the fuel storage basins. An estimate of ~1000 drums may be required for packaging the sludge.

100 Area Current Baseline End State

RODs for Interim Action are in place to excavate and remove contaminated soil to ~4.6-meter (~15-foot) depth where contaminated reactor cooling water, and other liquid waste were discharged to the soil in lieu of direct discharge to the Columbia River. This ROD for Interim Action also required excavation of pipelines to the river. Excavation may extend deeper, determined on a site-specific performance assessment, on residual contamination to prevent further degradation of groundwater (4 mrem/year drinking water standard) or may be terminated based on an analysis of technical feasibility. RODs for Interim Action are also in place to excavate and remove the contaminated contents and soil from solid waste burial grounds. Remedial action objectives for these activities are designed so that hypothetical future site users do not exceed $3x10^{-4}$ increased cancer risk for a rural resident (15 mrem/year) for an unlimited surface use of the land. Remediation of waste sites is reducing risk from contaminated soils from greater than $1x10^{-3}$ to approximately $3x10^{-4}$ for radionuclides and from greater than $1x10^{-3}$ to approximately $1x10^{-6}$ for metals and organics based on protection of a hypothetical rural resident farmer.

The exposure scenario consists of a resident farmer who spends 80% of his life for 30 years on the waste site (60% indoors, 20% outdoors and 20% offsite); eats plants, fish, milk and meat raised on the waste site. The farmer irrigates with 3 feet of water per year that can drive residual contamination towards the groundwater. For these calculations groundwater was considered to be a future drinking water source in order to isolate the effect of the individual waste site on the groundwater and evaluate the non-degradation requirement. The key contaminants that contribute to this risk scenario are cobalt-60, tritium, and silver-108. The scenario applied did not consider radioactive decay of these contaminants. The exposure scenario is not the actual use intended, it was a conservative way to address uncertainties and support the "bias for action" direction. The environmental risk is assumed to be bounded by the risk to human health.

Reactors are being demolished down to the shield walls and new 75-year roofs installed to stabilize these facilities to allow for natural decay of the activation products within the reactors. A National Environmental Policy Act (NEPA) Environmental Impact Statement (EIS) considered transporting the cocooned reactor cores to the Central Plateau for permanent burial. The EIS record of decision (NEPA ROD) commits the DOE to determine disposition of the reactor when the CERCLA record of decision is made for the surrounding waste sites. The NEPA ROD decision to remove the cocooned reactors will be re-evaluated by July 2006. The B Reactor may be left in place and used as a museum. All above-ground structures in the 100 Areas, except the cocooned reactors, will be demolished and excavated to 0.9 meters (3 feet) below grade. Contamination under structures is remediated similar to other waste sites in the 100 Area (15 mrem/year, 15 feet).

Detailed ecological evaluations were not made for the RODs for Interim Action. It was generally assumed that the remedy, based on a qualitative risk assessment for the protection of human health, would also be protective of the environment because a conservative exposure scenario was used. However, the RODs for Interim Action for the remediation of chromium-contaminated groundwater is based on exceedence of ambient water quality criteria (protection of biota) for hexavalent chromium in the localized area where such plumes up well into Columbia River gravel beds.

Final CERCLA ROD decisions have not been written for 100 Areas soil and groundwater cleanup. A baseline risk assessment of the river corridor has been initiated and will assess potential impact on human health and the environment to support final ROD decisions.

The K Basin current end state specifies all fuel, sludge, debris, and water be removed from the K Basins. The fuel would be stabilized and repackaged for interim storage in the Canister Storage Building within the Central Plateau with final disposition at a geologic repository. The sludge would be sent to T Plant for storage in special containers for up to ten years prior to disposition at WIPP, and debris from the facility will be removed during decommissioning of the basins and disposed of in burial grounds on the Central Plateau or through the Central Waste Complex. Water from the basins would be treated and disposed of in the 200 Area.

100 Area Risk-Based End State

Cleanup will be based on adequate protection to humans and environmental resources based on the CLUP identified conservation and preservation land use. Under the conservation and preservation land use there will be no full time residences or consumptive use of groundwater. The applicable range of exposure scenarios for this land use is envisioned to include the avid recreationalist, non-resident park ranger, and tribal fisherman.

These exposure scenarios will be developed in the River Corridor baseline risk assessment. A reasonable Tribal land use scenario will also be included to ensure the decision makers and Tribal members can compare cleanup levels and the level of protectiveness. The risk assessment will be a transparent and open CERCLA process and it will serve as the basis for final remedy decisions in the 100 Area. Actions under the RODs for Interim Action will continue but excavation of sites that would likely be removed under the RBES Vision will be prioritized while the final ROD is expedited. During excavation, characterization data will be developed to reduce uncertainty about remaining waste site and burial ground hazards to support RBES Vision recommendations.

The land in the 100 Area is envisioned to remain in Federal control in perpetuity. DOE will maintain its legacy management responsibilities required by the final remedy decisions. There will be continued surveillance and maintenance of the reactor cores for the foreseeable future. Should the final remedy choose caps for the larger burial grounds, there will be ongoing maintenance and groundwater monitoring for those caps as required by the ROD.

Up to 14 of the larger burial grounds could remain in place with caps as determined by the final ROD. The 100 Area Burial Ground Focused Feasibility Study (DOE/RL-98-18, Rev 1) recommended caps for these burial grounds however, it was determined that due to the uncertainty of the data that it was prudent to excavate and transport the contents of the burial grounds to the 200 Area. In order to reduce the uncertainty in our understanding of what is in these burial grounds, several small burial grounds and at least one larger burial ground will be characterized during excavation to validate contents.

The groundwater end state will be similar to the baseline (see Section 3.5.1). The RBES Vision for the 8 cocooned reactors recommends that they remain in place, be surrounded by fencing and sealed with welded doors. Large underground pipelines in the river bed will be evaluated in the River Corridor Risk Assessment and may remain in place in a safe configuration as determined by the ROD. Underground pipelines between the reactors and the liquid effluent disposal facilities may remain in place in a stabilized condition as determined by the ROD. The B Reactor may be used as a museum. Approximately 250 above-ground structures in the 100 Areas, except the cocooned reactors, will be demolished as determine by the ROD.

The risk-based end state for the K Basin would also be modified from the baseline. The fuel will be stabilized and repackaged for interim storage in the Canister Storage Building within the Central Plateau awaiting final disposition at a geological repository. In addition, water from the basins will be treated and disposed of in the 200 Areas. Fuel pieces comprising about 0.4 cubic meters of the 50 cubic meters of sludge will be removed from the sludge and be dispositioned with the fuel. The sludge will not be stored in T Plant but instead stabilized using in-container solidification processes similar to that used by commercial nuclear power plants and directly disposed at WIPP or on-site if the waste acceptance criteria are met. Most of the debris will remain in the basins, and the lower half of the basins will be filled with grout. The basins would then be cut into pieces and transported to an onsite disposal facility.

The 300 Area

The 300 Area is located in the southeast portion of the Hanford Site, along the west bank of the Columbia River, 2.4 kilometers (1.5 miles) north of the city of Richland. Some of the facilities in the 300 Area are still in use. Starting in 1943, the 300 Area was the location of the uranium fuel fabrication facilities and provided fuel for the reactors in the 100 Area. It also was the center for much of the Hanford Site's research and development activities. Facilities in the 300 Area include chemical processing laboratories, test reactors, and numerous ancillary/support structures. Later work included research for energy, waste management, biological, and environmental sciences. Over the years, each contributed to liquid and solid waste streams, contaminated buildings, and unplanned releases to the environment. The 300 Area contains a total of 195 waste sites of which 13 are burial grounds (includes 618-7, -10, and -11). Eight of these sites are outside of the 300 Area industrial complex in remote locations. They are the 300 vitrification test site, 316-4 crib at 618-10 burial ground, 600-47 dumping area north of 300 Area, 600-63 a 300-N lysimeter facility, 600-259 a lysimeter site, 618-7 drums of pyrophoric zircaloy chips, 618-13 contaminated soil mound, 618-10 transuranic contaminated waste. Sixty-eight of the 195 waste sites have been remediated of which 5 are burial grounds. Over 600,000 tons (over 33,000 truckloads) have been excavated from the 300 Area at a cost of approximately $60.5 million. The transportation risk of this campaign was 6.6×10^{-3} fatalities. No fatalities have occurred as a result of the 100 and 300 Area cleanup campaigns to date, however there have been 53 near miss incidents conducting this work. In addition there was one significant transportation incident and 40 events involving movement of material and equipment.

The primary source of groundwater contamination is from waste discharge to engineered facilities such as trenches. The primary environmental concern is uranium; a plume of uranium currently reaches the Columbia River. Refer to Section 3.5.1 for more detail.

300 Area Current Baseline End State

The land use for the 300 Area is industrial restricted surface use. The 300 Area has one final record of decision and one ROD for Interim Action. The remedial action objectives in these records of decision are based on the default MTCA industrial land use scenario for soil. Direct exposure, inhalation and ingestion are the primary pathways of concern. Direct exposure is from an 8 hour a day worker that is both indoors (15 feet below grade) and outdoors. There is also the assumption that contamination from wastes sites and burial grounds is at the surface. According to the RODs, human health risk is being reduced for the industrial worker from greater than 10^{-2} to 10^{-5} probability of additional cancer incidence for metals and organics and from $\sim 10^{-2}$ to $\sim 10^{-4}$ probability of additional cancer incidence or 15 mrem/year (based on EPA guidance on dose rate to risk conversion) for radionuclides. 300-FF-1 remedial actions that removed contaminated soils down to 15 feet from 16 waste sites including, the major liquid/process waste disposal sites, one burial ground and 3 small landfills are complete. 300-FF-2 remedial actions are underway to excavate solid waste burial grounds and haul the contaminated contents and soil to the Environmental Restoration Disposal Facility. Sixty eight have been completed as of September 2003. Final RODs have not been written for the entire 300 Areas soil and groundwater cleanup. A baseline risk assessment for the river corridor has been started that will assess human health and the environment to support final RODs.

Remedial actions will strive to prevent further degradation of groundwater through the leaching of residual contaminants to the extent practicable. Remaining burial grounds may remain in place with caps if they are protective and cost effective. Groundwater use will be restricted because of residual groundwater contamination. Contaminant discharges to the Columbia River will be below levels resulting in unacceptable risk to the environment or groundwater control actions will be put in place.

Eight waste sites/burial grounds are outside of the 300 Area industrial complex in remote locations. They are surrounded by undisturbed desert habitat. Discussions are underway with EPA to clean up these waste sites and burial grounds to unrestricted surface use for a residential non-farmer scenario even though the land use remains industrial. This scenario is similar to current scenarios in the 100 Area RODs for Interim Action with the exception that no irrigation is allowed. This is being pursued because excavation is believed to be a cost-effective way to shrink the contaminated footprint on the River Corridor. The additional cost to remediate the eight waste sites/burial grounds to meet the unrestricted surface use criteria has been estimated to be $750,000 (or just over 1%). Approximately $500,000 of the extra cost is attributable to the 618-10 burial ground.

Relatively few facilities in the 300 Area have decision documents associated with them. However, approximately 150 buildings and structures need to be removed to expose the 40 soil contamination areas within the 300 Area Industrial Complex that need to be cleaned up pursuant to the record of decision. A total of 220 facilities are slated to come down in the 300 Area.

300 Area Risk-Based End State

This section describes the hypothetical risk-based end state for the 300 Area in accordance with DOE Policy 455.1. The land use for the 300 Area is industrial restricted surface use. A site specific industrial exposure scenario as allowed by MTCA will be developed in the River Corridor baseline risk assessment. Other scenarios, (e.g., traditional Tribal scenario and the current MTCA industrial exposure scenarios) will also be included to ensure the decision makers and Tribal members can compare cleanup levels and the level of protectiveness. The River Corridor risk assessment will be a transparent and open CERCLA process and it will serve as the basis for final remedy decisions in the 300 Area. The interim actions will continue until the final CERCLA remedy decision for the 300 Area is in place.

The 618-7, 10 and 11 burial grounds are the largest contributors to risk based on current risk assessments and may be exhumed as determined by the final remedy ROD to remove waste and contaminated soil posing unacceptable risks for the site specific industrial use scenario or to prevent further groundwater contamination.

Some sites may require no action as determined by the final remedy ROD, however, characterization will be needed to support such final decisions. All remaining waste sites will be remediated or capped as determined by the final remedy ROD. All above-ground structures will be demolished to meet the site specific land use scenario as determined by the final remedy ROD. DOE will maintain its legacy management responsibilities required by the final remedy decisions. For example, should the final remedy choose caps for any remaining burial grounds, there will be ongoing maintenance and groundwater monitoring for those caps as required by the ROD.

3.5.3 Central Plateau - 200 Area Background, Baseline, and Risk-Based End State Descriptions

The Central Plateau consists of ~194 square kilometers (~75 square miles) near the middle of the Hanford Site. The plateau contains about 900 excess facilities formerly used in the plutonium production process, including five massive chemical processing facilities, or canyons, and PFP as well as about 1000 individual waste sites including both buried solid waste and contaminated soil.

The Central Plateau Core Zone of 64.7 square kilometers (25 square miles) will be an industrial exclusion zone land use for ongoing waste disposal operations and infrastructure services, which are needed for continued use or to support the cleanup mission. This collection of facilities, waste sites, canyons, and ongoing waste disposal operations is spread across the plateau. The rest of the Central Plateau, ~129.5 square kilometers (~50 square miles), will be designated conservation/preservation land use with restricted surface use, the majority being designated as conservation use. The receptors are the industrial nuclear workers, non-nuclear workers and authorized visitors.

Tank Farm Background. Today, ~$2x10^8$ liters (~54 million gallons) of liquid, sludge, and saltcake waste containing ~200 million curies of radioactive material are stored in 149 single-shell tanks and 28 double-shell tanks. The tanks are distributed among 18 tank farms within the 200 East and 200 West Areas on the Central Plateau. DOE-ORP was created to execute cleanup of the Hanford tank farms. The responsibilities of DOE-ORP include retrieving waste from the tanks in accordance with the Tri-Party Agreement (Ecology et al. 1998), treating and disposing of the waste to authorized disposal locations, executing targeted remediation actions when necessary if soil and/or ancillary equipment contamination levels so warrant, and closing the tank farms in a manner that will protect human health and the environment for extremely long times (hundreds or thousands of years).

Most of the tanks are beyond their design life and 67 have leaked or are assumed to have leaked approximately one million gallons. Some of the leaked waste has reached the groundwater that flows to the Columbia River. Airborne releases are also a hazard. Currently, workers are exposed to chemical vapors that are occasionally emitted from the tanks, however exposures are controlled within established safety limits. Radioactive airborne releases with potential to reach off site could occur if, as a result of a leak in a pressurized transfer line, waste was sprayed into the air. As of the end of FY 2001, all urgent tank safety issues were resolved including the flammable gas and high heat tank issues. During the past few years of active tank remediation, there have been 29 uptakes less than 100 mrem and numerous work stoppages due to tank vapor concerns.

200 Area Current Baseline End State

Most of the contaminant inventory from the Hanford production era is stored or disposed in the 200 Areas within the Central Plateau. The 200 Areas also receive waste from cleanup operations from the rest of the Hanford Site as well as offsite waste from other DOE sites. The likely end state for Central Plateau, under current plans, is described in the following paragraphs:

The 200 Area remedial investigation/feasibility study Implementation Plan (DOE/RL-98-28) proposes a standard dose of 15 mrem/year or a risk of 10^{-4} to 10^{-6} for risk evaluations. Current baseline remediation goals for all waste sites incorporate a cleanup dose rate standard of 15 mrem/year for industrial workers under an industrial-use scenario. This is based on an industrial scenario for all remedial actions inside the Central Plateau Core Zone. Outside the Core Zone, land use is identified as conservation (mining). The baseline remediation goals are based on the risk range of 10^{-4} to 10^{-6} under CERCLA using an industrial scenario as a conservative estimate for the conservation (mining) land use. Other scenarios (residential, recreational, Tribal) are also evaluated to provide the DOE, regulators, Tribes and stakeholders a comparison for evaluating ultimate cleanup objectives.

The 200 Areas will continue to receive waste from Hanford cleanup activities and from offsite sources. DOE has committed to the state of Washington to dispose of future radioactive low-level waste in burial grounds equipped with liner/leachate collection systems equivalent to RCRA requirements. This is supported by some stakeholders based on the presumption that such systems provide an increased environmental benefit at Hanford. Liner/leachate systems are used to collect precipitation and dust control water during active waste disposal operations. They have very short design lives (~30 yrs) and are not relied on for post-closure performance, although they will collect leachate if generated for some period. After waste operations cease, containment of the waste site is controlled by the surface cap or barrier. Liner/leachate systems are not required in the commercial low-level burial grounds licensed by the U.S. Nuclear Regulatory Commission located at Hanford. We estimate a need for up to 3 more burial ground cells that will cost ~$9.5M each for the liner and leachate system.

The five canyon facilities will be disposed in place with a suitable surface barrier or cap to prevent infiltration of water and/or to prevent intrusion by human or ecological receptors. No additional waste will be disposed in the canyons; however, existing contaminated equipment from the canyon deck would be reduced in size and placed in the canyon process cells and grouted. Transuranic material will be disposed at the Waste Isolation Pilot Plant. The upper part of the canyon building would then be demolished to approximately the level of the canyon deck. Debris from this partial demolition would be placed on or adjacent to the canyon deck and then filled with grout to minimize voids. The partially demolished building and debris would be covered with a surface barrier. The PUREX tunnels will be filled with grout and covered with a surface barrier.

The Plutonium Finishing Plant had approximately 17 metric tons of bulk plutonium bearing material that has been stabilized and repackaged into approximately 2,200 Specification 3013 cans awaiting final disposition offsite and approximately 2,400 Pipe Overpack Containers stored at PFP and the Central Waste Complex awaiting shipment to WIPP. In addition, there is less than 0.1 metric ton of plutonium hold-up that will be packaged as transuranic waste to WIPP or low-level waste to an onsite disposal facility. PFP and other 200 Area ancillary facilities will be removed to ground level and disposed in an approved facility (currently the Environmental Restoration Disposal Facility or Waste Isolation Pilot Plant, as required). Potential sub-surface contaminants will be disposed in a manner consistent with waste site remedial alternatives discussed below.

Approximately 15,000 cubic meters of suspect transuranic waste were placed in retrievable storage trenches in 4 low-level burial grounds starting in 1970. The waste is being retrieved from the trenches and characterized to determine if it is transuranic or low-level waste. Two additional waste sites located outside the 200 Areas (618-10 and 618-11) contain ~10,000 cubic meters of suspect transuranic waste. The low level fraction will be treated and disposed on-site as mixed low level waste in a permitted disposal facility, and the transuranic fraction will be shipped to WIPP. This could require an estimated 3000 shipments to WIPP. All retrieval actions will be completed by 2018.

The Central Plateau includes approximately 1000 waste sites including 132 burial grounds/landfills/dumps. Sixty nine of these waste sites including 29 landfills/dumps are outside the core zone. There are 33 burial grounds inside the Core Zone.

No action is proposed for 17 of the 69 waste sites outside the Core Zone. Three of the waste sites outside the Core Zone are landfills containing solid waste or dangerous non-radioactive wastes. Only one soil waste site (the 200-B-57 crib), has been remediated, however, the CERCLA final ROD covering that waste site has not been approved. This waste site was covered with the Hanford prototype surface barrier in 1994.

The cribs, trenches, ponds, and burial grounds, i.e., waste sites, will be generally addressed by one of four alternatives: 1) capped with a suitable surface barrier; 2) removed, treated, and disposed to an approved disposal facility; 3) existing soil covers maintained under institutional controls and natural attenuation; or 4) no action. Other actions may be needed for site-specific remediations, such as the presence of organic constituent. Surface barriers will be designed to limit the infiltration of water and thereby slow the movement of contaminants currently in the vadose zone into the underlying ground-water. Barriers will be designed to reduce infiltration and prevent intrusion by plants and animals so that the underlying contamination is not dispersed. Smaller 200 Area waste sites may be consolidation if cost efficiencies can be gained and worker risk associated with moving the contaminated material is acceptable. Current baseline cost estimates assume 32% of the waste sites or approximately 825 acres will receive a surface barrier (Hanford Barrier or Modified RCRA C), 40% of the waste sites removed and disposed, and 28% under natural attenuation or no action. The required surface barrier material to cover the ~825 acres of waste sites 2 meters thick totals close to 6.7 million m^3 or ~570,000 truck trips.

Disposition of over 400 miles of buried pipelines in the Central Plateau has not been resolved. Few resources have been identified in current cleanup plans. One possibility is that limited sections may be removed, treated, and disposed to the Waste Isolation Pilot Project or other approved disposal facilities.

Institutional controls under federal control will be an integral component for appropriate remedies. Controls may include restrictions to prevent intrusion or modifications to the cap, environmental monitoring, and/or deed restrictions.

Approximately 2000 cesium and strontium capsules stored at Hanford contain ~130 million curies of radioactivity, which amounts to ~37% of the total radioactivity at the Hanford Site. Currently, the capsules are stored under shielding water in a basin within the Central Plateau. DOE manages the capsules as high-level mixed waste subject to regulation under RCRA. The previous planning assumption was that the capsules would be transferred to the Waste Treatment Plant for vitrification and subsequent disposal offsite. Because the present storage configuration for the capsules presents challenges including vulnerability to accidents, security threats, and high annual surveillance and maintenance costs (~$5 million/year), DOE is considering placing the capsules in dry storage and believes they could be directly disposed at a national geologic repository.

The main challenges for managing and disposing of the capsules are well described by the National Research Council, Board of Radioactive Waste Management, *Improving the Scientific Basis for Managing DOE's Excess Nuclear Materials and Spent Nuclear Fuel* (2003). The main challenges identified by the Board are the intense radiation and the relatively large amount of heat that the capsules produce. Dose rates range from 8,600 to 18,000 rem/hour for the cesium-137 capsules and from 20 to 420 rem/hour for the strontium-90 capsules. Compared to other nuclear materials in DOE's inventory, cesium-137 and strontium-90 have relatively short half-lives, 30 years and 29 years, respectively. Cesium and strontium have limited mobility in the environment due to adsorption on clays and other alumino-silicates. The capsules are considered in good condition; however, 23 capsules have been overpacked, i.e., sealed in a larger stainless steel container. The 23 capsules were overpacked due to integrity questions from abuse by commercial users during offsite beneficial use, or because the capsule has been altered during destructive tests or other research. Various mechanisms for capsule failure have been anticipated including poor welds and phase changes in the material as a function of temperature. Capsules "may have experienced chloride-induced stress corrosion cracking near the outer capsule welds due to lack of water chemistry requirements and control." (BRWM 2003)

In addition to the cesium/strontium capsules, transuranic waste and spent fuel from 100-N Area will be packaged and disposed offsite in selected high-level waste and spent fuel geologic repository, Yucca Mountain Nuclear Waste Repository or the Waste Isolation Pilot Project, for permanent disposal. This does not change for the RBES vision.

Tank Specific Current Baseline End State. DOE-ORP's cleanup approach integrates its commitments under the Tri-Party Agreement with its responsibilities under the Atomic Energy Act of 1954, the National Environmental Policy Act (NEPA), and applicable DOE Orders and environmental regulations that result from those acts, as well as other applicable requirements. While the Tri-Party Agreement cleanup and closure requirements are relatively prescriptive, the Tri-Party Agreement and the regulations it encompasses do include moderate levels of flexibility to deploy risk-based solutions for cleanup and closure actions. Examples include Appendix H to the Tri-Party Agreement (Ecology et al. 1998), which provides for alternative retrieval levels if the 99% goal cannot be reasonably attained. Under Appendix H, a balance can be struck between long-term risk, risk to workers, technical practicality, and cost to arrive at alternate levels. Similarly, while the Tri-Party Agreement's RCRA roots tend to focus on achieving clean closures, provisions exist that can lead to landfill closures based on similar tradeoffs considered under Appendix H. The result is that while some cleanup actions will be taken to meet prescriptive objectives, exercising the flexibilities within Tri-Party Agreement will result in protective conditions existing at the completion of cleanup and closure with risk analyses being a factor in determining the final end states. The tank farm end states are within the final closure of the Hanford Site and groundwater protection that are regulated under CERCLA using risk-based principles.

The high-level portion of waste contained in the single- and double-shell tanks will be stabilized in glass logs to be permanently disposed in the Yucca Mountain Repository. The low-level portion will be stabilized in glass logs, or another stable waste form approved by the state of Washington, and permanently disposed in the 200 Areas. After waste retrieval, single- and double-shell tanks will likely be backfilled, stabilized in place, and surface barriers placed over tank farms to prevent movement of contaminants to groundwater. This includes tank heels, tank waste discharged to soil in engineered structures, and inadvertent discharges to ground. Barrier construction over tank farms will be coordinated with adjacent waste site barrier construction. Further details regarding the current baseline include the following actions:

1. Waste will be retrieved to the extent technically possible as required by the Tri-Party Agreement. This should result in ~99% of the waste volume being retrieved and treated.

2. High-level waste, containing >90% of the current total tank radioactive material inventory, will be vitrified and, following several years of interim onsite storage, disposed of at the national high-level waste and spent nuclear fuel repository.

3. Transuranic waste retrieved from the tanks will be treated and packaged in a manner that should enable disposal off-site at the Waste Isolation Pilot Plant transuranic geologic repository.

4. Low-activity waste and secondary low-level mixed waste will be treated and put into stabilized forms that enable disposal onsite within the 200 Area Core Zone in DOE authorized and Washington State Department of Ecology permitted (RCRA) mixed waste disposal facilities.

5. Waste residues that cannot be removed from the tanks will be stabilized with grout formulations and/or other materials engineered to isolate and contain any radioactive and hazardous constituents associated with the residuals. The tank void space (above the stabilized residual level) will be back-filled with natural and/or engineered materials selected to both contribute to the defense-in-depth containment and isolation of the wastes and to stabilize the tank against structural failure, e.g., dome collapse.

6. Above grade structures within the tank farms will be decommissioned and brought to grade level. Contaminated rubble and other materials will be disposed of in RCRA and/or CERCLA compliant facilities. Ancillary equipment, pits, and piping will have any liquids removed to the extent it is possible to do so and be backfilled to fill major void spaces prior to final closure.

7. Engineered barriers (modified RCRA, Hanford barrier, hybrid barrier) will be placed over the tank farms to divert precipitation from contacting residual wastes in the tanks, ancillary equipment, and the soil column underlying the tank farms. The surface barriers will also provide protection against plants, animals, and certain forms of possible human intrusion, e.g., shallow excavations.

8. Tanks and tank farms will be landfill closed under the Tri-Party Agreement. Active and passive institutional controls (guards; fences; permanent surface and embedded markers; government held land, water, and mineral rights; extensive public records delineating the location and content of the closed tank farms) will be used to reduce the risk of inadvertent intrusion, e.g., major excavation or drilling to obtain groundwater for irrigation or potable purposes. Monitoring systems will be put into place and maintained for an indefinite period of time in the future (hundreds of years) to measure parameters that affect contaminant transport and determine whether any waste migration may be occurring. Specific approaches will be determined nearer the time when final closure of the Hanford Site occurs, using appropriate information/technology available at that time.

200 Area Risk-Based End State

Stakeholders, as articulated in *The Future for Hanford: Uses and Cleanup – The Final Report of the Hanford Future Site Uses Working Group* (DOE 1992b) and consensus advice from the Hanford Advisory Board (ADVICE # 132 see Appendix B), have recognized for many years that waste will remain in the 200 Areas. This view is captured in the CLUP by giving the Central Plateau an industrial-exclusive land use designation, i.e., an area suitable and desirable for treatment, storage, and disposal of hazardous, dangerous, radioactive, non-radioactive waste, and related activities. Adjacent areas will be conservation areas, i.e., areas reserved for the management and protection of archeological, cultural, ecological, and natural resources with possible limited and managed mining within appropriate areas.

Because the Central Plateau will remain an industrial area to be used exclusively for waste management operations (nuclear and non-nuclear) for the foreseeable future CERCLA records of decision for the 200 Area will define cleanup and future exposure levels to be compatible with an industrial-exclusive land use. Cleanup will be designed so that workers under industrial nuclear and non-nuclear worker scenarios are at acceptable exposure levels. A reasonable industrial exposure scenario will be used that includes direct exposure to surface soil, exposure during limited excavation, inhalation, absorption, and ingestion of contaminants. This scenario assumes no groundwater use. Waste sites containing contaminated soil will be remediated through the use of a surface barrier or will be clean enough to: not further degrade the groundwater through the leaching of residual contaminants (>4 mrem/year drinking water standard) from natural recharge, protect the environment, and protect human health within the acceptable CERCLA risk range for restricted surface use as allowed by industrial exclusion land use.

An optimization strategy for Central Plateau closure is being developed that adopts a regional or "zone" approach to optimize and prioritize the cleanup of facilities, waste sites and structures to achieve closure. The RBES Vision is to continue development of and to finalize this approach for implementation. The 200 Area will continue to receive waste (radioactive and mixed) from Hanford cleanup activities and from offsite sources. These materials will continue to be disposed in trenches, and resources will focus on measures to reduce infiltration at closed Hanford burial grounds. One variance that was considered but will not be pursued is to reconsider the commitment that was made to dispose all future low-level radioactive waste in lined trenches with leachate collection systems – DOE-EM-1 has committed to the state of Washington that all future solid waste disposed at Hanford will be in lined trenches. Liners will provide limited additional risk benefit because waste for new cells must meet waste acceptance criteria that will minimize probability of liquid generation. Long-term protection, including ground water protection can be adequately provided by surface barriers. Putting waste in lined trenches is not expected to result in significant risk reduction and increases costs for construction and operation. An estimated 3 more burial ground cells are needed in the Central Plateau Core Zone. RCRA subtitle C liners and leachate systems will cost ~$9.5 million for each cell. The RBES vision proposes to focus resources on improving caps and covers at the many existing closed low-level waste burial grounds at Hanford where minimal operational covers have been constructed.

Several options have been considered to dispose of the cesium and strontium capsules. These options include continued storage in the pools at the Waste Encapsulation and Storage Facility, passive storage in air at a new facility, overpacking and disposal of the capsules at a geologic repository, and vitrification into a glass or calcination into an oxide followed by disposal at a geologic repository.

Onsite dry storage for up to 50 years in the Central Plateau of the Hanford Site should be considered as a potential cost efficient risk-based option until it can be shipped to an offsite geological repository. The National Research Council, Board of Radioactive Waste Management (2003), identified that "Intermediate or long-term storage on site has the advantages of allowing monitoring and surveillance, providing physical protection, saving the material as a potential resource, and maintaining the material in disposal-ready condition while avoiding interstate transportation issues. Given their approximately 30-year half-lives, the isotopes could decay significantly during storage thus reducing their hazard and difficulty of eventual disposal. Issues for long-term storage include the commitment to maintain the storage facility and the capsule failure risk due to a lack of understanding of the processes occurring in the capsules. For dry storage, the capsules would be moved using robotics and stored in air in a special facility designed to convectively exhaust the heat generated."

The five canyon facilities will be disposed in place with a suitable surface barrier or cap to prevent infiltration of water and/or to prevent intrusion by human or ecological receptors. Additional waste may be disposed along with existing contaminated material and equipment from the canyon deck in the canyon process cells, and/or on the canyon deck, and then all voids filled with grout. The upper part of the canyon building would then be demolished to approximately the level of the canyon deck. Debris from this partial demolition would be placed on or adjacent to the canyon deck then filled with grout to minimize voids. The partially demolished building and debris would be covered with a surface barrier. The PUREX tunnels will be filled with grout and covered with a surface barrier.

The surface barrier for each partially demolished canyon will require an estimated 460,000 m^3 of borrow source material. For all five canyons this equates to 2.3 million m^3 of material or approximately 200,000 truck trips at 11.5 m^3 per truck. Due to this magnitude of material and the potential ecological impact to the borrow source area and industrial risks, an alternative to leave the canyon structure intact without a surface barrier may be considered. This will be carried as a variance to the baseline pending further trade-off studies and evaluation.

Ancillary facilities in the 200 Areas will be removed to ground level and disposed under the surface barrier of the nearest canyon facility. Potential sub-surface contaminates will be disposed of consistent with waste site remedial alternatives.

Following removal of transuranic material, the Plutonium Finishing Plant and Plutonium Reclamation Facility will be partially demolished to the concrete structure surrounding the RMC/RMA glovebox lines and the lower canyon structure of the Plutonium Reclamation Facility. Debris from this partial demolition would be placed on or adjacent to these areas then filled with grout to minimize voids. Remaining contaminated material will be left in place. The partially demolished building and debris would be covered with a surface barrier.

More than 1000 waste sites such as cribs, trenches and ponds, including 132 burial grounds/landfills/dumps will still be generally addressed by one of four baseline alternatives: 1) capped with a suitable surface barrier; 2) removed, treated, and disposed to an approved disposal facility; 3) existing soil covers maintained under institutional controls and natural attenuation; or 4) no action. Other actions may be needed for site-specific remediations, such as the presence of organic constituent. Surface barriers will be designed to limit the infiltration of water and thereby slow the movement of contaminants currently in the vadose zone into the underlying groundwater. Barriers will be designed to reduce infiltration and prevent intrusion by plants and animals so that the underlying contamination is not dispersed. Remove, treat, and dispose will be minimized and monitored natural attenuation will be maximized. Waste site consolidation will be considered to consolidate smaller 200 Area waste sites if cost efficiencies can be gained. Thirty-two percent of the waste sites will still require a surface barrier; however, in lieu of the more complex and expensive Hanford barrier or Modified RCRA C barrier, a less complex highly effective evaporative transport barrier will be used with an expected cost savings of 25% or more. In addition, fewer of the sites will require removal, treatment, and disposal of waste, and more of the waste sites will use natural attenuation or require no action.

One of the reasons for pursuing this approach is that worker risks associated with the remove, treat, and dispose activities are greater than those associated with capping. The risks to the worker are greater based on the multiple stages of operation in remove, treat, and dispose remediation activities. The potential for both common industrial accidents and accidents associated with exposure to radiological contamination are increased. There is also a cost risk associated with implementing the remove, treat, and dispose alternative; that is the cost of employing mitigative actions to protect the workers from potential exposure during various stages of operation.

Approximately 15,000 cubic meters of suspect transuranic waste that was placed in 4 burial grounds after 1970 remain in place with a cap. The baseline assumes removal and offsite disposition of the TRU waste component (approximately 1000 shipments to WIPP) and treatment and on or off site disposal of any low level waste component resulting from removal activities. The current cost estimate to complete waste retrieval in burial grounds 218-E-12B and 218-W-3A is about $355M. Estimated treatment costs for the non-TRU waste retrieved from the low-level burial grounds are about $340M and for thermally treating 600 m^3 of mixed low-level waste about $36M. Under the RBES Vision these wastes could be safely left in place based on the 200 Area Industrial Exclusive land use and impacts to ground water would not change. This action would also reduce risk from offsite transportation of this TRU waste to WIPP and would avoid workforce risk to remove and treat the waste. This variance will not be pursued because of recently negotiated milestone changes acceptable to DOE-RL and because implications for DOE TRU Waste disposition NEPA decisions are not well understood at this time.

The miles of buried pipelines in the Central Plateau would be stabilized in place with very few sections removed, treated, and disposed to the Waste Isolation Pilot Plant or other approved disposal facilities.

Institutional controls under federal control will be an integral component for appropriate remedies. Controls may include restrictions to prevent intrusion or modifications to the cap environmental monitoring, and/or deed restrictions.

Future 200 Area waste management and disposal operations will be designed, in concert with non-degradation policies, to minimize the contamination of underlying groundwater to the extent practicable. Current and future groundwater remediation will focus on contaminant plumes that are currently contained within the Central Plateau but have the potential to migrate outside the plateau. CERCLA processes under the Tri-Party Agreement will be used to reach final records of decision for the 200 Area groundwater plumes. It is expected that remediation efforts in this region will focus on carbon tetrachloride, uranium, and technetium-99. It is also expected that natural attenuation processes will be used to address the tritium, iodine-129 and nitrate plumes that have migrated from the 200 East Area.

Tank-Specific Risk Based End State. The RBES envisioned by DOE-ORP for the tank farms is the same as the baseline described above except for:

- Risk based criteria for expected land use (industrial exclusive in the 200 Area Core Zone and Conservation/Preservation outside of the Core Zone) will be used for tank waste retrieval and tank closure decisions. It is anticipated that this will result in an increase in the amount of remaining tank residues.

- Tank closure conducted under full integration of RCRA and CERCLA. This integration will provide a more efficient process and ensure that all tank closure actions will lead to closure under both sets of requirements without the need for any "rework."

- Tank cleanup and closure will be integrated with other 200 Area RBES cleanup strategies utilizing the geographical area closure concept. This will enable joint actions with nearby waste sites and will consider the composite impacts from all remaining waste residuals on the Central Plateau.

4.0 Hazard Specific Discussion

This chapter describes the specific hazards at the Hanford Site and is organized by the major areas at Hanford: 100 Areas, 200 Areas and 300 Area (including key waste sites located in the 600 Area). In September 1996, the 1100 Area of the Site was cleaned up and deleted from the National Priorities List. This chapter also describes the potential exposure pathways (Conceptual Site Models) for both the current baseline end state and the RBES vision.

Hazards at the Hanford Site can be grouped in two broad categories:

- **Near-term (safety-related) hazards** – where hazards with potentially large consequences could result from the release of radionuclides and chemical contaminants in the current or remediation phase. The major exposure pathway to receptors is via the air. Near-term releases are characterized by a relatively low likelihood of occurrence but with moderate-to-high consequences. These hazards affect directly involved workers, co-located workers, and potentially the public and ecosystem receptors. Examples of these hazards include the spent nuclear fuel stored in the K Basins, other larger inventories of radionuclides such as the cesium and strontium capsules stored in the Central Plateau, the plutonium inventory at PFP, the TRU waste drums at CWC, and the former safety issue tanks. Current systems and procedures are in place to safely manage the risk posed by these materials and to minimize the potential for accidents that could lead to adverse consequences.

- **Long-term (environmental and human health) hazards** – where harm results from transport of radionuclide and chemical contaminants through the groundwater to human and ecological receptors or directly to future site uses. Long-term risks are characterized by a relatively high likelihood of occurrence but releases occur over a long time. The time frame of concern is primarily post-closure (e.g., 100s or 1000s of years in the future). Examples of these hazards include the past releases of contaminants to the soil column in both the 100 and 200 Areas and existing groundwater plumes that discharge to the Columbia River.

In considering hazards, it is also important to understand the additional hazards that can be caused during remediation activities to workers and to ecological receptors through physical disruption of natural habitats.

Since the beginning of the Environmental Management mission at the Hanford Site in 1989, the highest priority has been given to the reduction and elimination of the near-term risk contributors. These hazards represent the dominant source terms for near-term, safety-oriented risk assessments at the Hanford Site. These hazards are reduced and eliminated through removal to the 200 Area away from the River and population sources, through stabilization to less

Risk and Hazard

Risk is generally described as the product of the consequences and the likelihood of a receptor being exposed to a hazard. To understand risk it is necessary to understand the hazard source (e.g., quantity, toxicity, dispersability), the likelihood of its release, the potential transport path-ways (e.g., air, soil groundwater), and the specific exposure mechanisms for potential receptors (e.g., inhalation, ingestion).

hazardous forms, and through shipment off-site for final disposition. Among the most significant reductions in the near-term hazards that have been achieved to date include:

- As of February 2004, ~80% of the spent nuclear fuel stored in the K Basins had been removed and placed in safe, dry storage in the 200 Area.
- In February 2004, PFP plutonium stabilization activities were completed.
- As of the end of FY 2001, all tank safety issues were resolved including the flammable gas and high heat issues, the two most problematic issues.
- In 2001 through 2002 the largest radiological inventories in the 300 Area were removed including the 324 Facility B Cell cleanout, removal of 13 MCi of isotopic heat sources (the German logs), and removal of other spent nuclear fuel.
- Significant hazards were removed from PUREX and B Plant in 1997 and 1998, respectively, resulting in less costly surveillance and maintenance.

Substantial progress has also been made in lowering the risk posed by long term hazards by reducing the potential for further environmental releases and by reducing the driving forces for prior environmental releases. These hazards represent the dominant sources for current and potential environmental contamination that can pose a threat to ecological receptors and to future human receptors. These hazards are reduced or eliminated by implementing treatment systems, including some removal actions, and by reducing the mobility and potential driving forces for transport through the environment. Among the most significant progress in eliminating long-term hazards are:

- Early in 2004, interim stabilization of all 149 single-shell tanks was completed by removal of pumpable liquid.
- From 2002 to 2004, extensive interim actions were implemented to minimize natural and man-made infiltration (e.g., water line leaks) into the vadose zone within tank farms to halt potential remobilization of previously leaked contaminants.
- Groundwater remediation was initiated in the 100 Areas for chromium in 1997 and for strontium-90 in 1995 to reduce the potential impact on the River ecosystem.
- Vapor extraction for the carbon tetrachloride plume in the 200 Areas (ZP-1) was initiated in 1996 and continues to remove contaminant mass from this plume.
- From 1990 to 1995, liquid discharges to the 200 Areas soil column were reduced by ~6 billion gallons per year, thus reducing new sources of contamination and eliminating a key driving force for previous vadose zone and groundwater contamination.

The following sections summarize the remaining hazards in the 100 Areas, 200 Areas and 300 Area. The potential exposure pathways are also described for both the current baseline end state and the risk based end state.

4.1 100 Areas

The 100 Areas are located on the Columbia River shoreline, where nine nuclear reactors operated from 1944 to 1987. The nine plutonium production reactors are ~30 miles from Richland in the northern portion of the Hanford Site along the south bank of the Columbia River. The reactor areas had to be close to the river because large quantities of water were required for cooling.

4.1.1 Summary of Existing Hazards in the 100 Areas

Table 4.1.1 summarizes the existing hazards in the 100 Areas. The top priority hazards in the 100 Areas are the following in descending order of their relative importance:

- **N Reactor fuel and sludge at K Basins**. The remaining N Reactor fuel stored in the K Basin storage pools along with the sludge pose the most significant risk to workers and the public. Current systems and procedures are in place to safely manage the risk posed by this material and to minimize the potential for accidents that could lead to adverse consequences. Also, work is approaching completion on transferring the fuel to a safer dry storage configuration in the Central Plateau away from the Columbia River.

- **Existing groundwater plumes that release contaminants to the Columbia River**. Several groundwater hexavalent chromium plumes, resulting from previous liquid discharges, have been found to be upwelling into the Columbia River at levels that exceed ambient water quality criteria for the protection of aquatic species by a factor of ~xx. In addition, there is a strontium-90 plume at 100-N that exceeds drinking water standards by a factor of ~1,000. Active systems are in place to reduce potential releases to the River...

- **Former production reactors**. Nine former production reactors include de-fueled graphite cores with a significant inventory of radionuclides.

Figures 4.1.1 – 4.1.6 display maps of the hazards in each of the 100 Areas.

4.1.2 Exposure Pathways and Potential Implications of the Risk-Based End State Vision

Table 4.1.2 summarizes the assumptions for land use, exposure scenarios and pathways, remediation goals, and institutional controls (including final barriers if any) for both the current/baseline end state and the risk based end state vision. The current RODs for Interim Actions for waste sites in the 100 Areas preceded the issuance of the ROD for the CLUP. The waste site RODs established cleanup goals based on a presumed "rural residential farmer" exposure scenario. Subsequently, the CLUP established the land use for the 100 Areas as conservation/preservation. While the original RODs for Interim Actions only envisioned land use that was "unrestricted surface use," the remediation goals were based on an assumed rural residential farmer scenario that included use of future groundwater. The CLUP land use scenario and the National Monument designation do not envision residential land use or groundwater use (current or future). The intent of the RBES vision is to align the remediation goals with an exposure scenario that is consistent with the CLUP land use designation.

Table 4.1.1 Summary of Hazards in the 100 Areas

Material Category	Current Hazard
Surface	
Spent Nuclear Fuel and Sludge	• Reactor fuel in K Area storage basins. Approximately 50 million curies. Currently undergoing removal, repackaging and shipment to 200 Area. Completion scheduled for July 2004. 79 containers remain to be filled out of a total of 383 required as of February 2004. • K Basin sludge and debris. 200,000 curies. Approximately 50 cubic meters require packaging for removal with less than 0.5 m^3 of fuel pieces contributing the majority of this source term.
Surplus Production Reactors	• Nine surplus production reactors. Radioactive inventory includes tritium (~98,000 curies); carbon-14 (~37,000 curies); chlorine-36 (~270 curies); cobalt-60 (~74,000 curies); cesium 137 (~270 curies); and uranium-238 (about 0.01 curies). The dose to workers from cobalt-60 and cesium-137 is one of the main drivers leading to the decision to place the reactor cores in-situ stabilization for 75 years.
Ancillary Facilities	• Ancillary facilities supported operations and maintenance of reactors. There were a total of 250 ancillary facilities in the 100 Areas with the remaining facilities located primarily at 100-N (59), KE/KW. Hazards range from industrial to potential contamination with radiological constituents, i.e. fission and activation products, metals, inorganics, volatile organic compounds, and organic compounds.
Subsurface	
Liquid Waste Sites	• As of 1978, the deactivated 100 Area liquid waste sites contained a total radioactive inventory of 4,400 curies. The principal radionuclides remaining in the waste sites were reported to be tritium, carbon-14, cobalt-60, nickel-63, strontium-90, cesium-137, europium 152, europium-154, europium-155, and plutonium-239/240. DOE (1994) reported a 1988 inventory of about 10,000 curies of radionuclides (cobalt-60, strontium-90, ruthenium 106, cesium-134, cesium-137, and plutonium-239) in the two main 100-N Area liquid waste sites. Additional non-radioactive contaminants, such as sodium dichromate, are also common in the liquid waste sites.
Solid Waste Burial Grounds	• 45 sites are estimated to have over 1 million cubic meters of solid, low-level radioactive wastes associated with reactor operations. Waste containing plutonium or any other alpha emitters, cobalt-60 in amounts greater than 1 millicurie/gram, or beryllium was packaged and shipped to the 200 Area for burial in designated trenches. The main radionuclides are tritium, carbon-14, cobalt-60, nickel-63, strontium-90, cesium-137, silver-108m, europium-152, europium-154, and europium-155. Because disposal records prior to the late 1960s were not detailed, the estimates of the radionuclide inventory are uncertain and largely drawn from evaluations of analogous sites. The predominant radionuclides anticipated in the 45 burial grounds (compiled) are: tritium ~19,000 curies; cobalt-60~ about 3,000 curies; nickel-63 about 2,000 curies; strontium-90 < 10 curies; cesium-137 <10 curies; and silver-108m – about 60 curies.
Groundwater	
Groundwater	• The most prominent contaminants in 100 Areas groundwater are tritium, strontium-90, hexavalent chromium, and nitrate. These contaminants originated primarily from disposal cribs and trenches, condensate cribs. Other sources include leaks from the 100-K East fuel storage basin, leaks from the 183-H basin and leaking retention basins. Because these sites are close to the Columbia River, these contaminants have been detected in springs that discharge to the river.

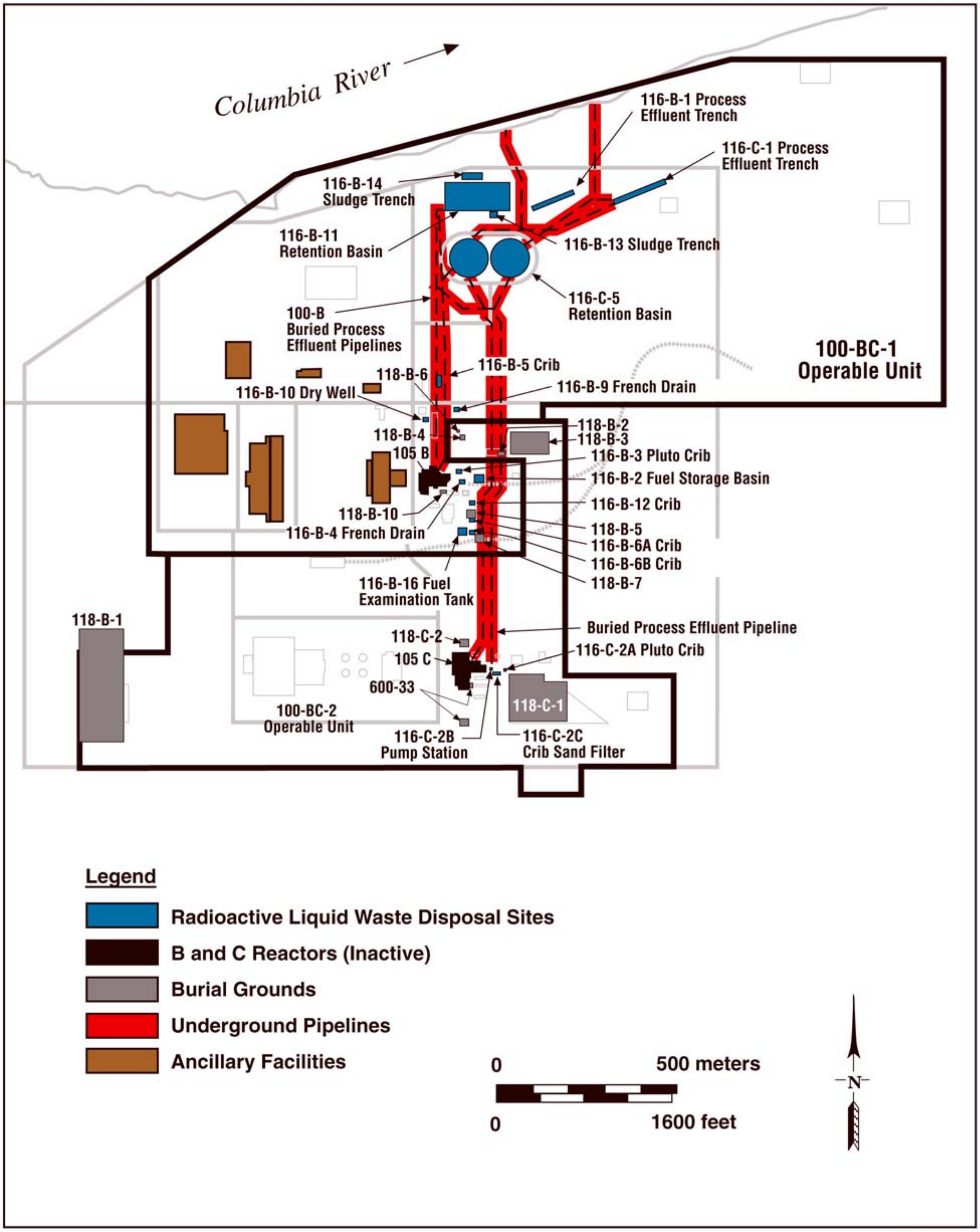

Figure 4.1-1. 100-B/C Area

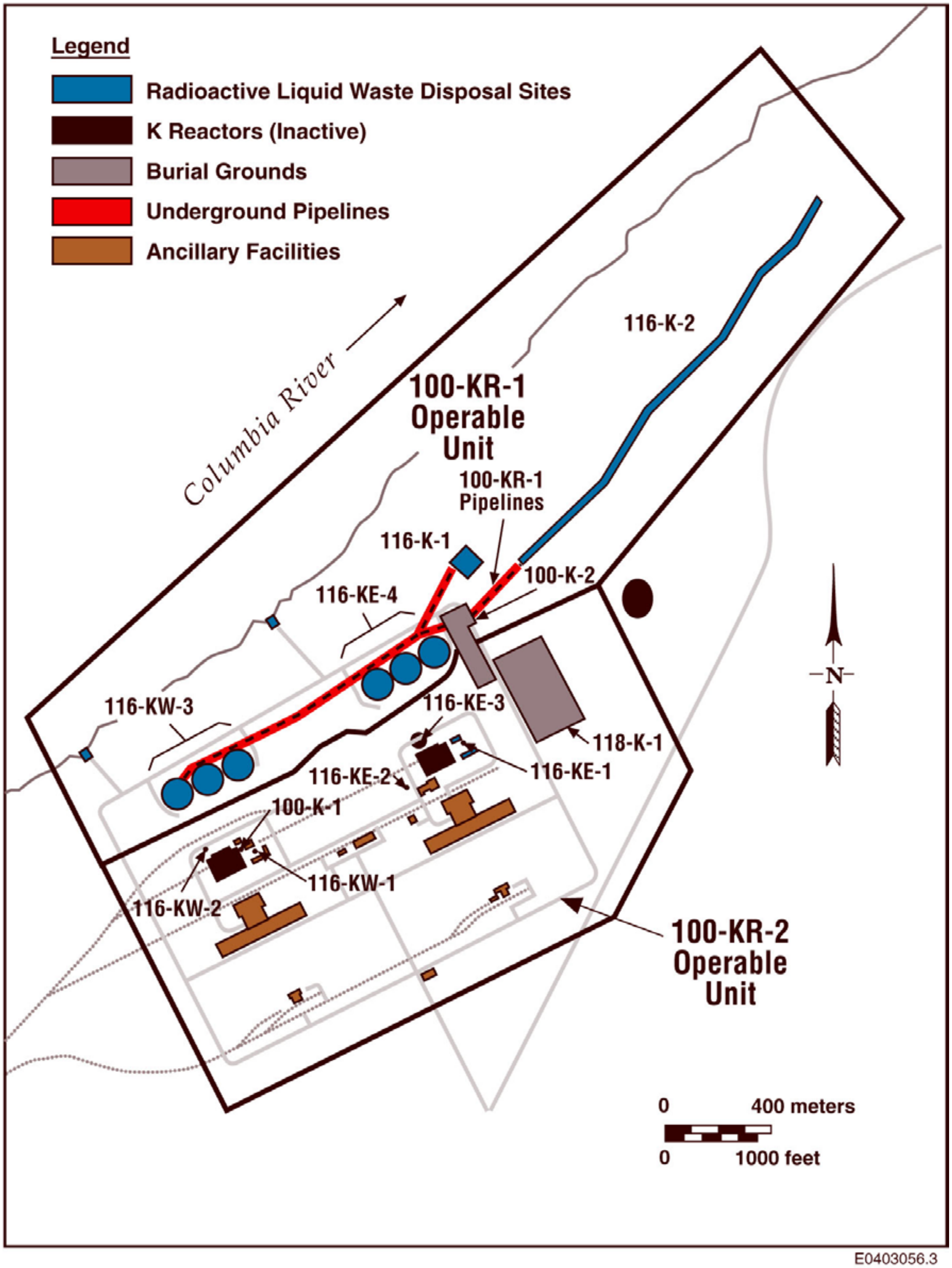

Figure 4.1-2. 100-K Area

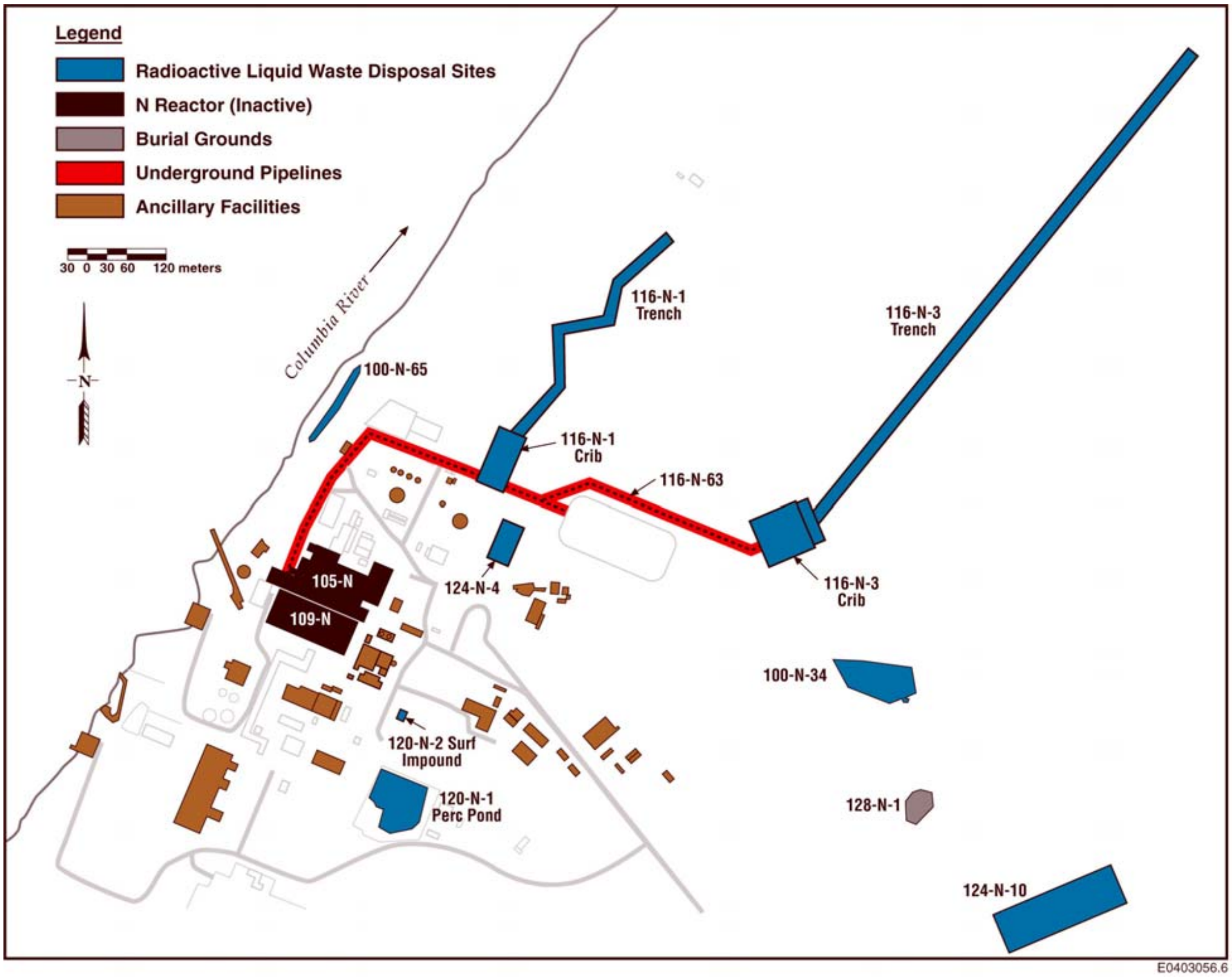

Figure 4.1-3. 100-N Area

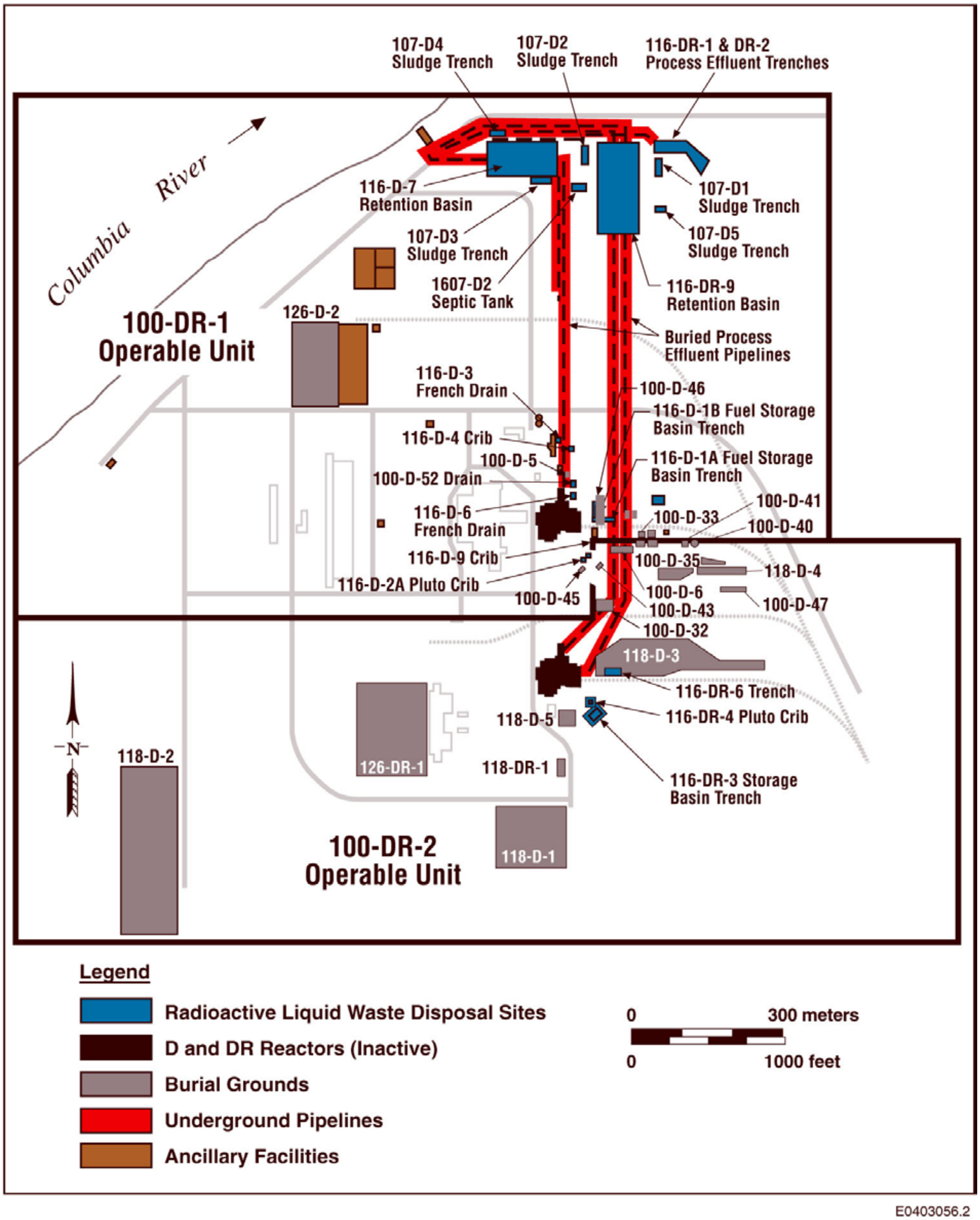

Figure 4.1-4. 100-D Area

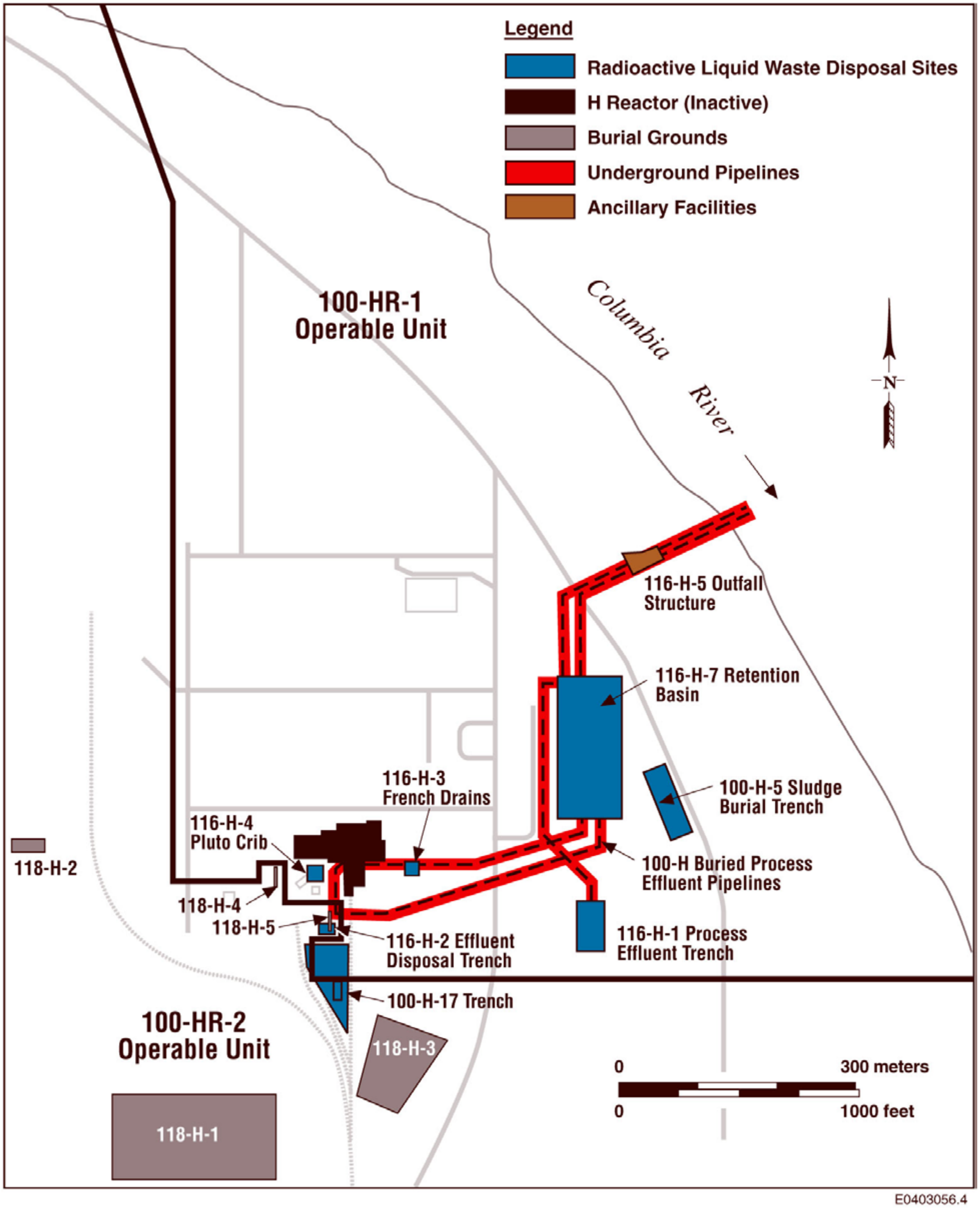

Figure 4.1-5. 100-H Area

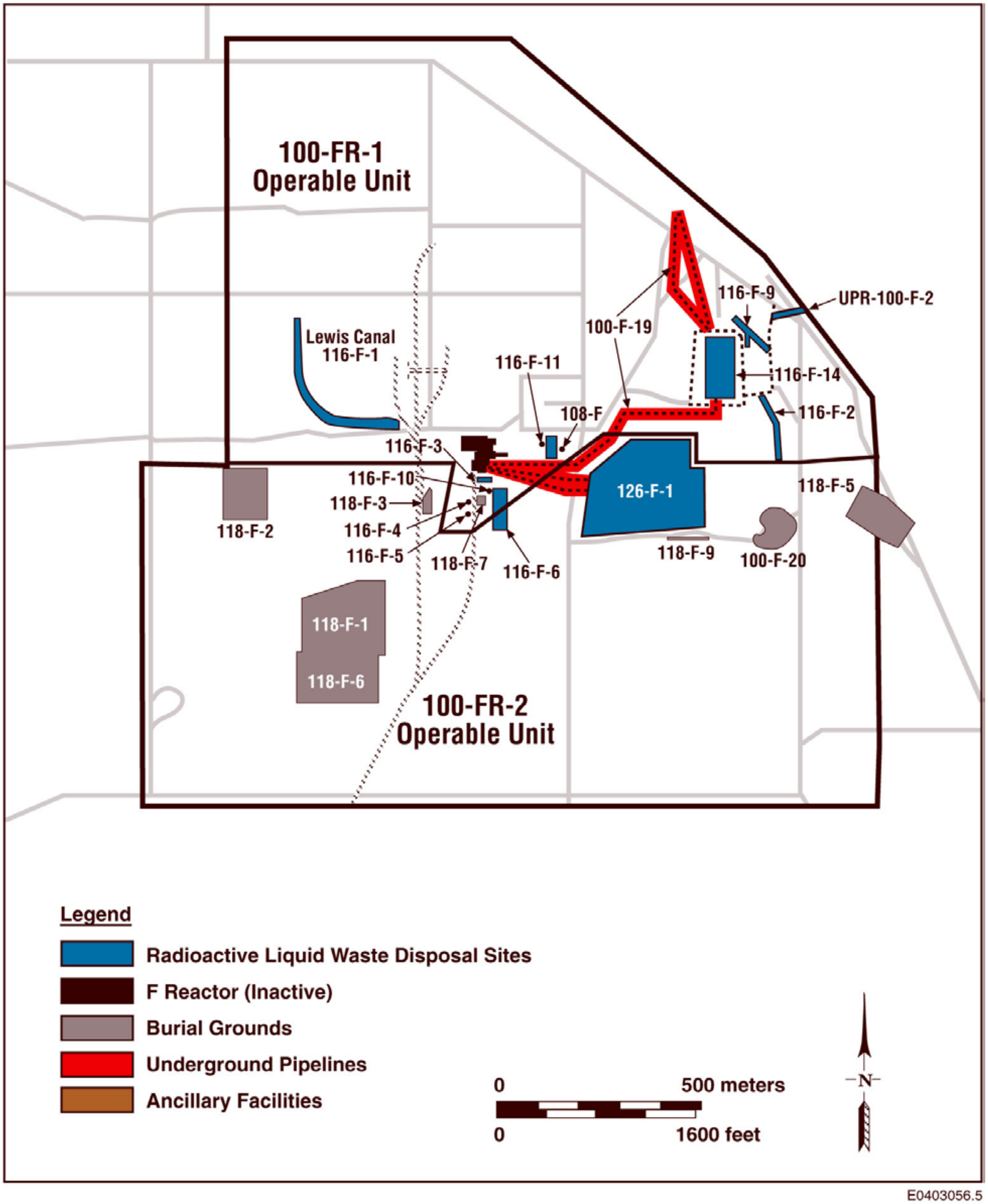

Figure 4.1-6. 100-F Area

Table 4.1.2. 100 Areas – Overview and Comparison of Current and Risk-Based End State Assumptions for Land Use, Exposure Scenarios, Risk Protection Goals, and Potential Institutional Controls

	Current Baseline End State	Risk Based End State Vision
Land Use & Key Assumptions	**Unrestricted surface use.**	**Conservation Preservation** (consistent with CLUP and National Monument Designation) Restricted land use: with recreational activities, non-resident park ranger activities and tribal activities
Exposure Scenarios for Determining Cleanup Levels	**Rural residential farmer scenario**: • Exposure from soils due to direct contact, inhalation and external radiation to a depth of 15 feet. • **Ingestion of vegetables, meat and milk** • **Potential for soil excavation to 12' for dwelling basement construction**. • **36.5 inches of annual irrigation and precipitation (used to evaluate mobilization of contaminants below 15' and potential for degradation of groundwater**). Future groundwater under the waste site is used as drinking water and irrigation for crops. • No decay of radionuclides	**Recreational Scenario** • Exposure from soils due to direct contact, inhalation and external radiation from surface use • **No food ingestion.** • **No soil excavation**, but possible animal intrusion • No groundwater use for drinking water or **irrigation**; incidental contact only • Decay of radionuclides **Non-Resident Park Ranger (TBD)** **Tribal Uses (TBD) ???**
Risk Protection Metrics/Goals	• 15 mrem/yr. from radionuclides to restricted surface user (3x10-4 risk based on EPA guidance) • 1x10-6 risk from other contaminants • Source removal to promote restoration of groundwater to beneficial drinking water use, if practicable, based on 4 mrem/yr from MCL radionuclide concentrations • Excavation depth also protects deep rooting plant pathway and may provide adequate protection of other ecological resources.	• CERCLA risk range 1x10-4 to 1x10-6 risk from other contaminants • Source **containment or removal** and treatment if practicable only where needed to promote restoration of groundwater to beneficial drinking water use, based on 4 mrem/yr from MCL radionuclide concentrations • Protection of ecological resources
Cleanup Actions		
Surface	• Remedial actions taken as needed to protect human health and ecological resources for this land use scenario. • Human health based cleanup must be verified to be adequately protective of ecological resources.	• Remedial actions taken as needed to protect human health and ecological resources for this land use scenario.
Subsurface	• Waste sites excavated to depth of 15 feet	• **Cap-in-place or removal to achieve risk goals.**
Groundwater	• Remedial actions taken to prevent groundwater degradation, protect the River and return to beneficial drinking water use if practicable	• SAME as Current Baseline End State.
Institutional Controls	Institutional Controls: • Restrictions in place to preserve land uses and prevent use of groundwater. • Prevention of excavation below 15 feet. • Continued groundwater monitoring as required by CERCLA 5 year reviews.	Institutional Controls: • Restrictions in place to preserve land uses and prevent use of groundwater. • Continued groundwater monitoring as required by CERCLA 5 year reviews. • **Prevention of excavation into capped-in-place waste sites.** • **Surveillance and maintenance of disposal sites and caps.**

Figure 4.1.7 displays the Conceptual Site Models (CSMs) for both the current baseline end state and the RBES vision. The CSMs illustrate the primary environmental release mechanisms, transport pathways, exposure routes and scenarios, and the actions or barriers that are planned to eliminate or mitigate exposure.

Contamination release and transport mechanisms from these waste sites that may lead to exposure are: a) intrusion of biota (roots and burrowing animals) into the waste sites, b) infiltration to the groundwater, and outflow of the groundwater to the Columbia River via springs and upwelling under the river, c) volatilization and d) direct contact with the soil. These contaminants could then be taken up by biota or humans from various exposure scenarios as depicted in Figure 4.1.7.

The primary receptors that are potentially at risk due to contaminated groundwater are biota in the Columbia River that reside in the areas of groundwater upwelling and plants in the riparian zone that have roots down to groundwater. Chromium in its chemical form is highly mobile in the Hanford subsurface and because of the risk it represents to certain aquatic species at very low concentrations (well below drinking water standards), it will most likely represent a continuing potential risk until source control actions and pump-and-treat actions are complete.

Figure 4.1.7 shows the remediation and control actions that would be applied in both the current baseline end state and in the RBES vision. The principal difference between the two cases derives from the elimination of the Rural Residential Farm Scenario as a driver for cleanup objectives in the RBES vision. This leads to a land use that is compatible with the conservation preservation land use and eliminates the assumption of ~30 inches of irrigation per year on top of previous waste sites. Consequently, Action #1 differs slightly between the two scenarios as less excavation may be required to be equally protective and RBES Action #2 (Intrusion & Infiltration Barrier) may be needed to minimize plant, animal and human intrusion into remaining waste sites. In both cases, institutional controls will be needed to restrict surface use to prevent excavation below 15 feet for the current baseline end state and to prevent excavation into capped waste sites in the RBES.

Under both cases, groundwater treatment systems will be operated in accordance with final RODs; monitored attenuation is likely to be applied to the more recalcitrant plumes; and institutional controls will be required to prevent onsite groundwater use.

As the risk assessment process proceeds, detailed evaluation of the ecological hazard posed by capped waste sites will be considered. In addition, the tribal uses scenario will be defined and evaluated to ensure that remedial actions and controls are protective.

[Additional Conceptual Site Models for the 100 Areas are under development.]

4.2 300 Area

The 300 Area is one of the four NPL areas at Hanford, encompasses ~1.35 square kilometers (~0.52 square mile), is adjacent to the Columbia River, and is ~1.6 kilometers (~1 mile) north of the Richland city limits.

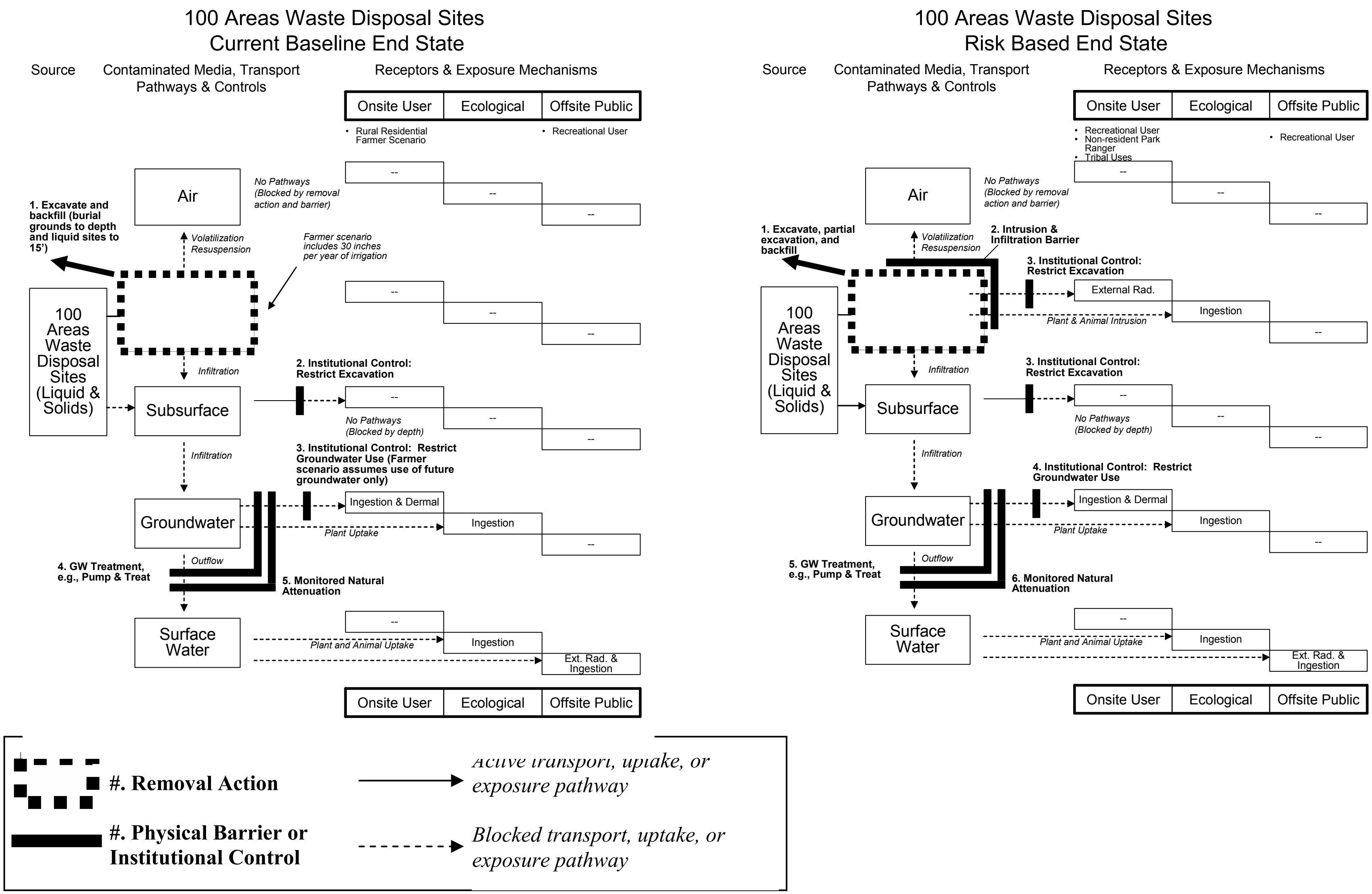

Figure 4.1.7. Conceptual Site Models for 100 Areas Liquid and Solid Waste Disposal Sites, Current Baseline End State and RBES Vision

4.2.1 Summary of Existing Hazards

Table 4.2.1 summarizes the existing hazards in the 300 Area. The top priority hazards in the 300 Area are the following:

- **324 and 327 facilities**. The current radiological inventory is estimated to be 65,000 and 1500 curies respectively.

- **Solid waste burial grounds**. 618-10 and 618-11 are large burial grounds with low- to high-activity waste including ~10,000 m^3 of suspect transuranic contaminated waste.

- **Existing groundwater plumes**. The most prominent contaminant in the groundwater underlying the 300 Area is uranium, which does intersect the Columbia River. In the vicinity of the 618-11 burial ground, tritium reaches its highest concentration on the Hanford Site at 4 million pCi/L in 2002, but this plume does not reach the Columbia River.

- Former liquid disposal sites that were original sources for groundwater contamination. Removing the hazard posed by groundwater contamination necessitates the elimination of any future sources of new contamination to the groundwater.

Figure 4.2.1 displays the hazard map for the 300 Areas.

4.2.2 Exposure Pathways and Potential Implications of the Risk-Based End State Vision

Table 4.2.2 summarizes the assumptions for land use, exposure scenarios and pathways, remediation goals, and institutional controls (including final barriers if any) for both the current/baseline end state and the RBES vision. The current RODs use the default MTCA industrial scenario as the exposure scenario that assumes excavation to a depth of 15 feet. Under the risk based end state vision a 300 Area specific exposure industrial scenario (allowed by MTCA) will be developed to determine what clean up levels are protective of human health. The intent of the risk based end state vision is to align the remediation goals with an exposure scenario that is site specific to the 300 Area. The implications to changing the exposure scenario may be that excavations, if needed, may be less the current 15 feet. It is difficult to expand on the extent of differences until the site specific industrial scenario is developed. Details of the current baseline end state and RBES vision conceptual model exposure pathways are described below.

[Conceptual Site Models for the 300 Area are under development.]

Table 4.2.1 Summary of Hazards in the 300 Area

Material Category	Current Hazard
Surface	
Facilities	• The 300 Area has 220 facilities that will be demolished. The hazards for the 300 Area are wastes embedded in facilities in ductwork, concrete, piping, paint, equipment, insulation, cracks, crevices and other places exist in multifaceted variety. Given the multitude of missions, processes, materials, isotopes, and other substances used in 300 Area facilities over the years, a comprehensive list is not possible in this venue. • 324 is the former Waste Technology Engineering Laboratory. The building contains two major hot cell complexes for irradiated materials, and cold side demonstrations of nuclear waste processes. Current fissile inventory has been reduced to only what is known to be held up as contamination in glove boxes, hot cells, and ventilation system ducting. The estimated inventory of radionuclides is 65,000 curies. • 325 is the Radiochemical Processing Laboratory. This facility is an active radiochemical analytical laboratory. It contains an estimated in-process inventory of ~6,200 curies of tritium and ~440 curies of plutonium. An additional inventory of ~7,400 curies of plutonium-238 is contained in a non-dispersible form (mostly in solid ceramic radioisotope thermal generators built of use with NASA spacecraft). • 327 is the former Post Irradiation Testing Laboratory. The building contains ten hot cells, a water fuel storage fuel basin, and a water transfer basin leading into A Cell. It also contains a dry storage carousel for holding samples from fuel and reactor material testing and examination programs. The facility is assumed to contain 1500 curies of material including less than 200 grams of plutonium.
Subsurface	
Liquid Waste Sites	• There are a total of 120 liquid waste disposal sites. Prior to 1994, liquid waste was discharged to a series of unlined ponds and process trenches just north of the 300 Area. The primary contaminant in the 300 Area is uranium from the fuel fabrication processes. However, numerous other potential contaminants exist for individual waste sites based on the history of their use and operation.
Solid Waste Burial Grounds	• There is a total of 8 burial grounds remaining in the 300 Area, including 618-10 and 618-11. • 618-10 and 618-11 Burial Grounds contain three categories for waste disposal; <10 Ci/ft^3 (low activity) m 10 to 1,000 Ci/ft^3 (moderate-activity) and above 1,000 Ci/ft^3 (high activity). The low activity waste was primarily disposed of in trenches, while moderate and high activity wastes were disposed in vertical pipe units and caissons and sometimes to trenches in concrete/lead-shielded drums. 618-11 is a known contributor of tritium in groundwater. These burial grounds include 10,000 m^3 of suspect transuranic contaminated waste. • 618-7 burial ground include hundreds of 30 gallon iron drums of Zircaloy chips stored in water to mitigate their pyrophoric attributes. • The general content burial grounds received a broad spectrum of chemical and radiological waste as well as solid waste and debris. None appear to be impacting groundwater. The 300 Area burial grounds have a greater amount of uncertainty with regards to their contents in comparison to the 100 Area burial grounds. For example the 618-4 burial ground unexpectedly encountered 1500 drums of uranium chips in oil during excavation.
Groundwater	
Groundwater	• The most prominent contaminant in groundwater is uranium. • A plume of trichloroethene is attenuating naturally, and concentrations remain below MCLs. • Tritium in groundwater near 618-11 Burial Ground is the highest on site (4 million pCi/L in 2002). Tritium has migrated from the 200 Area below MCLs into the 300 Area.

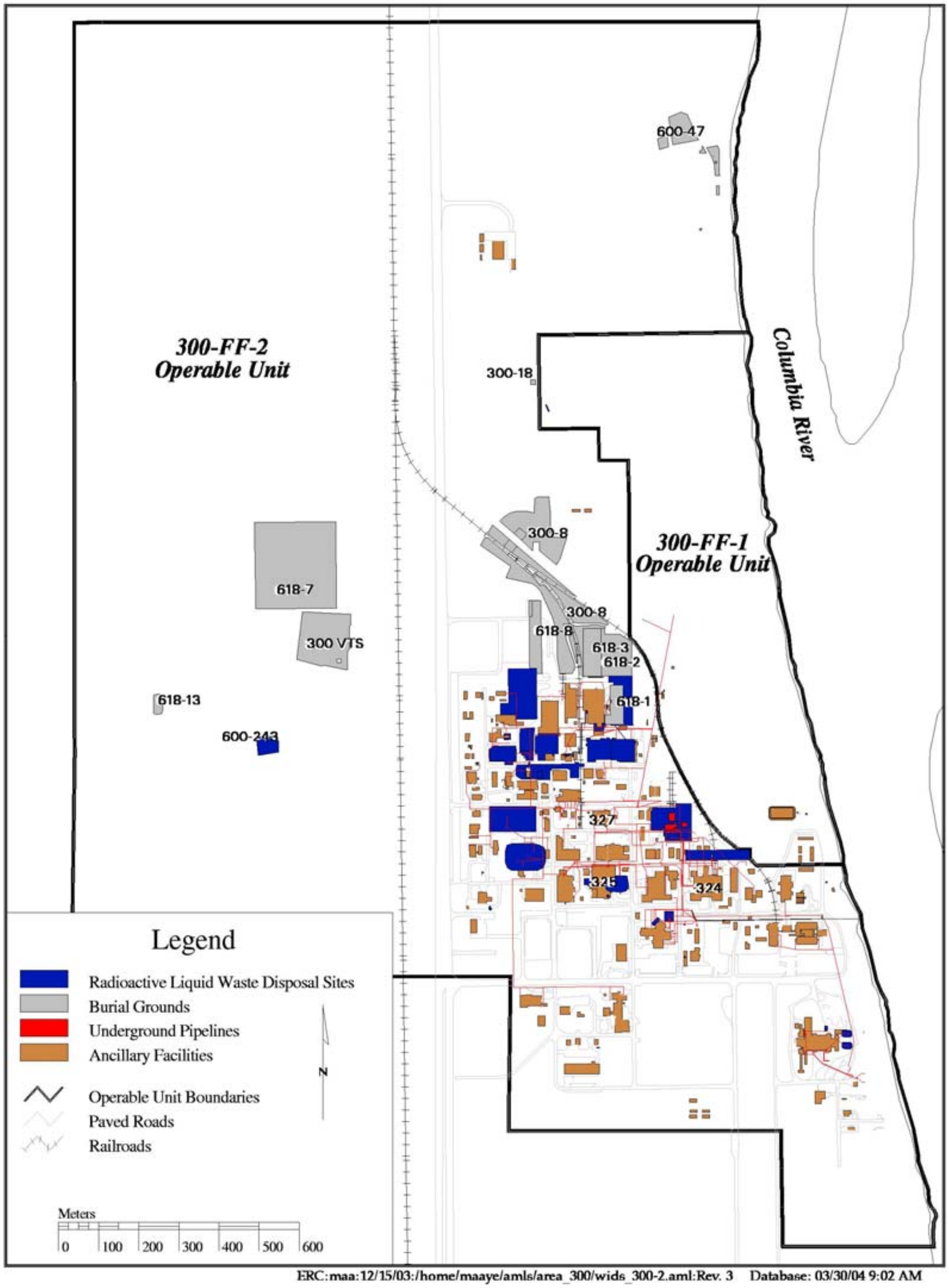

Figure 4.2-1. Hazard Map for the 300 Areas

Table 4.2.2. 300 Areas – Overview and Comparison of Current and Risk-Based End State Assumptions for Land Use, Exposure Scenarios, Risk Protection Goals, and Potential Institutional Controls

	Current Baseline End State	Risk Based End State Vision
Land Use & Key Assumptions	**Industrial use**	Industrial use
Exposure Scenarios for Determining Clean Up Levels	MTCA default industrial scenario (15 feet excavation) Human health based cleanup must be verified to be adequately protective of ecological resources.	Site specific industrial scenario and ecological assessment as basis for final ROD
Risk Protection Metrics/Goals	• 15 mrem/yr. from radionuclides to industrial worker (3x10-4 risk based on EPA guidance) • 1x10-6 risk from other contaminants • Source removal to promote restoration of groundwater to beneficial drinking water use, based on 4 mrem/yr from MCL radionuclide concentrations [dose limit for hypothetical drinking water pathway] • Excavation depth also protects deep rooting plant pathway and may provide adequate protection of other ecological resources.	• CERCLA risk range 1x10-4 to 1x10-6 risk from other contaminants • Source **containment or removal** and treatment if practicable only where needed to promote restoration of groundwater to beneficial drinking water use, based on 4 mrem/yr from MCL radionuclide concentrations • Protection of ecological resources
Cleanup Actions		
Surface	• Remedial actions taken as needed to protect human health and ecological resources for this land use scenario.	• Same
Subsurface	• Waste sites excavated to depth of 15 feet	• **Cap-in-place or removal to achieve risk goals.**
Groundwater	• Remedial actions taken to prevent groundwater degradation, protect the River and return to beneficial drinking water use if practicable	• Same
Institutional Controls	Institutional Controls: • Restrictions in place to preserve land uses and prevent use of groundwater. • **Prevention of excavation below 15 feet.**	Institutional Controls: • Restrictions in place to preserve land uses and prevent use of groundwater. • **Prevention of excavation into capped-in-place waste sites.** • **Surveillance and maintenance of disposal sites and caps.**

4.3 200 Areas

4.3.1 Summary of Hazards

Table 4.3.1 summarizes the existing hazards in the 200 Areas. The top priority hazards in the 200 Areas are the following in descending order of their relative importance:

- **Radioactive Mixed Waste Tanks**. The 200 Area Core Zone contains 149 single- and 28 double-shell tanks distributed among 18 Tanks Farms. The tanks contain about ~54 million gallons of liquid, sludge, and salt cake waste. These tanks contain 1.03 x 10^8 curies of radioactivity.

- **Plutonium from the Plutonium Finishing Plant**. About 17 metric tons of bulk plutonium-bearing material has been stabilized and repackaged into ~2,200 specification 3013 cans awaiting final disposition to SRS and ~2,400 Pipe Overpack Containers (POCs) that will be shipped to WIPP. The disposition of these materials to a consolidated storage location for long-term storage is not expected until after 2007.

- **Waste Materials stored in facilities at the Central Waste Complex**. In 2003, ~8000 m^3 of TRU/M, mixed-low-level-waste and low level waste was stored at CWC pending stabilization, treatment, or shipment to a final disposal location. There is continual through-put which currently is rapidly decreasing the MLLW in storage and increasing the amount of TRU/M in storage based on currently available treatment, disposal and shipment capabilities.

- **Cesium and Strontium Capsules are currently stored in the Central Plateau**. Less than 2000 cesium/strontium capsules are currently being stored in basins. These capsules contain ~130 million curies of cesium-137 and strontium-90 removed from concentrated tank wastes to reduce heat generation in underground storage tanks. Efforts are underway to move these capsules from the water-filled basin to dry storage pending final disposition.

- **Spent Nuclear Fuel (SNF) stored in the Canister Storage Building**. Approximately 75% of the Spent Nuclear Fuel (SNF) in the entire DOE Complex is stored at Hanford. Most of this SNF, nearly 2300 tons is stored in the Canister Storage Building. Other SNF from the Fast Flux Test Facility is also planned for storage within the 200 Areas pending shipment and final disposal at the Nuclear Waste Repository.

- **Former liquid disposal sites that were original sources for groundwater contamination**. Of the ~1,000 past-practice waste sites on the Central Plateau, there are over 400 Liquid Waste Sites that received liquids from 200 Area operations. These waste sites dominate the past and potential hazards posed by the past practice waste sites. These waste sites included ponds, ditches, cribs, trenches, and injection or reverse wells. The major radioactive hazards associated with these sites include plutonium, uranium, strontium-90, cesium-137, iodine-129, and technetium-99. The chemical hazards associated with these liquid waste sites include volatile organics such as carbon tetrachloride, concentrated acids including nitric acid, and other organic compounds.

- **Solid waste burial grounds**. Nearly 100 landfills were constructed within the 200 Area to dispose of solid, low-level radioactive, and TRU wastes. Approximately 15,000 cubic meters of this waste is

Retrievably Stored TRU Waste that is scheduled to be exhumed and packaged for shipment to WIPP. Much of the low-level radioactive solid and hazardous waste was generated during reprocessing or from other DOE sites is to be isolated from the accessible environment using surface barriers.

- **Former production facilities**. Nine hundred facilities, including five canyon facilities and PFP, were constructed to conduct Irradiated Nuclear Fuel processing operations. These facilities are contaminated with a variety of hazardous and radioactive substances including acids, metals, other organic and inorganic chemicals and radioactive fission and activation products.

- **Existing groundwater plumes with contaminants slowly moving toward the Columbia River**. There are four primary groundwater plumes (and Operable Units) underlying the 200 Areas. These plumes contain the following contaminants at levels that exceed drinking water standards: tritium, iodine-129, technetium-99, uranium, nitrate, and carbon tetrachloride. Far less mobile strontium-90, cesium-137, and plutonium are present in the soil, but are not a major treat to the groundwater.

{Additional text describing hazards and Conceptual Site Models will be developed later.}

Table 4.3.1 summarizes the 200 Area hazards.

4.3.2 Exposure Pathways and Potential Implications of the Risk-Based End State Vision

Within the 200 Areas, the exposure pathways will differ between areas inside the Core Zone and areas outside of the Core Zone. Table 4.3.2 summarizes the assumptions for land use, exposure scenarios and pathways, remediation goals, and institutional controls for both the current/baseline end state and the RBES vision for areas outside of the Core Zone. Table 4.3.3 provides this information for areas inside of the Core Zone.

Figure 4.3.1 displays the Conceptual Site Models (CSM) for the tank waste sites for both the current baseline end state and the RBES vision. The CSMs illustrate the primary environmental release mechanisms, transport pathways, exposure routes and scenarios, and the actions or barriers that are planned to eliminate or mitigate exposure.

Release and transport of contaminants from closed tank farms can result from two primary mechanisms: a) the infiltration of water (natural recharge) into disposal systems leading to the slow release of residual contaminants from their final waste form, and b) inadvertent intrusion into disposal sites if institutional controls were lost. The potential exposure routes for these mechanisms are shown in Figure 4.3.2. For infiltration mechanism exposure could occur to a human receptor at the nearest point of groundwater use. For the direct human intrusion mechanism, there would direct exposure to contaminants and potentially secondary exposure depending on the assumptions for an intruder scenario (which are currently under development and not shown in Figure 4.3.3).

Table 4.3.1 Summary of Hazards in the 200 Areas

Material Category	Current Hazard
Surface	
Nuclear Materials	• Storage facilities located within Plutonium Finishing Plant and CWC currently store ~17 metric tons of stabilized plutonium-bearing materials. The disposition of these materials to a consolidated location for long-term storage is not expected until after 2007 • Approximately 75 % of the Spent Nuclear Fuel (SNF) in the entire DOE Complex is stored at Hanford. Most of this SNF, nearly 2300 tons will be stored in the Central Plateau. Other SNF from the Fast Flux Test Facility is also planned for storage within the 200 Areas pending shipment and final disposal at the Nuclear Waste Repository. • Less than 2000 cesium/strontium capsules are currently being stored in the Central Plateau. These capsules contain ~130 million curies of cesium-137 and strontium-90 removed from concentrated tank wastes to reduce heat generation in underground storage tanks. Efforts are underway to move these capsules from the water-filled storage to dry storage pending final disposition. • Approximately 8,000 m^3 of TRU/MLLW stored at CWC pending stabilization, treatment, or offsite shipment.
Nuclear Production Facilities	• Five Irradiated Nuclear Fuel Reprocessing Facilities were used to recover 64,000 kilo-grams of plutonium from SNF. These facilities are massive structures with thick concrete walls to shield the workers from the highly radioactive chemical processing operations and residual contamination. Currently, four of these five facilities, PUREX, REDOX, B Plant, and U Plant are in long-term Surveillance and Maintenance while T Plant remains active as a storage and processing facility for Remote-Handled (RH) mixed low-level and transuranic (TRU) waste. Final disposition of these facilities is expected to include collapsing the upper levels and isolating the facility remnants from the environmental with earthen barriers. • The Plutonium Finishing Plant (PFP) Complex was used to purify, process, and produce various plutonium product materials. These facilities contain extensive plutonium contamination within glove boxes, ducting systems, piping and other process vessels. Current plans are to demolish the PFP to slab-on-grade pending a future decision on the final disposition.
Ancillary Facilities	• More than 900 ancillary facilities were constructed to support Irradiated Nuclear Fuel processing operations. These support facilities were contaminated with a variety of hazardous and radioactive substances including acids, metals, other organic and inorganic chemicals and radioactive fission and activation products.
Subsurface	
Liquid Waste Sites	• Over 400 Liquid Waste Sites received liquids from 200 Area operations. These waste sites included ponds, ditches, cribs, trenches, and injection or reverse wells. The composition of the waste streams disposed to these sites varied widely from lightly contaminated steam condensate and cooling water to highly concentrated process and tank waste. The major radioactive hazards associated with these sites include plutonium, uranium, strontium-90, cesium-137, iodine-129, and technetium-99. The chemical hazards associated with these liquid waste sites include volatile organics such as carbon tetrachloride, concentrated acids including nitric acid, and other organic compounds.
Solid Waste Burial Grounds	• Nearly 100 landfills were constructed within the 200 Area to dispose of solid, low-level radioactive, and TRU wastes. Approximately 15,000 cubic meters of this waste is Retrievably Stored TRU Waste that is scheduled to be exhumed and packaged for shipment to WIPP. Much of the low-level radioactive solid and hazardous waste was generated during reprocessing or from other DOE sites is to be isolated from the accessible environment using surface barriers.

Table 4.3.1 (contd)

Material Category	Current Hazard
Radioactive Mixed Waste Tanks	• Within the 200 Area Core Zone are 18 tank farms containing 149 single-shell tanks, 28 double-shell tanks, and ancillary facilities. The tanks are below ground and contain ~54 million gallons of liquid, sludge and salt cake waste. The tanks contain 103 million curies of radioactivity and other hazardous metals and chemicals. Most of the tanks are beyond their design life and 67 have leaked or are assumed to have leaked ~1 million gallons. Some of this leaked waste has reached the groundwater that flows to the Columbia River. Additional leaks are likely to occur, presenting a hazard to the public and the environment as the contaminated groundwater moves away from the Core Zone. The long-term hazards are primarily via the groundwater pathway and by intruders digging into the waste after institutional control is lost. • Airborne releases are also a hazard. Currently, workers are exposed to chemical vapors that are occasionally emitted from the tanks. Radioactive airborne releases with potential to reach off site could occur if, as a result of a leak in a pressurized transfer line, waste was sprayed into the air.
Groundwater	
Groundwater	• 200 East Area - 200-PO-1 Operable Unit resulting from discharges from the PUREX Plant principle contaminants include tritium, nitrate, and iodine-129. These plumes extend from 200 East Area to the shoreline of the Columbia River where this groundwater discharges into the river. • 200 East Area - 200-BP-5 Operable Unit resulting from discharges of highly concentrated tank and process wastes to the soil. Principle contaminants include the mobile contaminants technetium-99 and nitrate as well as strontium-90, cesium-137, and plutonium that are far less mobile. • 200 West Area - 200-UP-1 Operable Unit resulting from REDOX and U Plants liquid discharges. Includes a plume containing tritium, nitrate, and iodine-129 located near the REDOX Plant and a second plume near U Plant containing elevated concentrations of uranium, technetium-99, and nitrate. • 200 West Area - 200-ZP-1 Operable Unit resulting from discharged from the Plutonium Finishing Plant. Carbon tetrachloride has spread well beyond the area surrounding Plutonium Finishing Plant and contaminate much of the groundwater beneath the 200 West Area • The primary receptors that are potentially at risk due to contaminated groundwater are biota in the Columbia River that reside in the areas of groundwater upwelling and plants in the riparian zone that have roots down to groundwater. The tritium, iodine-129 plumes from 200 East Area pose a hazard for an estimated 150 years by which time the tritium will have decayed to below drinking water standards and the iodine-129 will have dispersed to below drinking water standards. Other contaminant plumes are expected to remain beneath the Core Zone through effective source control and groundwater remedial action.

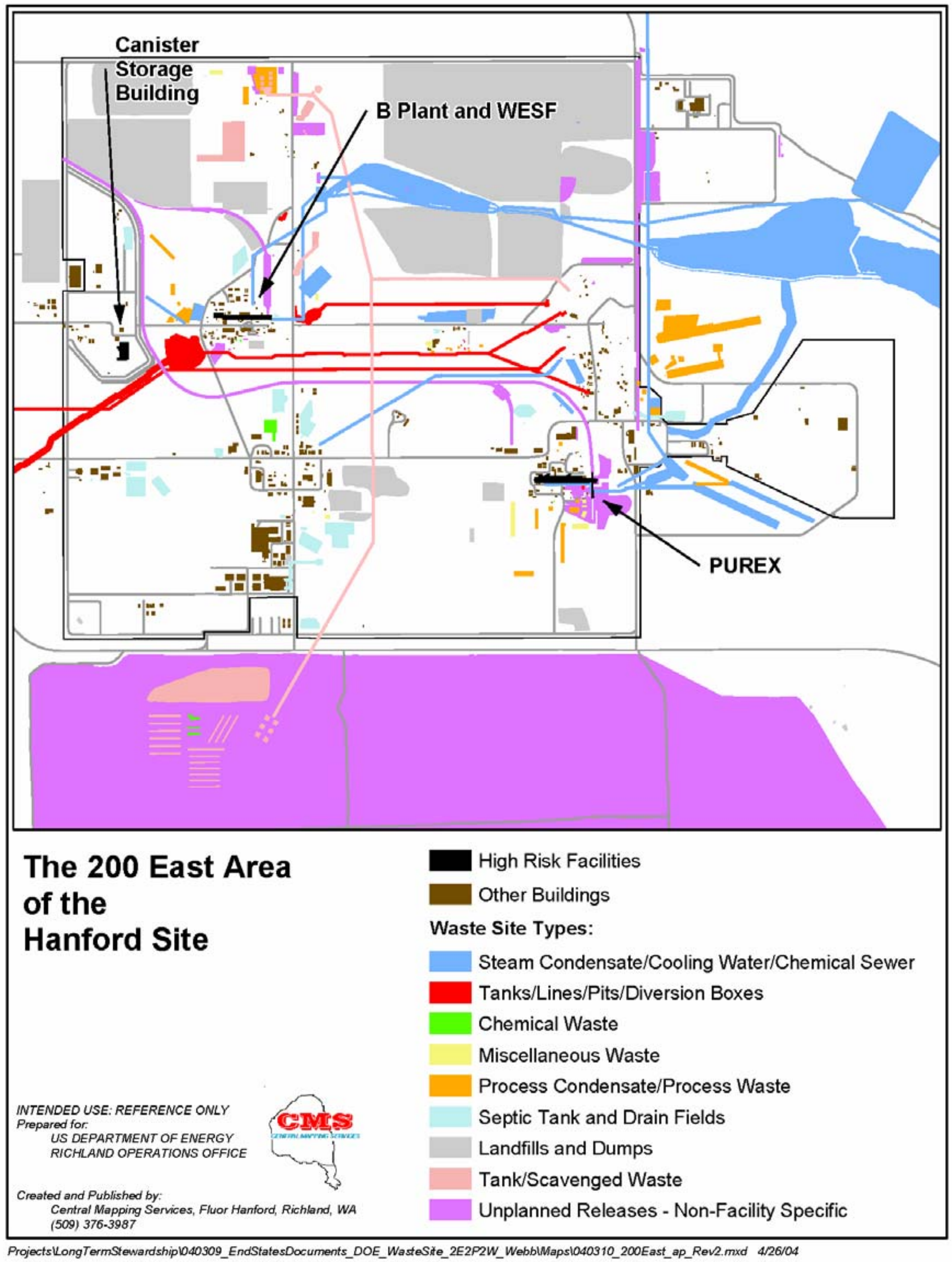

Figure 4.3-1. 200 East Area Hazard Map

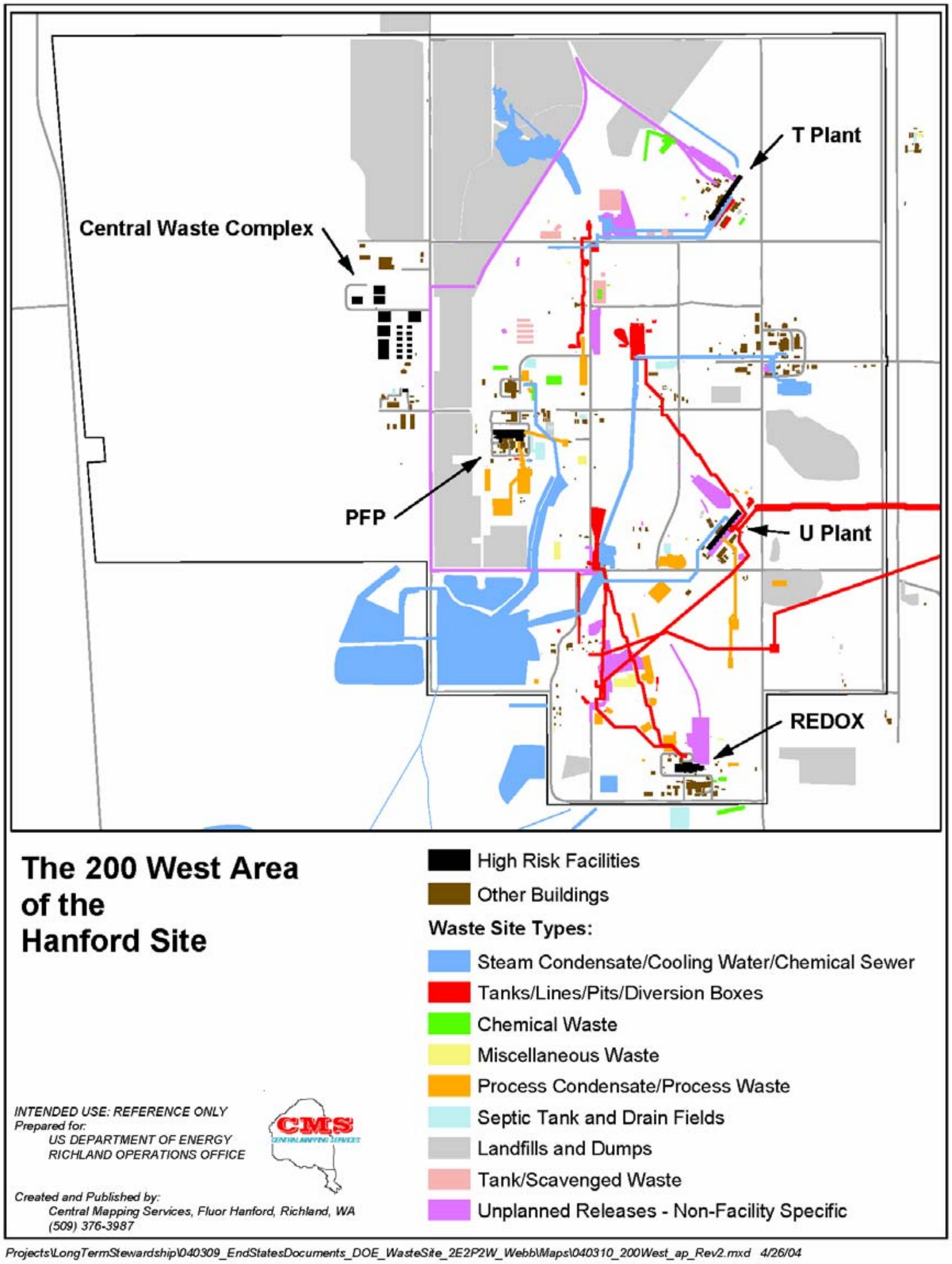

Figure 4.3-2. 200 West Area Hazard Map

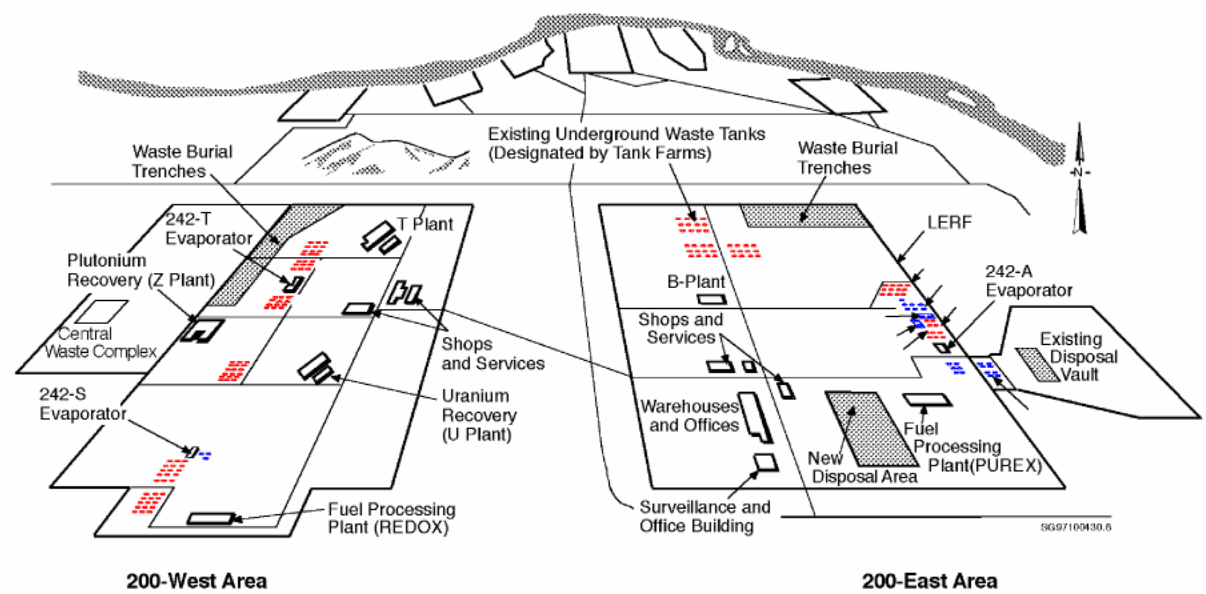

Figure 4.3-3. Tank Farm Map

The principal difference in the remediation and control actions between the current baseline end state and the RBES results from assumption that the Core Zone remains industrial exclusive use and therefore, there is no expected groundwater consumption adjacent to tank farm boundaries. The Offsite public receptor is locate outside of the core zone. Thus, there is one additional institutional control in the RBES vision, #4 – no onsite groundwater use. This assumption is consistent with all other cleanup actions within the Core Zone of the Central Plateau. The expected impact of this control is that the expected retrieval amount could be less than the current assumption of 99%.

There are no pathways shown for ecological receptors as the depth of disposal, including final barriers, is expected to be less than 15 feet. Potential ecological pathways and additional exposure scenarios will be evaluated in 200 Area risk assessments.

[Additional Conceptual Site Models for the 200 Areas are under development.]

Table 4.3.2. 200 Area Waste Sites Overview and Comparison of Current and Risk-Based End State Assumptions for Land Use, Exposure Scenarios, Risk Protection Goals, and Potential Institutional Controls – Outside Core Zone

	Current Baseline End State	Risk-Based End State Vision
Land Use & Key Assumptions	Conservation	Conservation/Preservation
Exposure Scenarios for Determining Cleanup Levels	**Recreational user** • Exposure from soils due to direct contact, inhalation, and external radiation • No soil excavation, but possible animal intrusion • Groundwater is not used for drinking water **Occasional Native American use scenario** • Exposure from soils and biota due to direct contact, inhalation, external radiation and ingestion • No soil excavation, but possible intrusion of plants and animals then consumed or used • No groundwater use assumed **Residential scenario** • Exposure from soils due to direct contact, inhalation, and external radiation • Potential for soil excavation to 15 ft for construction activities • Groundwater is not used for drinking water **Biological receptor** • Exposure from soils due to direct contact, ingestion, inhalation, and external radiation • Exposure to 15 ft • Exposure to contaminated biota	**Recreational user** • Exposure from soils due to direct contact, inhalation, and external radiation • No soil excavation, but possible animal intrusion • Groundwater is not used for drinking water **Occasional Native American use scenario** • Exposure from soils and biota due to direct contact, inhalation, external radiation and ingestion • No soil excavation, but possible intrusion of plants and animals then consumed or used • No groundwater use assumed **Biological receptor** • Exposure from soils due to direct contact, ingestion, inhalation, and external radiation • Biologically active zone to 6 ft • Exposure to contaminated biota
Risk Protection Metrics/Goals	• 10^{-4} to 10^{-6} risk range under CERCLA; 15 mrem/yr from radionuclide equates to 3×10^{-4} • Ecological screening per EPA 8-step process using WAC-173-340-900, Table 749-3 and BDAC BCGs as screening levels • Source containment or removal to protect human health, the environment, and the groundwater	• 10^{-4} to 10^{-6} risk range under CERCLA • Ecological screening per EPA 8-step process using WAC-173-340-900, Table 749-3 and BDAC BCGs as screening levels • Source containment or removal to protect human health, the environment, and the groundwater
Cleanup Actions		
Surface	• Remedial action taken as needed to protect human health and ecological resources for this land use scenario • Includes capping in place, removal, or use of existing soil cover with institutional controls and monitored natural attenuation	• Remedial action taken as needed to protect human health and ecological resources for this land use scenario • Includes capping in place, removal, or use of existing soil cover with institutional controls and monitored natural attenuation

Table 4.3.2. (contd)

	Current Baseline End State	Risk-Based End State Vision
Land Use & Key Assumptions	Conservation	Conservation/Preservation
Subsurface	• Remedial actions taken to prevent groundwater degradation and protect river • Includes capping in place with institutional controls or removal, treatment as needed, and disposal	• Remedial action taken as needed to protect groundwater degradation and protect the river; also protects human health and ecological resources • Includes capping in place with institutional controls or removal, treatment as needed, and disposal
Groundwater	• Remedial actions taken to prevent groundwater degradation and protect river • Includes capping in place with institutional controls or removal, treatment as needed, and disposal	• Remedial actions taken to prevent groundwater degradation and protect river • Includes capping in place with institutional controls or removal, treatment as needed, and disposal
Institutional Controls	Institutional Controls: • Restrictions in place to preserve land uses and prevent use of groundwater. • Continued groundwater monitoring as required by CERCLA 5 year reviews. • Prevention of excavation into capped-in-place waste sites. • Surveillance and maintenance of disposal sites and caps.	Institutional Controls: • Restrictions in place to preserve land uses and prevent use of groundwater. • Continued groundwater monitoring as required by CERCLA 5 year reviews. • Prevention of excavation into capped-in-place waste sites. • Surveillance and maintenance of disposal sites and caps.

Table 4.3.3. 200 Areas Waste Sites Overview and Comparison of Current and Risk-Based End State Assumptions for Land Use, Exposure Scenarios, Risk Protection Goals, and Potential Institutional Controls – Inside Core Zone

	Current Baseline End State	Risk-Based End State Vision
Land Use & Key Assumptions	Industrial land use	Exclusive Industrial land use
Exposure Scenarios for Determining Cleanup Levels	**Industrial worker** • Exposure from soils due to direct contact, inhalation, and external radiation • Potential for soil excavation to 15 ft for construction activities • Groundwater is not used for drinking water **Inadvertent intruder** • Exposure to soils due to direct contact, inhalation, and external radiation • Soils are taken from a borehole, spread on the surface in a 200 m^2 garden, and used by a residential intruder; no groundwater consumption is assumed **Biological receptor** • Exposure from soils due to direct contact, ingestion, inhalation, and external radiation • Exposure to 15 ft • Exposure to contaminated biota	**Nuclear industrial worker** • Exposure $\leq$5 rem/year whole body from soils due to direct contact, inhalation, and external radiation • Potential for soil excavation to 15 ft • No groundwater use assumed **Non-nuclear industrial worker** • Exposure $\leq$100 mrem/year from soils due to direct contact, inhalation, and external radiation • Potential for soil excavation to 15 ft • No groundwater use assumed **Inadvertent intruder** • Exposure to soils due to direct contact, inhalation, and external radiation • Soils are taken from a borehole, spread on the surface in a 200 m^2 garden, and used by a residential intruder; no groundwater consumption is assumed **Biological receptor** • Exposure from soils due to direct contact, ingestion, inhalation, and external radiation • Biologically active zone to 6 ft • Exposure to contaminated biota
Risk Protection Metrics/Goals	• 10^{-4} to 10^{-6} risk range under CERCLA; 15 mrem/yr from radionuclide equates to 3 x 10^{-4} • Ecological screening per EPA 8-step process using WAC-173-340-900, Table 749-3 and BDAC BCGs as screening levels • Source containment or removal to protect human health, the environment, and the groundwater	• 10^{-4} to 10^{-6} risk range under CERCLA • Ecological screening per EPA 8-step process using WAC-173-340-900, Table 749-3 and BDAC BCGs as screening levels • Source containment or removal to protect human health, the environment, and the groundwater
Cleanup Actions		
Surface	• Remedial action taken as needed to protect human health and ecological resources for this land use scenario • Includes capping in place, removal, or use of existing soil cover with institutional controls and monitored natural attenuation	• Remedial action taken as needed to protect human health and ecological resources for this land use scenario • Includes capping in place, removal, or use of existing soil cover with institutional controls and monitored natural attenuation
Subsurface	• Remedial actions taken to prevent groundwater degradation and protect river • Includes capping in place with institutional controls or removal, treatment as needed, and disposal	• Remedial action taken as needed to protect groundwater degradation and protect the river; also protects human health and ecological resources • Includes capping in place with institutional controls or removal, treatment as needed, and disposal

Table 4.3.3. (contd)

	Current Baseline End State	Risk-Based End State Vision
Groundwater	• Remedial actions taken to prevent groundwater degradation and protect river • Includes capping in place with institutional controls or removal, treatment as needed, and disposal	• Remedial actions taken to prevent groundwater degradation and protect river • Includes capping in place with institutional controls or removal, treatment as needed, and disposal
Institutional Controls	Institutional Controls: • Restrictions in place to preserve land uses and prevent use of groundwater. • Continued groundwater monitoring as required by CERCLA 5 year reviews. • Prevention of excavation into capped-in-place waste sites. • Surveillance and maintenance of disposal sites and caps.	Institutional Controls: • Restrictions in place to preserve land uses and prevent use of groundwater. • Continued groundwater monitoring as required by CERCLA 5 year reviews. • Prevention of excavation into capped-in-place waste sites. • Surveillance and maintenance of disposal sites and caps.

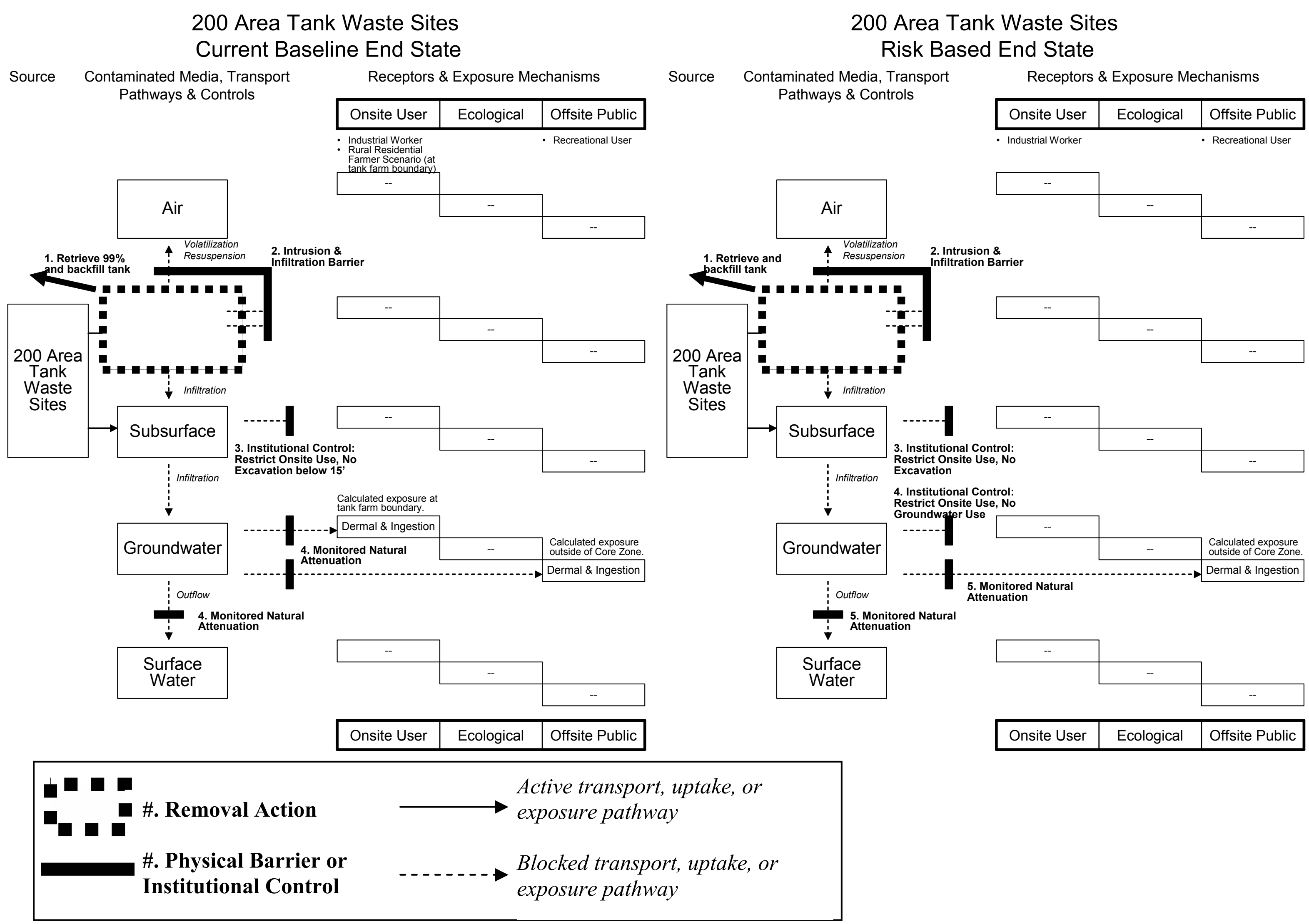

Figure 4.3-4. 200 Area Tank Waste Sites

5.0 Variance Discussion

The purpose of this section is to describe how existing Hanford-specific cleanup decisions and strategies may vary from the DOE Risk-Based End States Policy (455.1). This variance analysis evaluates existing cleanup decisions and planned actions reflected in the Integrated Hanford Baseline, in relation to land use determinations for Hanford.

Identification of a variance does not in itself mean that DOE will seek to renegotiate a cleanup decision document. DOE will examine the variance, consider the views of Tribes, stakeholders and regulators, and weigh the pros-and-cons of proposed changes to cleanup agreements. If the DOE decides to pursue a variance that involves activities regulated under RCRA or CERCLA, such changes would be pursued through the appropriate procedures defined in the Tri-Party Agreement (Ecology et al. 1998) which contains further provisions for public involvement. If the TPA is not applicable or binding DOE may pursue changes under its independent CERCLA authority.

The building blocks for developing a RBES vision for the Hanford Site have been accumulating since the cleanup mission was initiated. Risk in planning goes back to the development of the Tri-Party Agreement by DOE, EPA, and Ecology. The *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE 1999a) (CLUP) and the Presidential order creating the Hanford Reach National Monument which, together, identifies land uses following site cleanup provide a catalyst to re-evaluate the current cleanup baseline and Tri-Party Agreement Milestones to assure that the baseline will be in concert with the land use plans.

The following sections present 7 variances between the current baseline plans and the cleanup that would result if driven by the Hanford Site RBES vision. DOE/RL and ORP recommend further evaluation of these variances in cooperation with the regulators, Tribes, and various stakeholders.

5.1 Background

As discussed in the previous chapters, the RBES Vision assumes that the future land uses for Hanford will be the land uses decided upon in the CLUP. These land uses are consistent with the creation of the Hanford Reach National Monument. The RBES Vision is also aligned with the following EPA guidance about the role of land-use decisions in the CERCLA remedy selection process:

- *Land Use in the CERCLA Remedy Selection Process* (the Superfund Land Use Directive, OSWER 9355.7-04, EPA 1995b)
- *Reuse Assessments: A Tool To Implement The Superfund Land Use Directive* (OSWER 9355.7-06P, EPA 1995c)

A variety of EPA guidance documents provide additional discussions on how land use decisions are used in the CERCLA process. Published regulatory guidance and DOE Policy 455.1 recognizes that the regulatory agencies do not establish future land use at CERCLA sites; the agencies are to use appropriate determinations by established land-use authorities. Authority to make future use plans at DOE facilities was assigned to the Secretary of Energy by Congress in Public Law 104-201, requiring the Secretary of Energy to develop a future use plan for Hanford.

The EPA land-use guidance states that, to the extent possible, EPA is to use readily available information to assess future land use. At sites where land-use decisions have already been determined and documented, a simple review to confirm the information may be all that is necessary. The Hanford CLUP (DOE 1999a) serves as the basis of Hanford's land use planning. This Congressionally mandated land-use plan was formally developed using the process established by the National Environmental Policy Act (NEPA). See Chapters 2 and 3 for a detailed discussion about the Hanford lands and the CLUP land use decisions.

The reasonably anticipated land use is important to determining the types and frequency of exposures that could occur to exposed persons and ecological receptors from any residual contamination and the resulting risks. The degree of cleanup necessary, including any controls or barriers to prevent exposure, is determined in the CERCLA remedy selection process. Cleanup must be adequately protective of humans and ecological resources and also meet applicable or relevant and appropriate requirements imposed under environmental laws. Potential cleanup alternatives that meet the foregoing threshold criteria are further evaluated for cost effectiveness based on long term effectiveness and permanence; reduction of toxicity, mobility or volume through treatment; and short term effectiveness, compared to the cost of the potential remedy. Remedy selection also considers implementability and state and community acceptance of potential alternatives.

The RBES Vision is not a decision document or a CERCLA remedy selection document and it does not provide an evaluation of all CERCLA remedy selection criteria. It focuses on anticipated future land use as a primary factor in developing cleanup alternatives that are adequately protective based on risk as a perspective to look at cost effective, implementable means to achieve site closure. The Vision also helps in obtaining EPA, state and community feedback from stakeholders, including Tribes to understand issues that affect the degree of acceptance of a final closure that implements the RBES Vision.

5.2 Descriptions of Variances

Table 5.1 summarizes the identified variances and the impacts, barriers, and recommendations for each one. A number of potential variances were considered and Table 5.1 only contains those that DOE believes should be pursued at this time.

For Table 5.1 variances, it is important to note that at this point these should be considered "draft" variances and will require feedback and interaction with the regulators, Tribes, and stakeholders. Also, in some cases the current and planned actions are clear because they are required by existing cleanup decisions. In other cases, the current and planned actions are more conceptual or reflect what is perhaps ingrained thinking based on the outcome of interactions over the years with the regulators and stakeholders. Thus, it should be recognized that as discussions continue and planning becomes more certain, the current and planned actions could become more aligned with a risk-based approach and with the Vision.

Similarly, in some variances costs and other impacts are possible to categorize and estimate. In others, cost estimates or other factors may only be known to an order of magnitude or qualitatively and therefore, the impact from the variance is also fairly conceptual and qualitative.

Barriers identify challenges that DOE expects must be addressed to implement the variance. The level of the challenges and degree of difficulty to overcome them likely vary widely. Some barriers reflect DOEs current understanding of the issues of importance in regulator and community acceptance of the RBES Vision. Others reflect technical and programmatic challenges.

The recommendations serve to identify tasks that DOE believes should be implemented in pursuit of the RBES Vision reflected in the variance. These are tasks that DOE believes will help better quantify impacts and address barriers, but will also help focus ongoing planning and regulatory and community consultation on risk-based decision making tied to anticipated future land uses.

Any variances that are pursued by DOE will be done through the existing decision making processes that involve regulators, stakeholders, and tribal nations, as appropriate.

Variance Number	Current Baseline	RBES Vision	Impacts (scope, cost, schedule, risk)	Barriers to Achieving RBES	Recommendations
1	**Cleanup the 100 Area Waste Sites to achieve Remedial Action Objectives that are based on CLUP Conservation and Preservation land use exposure scenarios** ● Unrestricted surface use. ● Exposure scenario based on rural residential use - Farming with 36.5 inches of annual irrigation and precipitation ● Future ground water used for drinking. ● Achieves 15 mrem/yr (3x10-4 risk based on EPA guidance) and 1x10-6 risk from other contaminants. ● Assumed to be protective of ecological resources. ● No decay of radionuclides. ● Excavate waste sites to at least 15 feet depth and to bottom of burial grounds and dispose at ERDF. ● Return ground water to beneficial drinking water use, based on 4 mrem/yr (MCL) for radionuclides, if practicable.	● Cleanup based on Conservation and Preservation land use exposure scenarios for recreational, non-resident park ranger and tribal activities, including fishing. ● Cleanup based on Conservation and Preservation land use exposure scenarios for recreational, non-resident park ranger and tribal activities, including fishing. ● No ground water use for drinking water or irrigation until reach MCLs (4mrem/yr). ● Meet CERCLA risk range (10-4 to 10-6 risk) for radionuclides and other contaminants and protect ecological resources for CLUP land uses. ● Radionuclide decay assumed. ● Containment and/or monitoring of some waste sites instead of excavation. ● No further degradation of ground water. ● Restore ground water to beneficial drinking water use if practicable.	● 550 waste sites including 45 solid waste burial grounds in 100 Area. ● 192 waste sites (but no burial grounds) excavated so far under interim action Records of Decision. ● Over 3.6 million tons excavated for over $307 M. ● 202,000 truckloads of waste have been disposed at ERDF. ● Transportation risk calculated to be 2 x 10^{-2} fatalities – for 100 and 300 Area campaigns so far: no fatalities; 1 significant transportation incident and 40 events involving movement of material and equipment. Under current and planned actions: ● 230 more waste sites and 45 burial grounds are expected to require excavation. 250 facilities must be dispositioned. ● Current cost estimates are $300 million for burial grounds and total of $550 million. Being revised and expected to be lower based on experience. ● Cost estimate does not include on site disposal costs. Under RBES Vision: ● Estimated 14 burial grounds could be closed by containment for about $77 million. 31 other burial grounds are estimated to cost $65M to remove. ● Lower worker and transportation risks for containment vs. excavation.	● The level of regulator and stakeholder acceptance of the CLUP identified land uses as the basis for final remedy decisions appears low. ● Regulator and stakeholder preferences of institutional and other controls for CLUP land uses may differ from DOE's preferences. ● Additional data to support the RBES Vision containment and/or monitoring remedies decisions could be extensive. ● Timely completion of risk assessments and acceptable exposure scenarios based on CLUP land use to implement Vision may be difficult. ● Washington State Regulations require 10-5 cumulative risk and 10-6 individual risk for other contaminants. ● How to balance the remediation risks to workers and risks from transportation with the potential long-term environmental impacts needs to be better understood.	● Continue the Records of Decision for Interim Actions and expedite development of risk assessment methodology and Sampling and Analysis Plans (SAPs) to support RBES modifications to the Interim action RODs. ● Expedite final risk assessments and Final RODs. Develop pathway analysis and exposure factors for the 100 Area CLUP identified land use scenarios. Supports Variance 7 for reactor cocooning and Reactor Cooling Water Discharge Piping that extends into the Columbia River.

Variance Number	Current Baseline	RBES Vision	Impacts (scope, cost, schedule, risk)	Barriers to Achieving RBES	Recommendations
	• Transfer post remediation land to other federal agency to manage as part of the National Monument	• Transfer post remediation land to other federal agency to manage as part of the National Monument	• Costs could increase for long term monitoring and maintenance and periodic review to determine continuing remedy protectiveness. • Characterization costs could be significantly higher than excavation cost for some sites. • Land where waste left in place may go to Office of Legacy Management if unacceptable to other federal agency		
2	**Cleanup the 300 Area Waste Sites to achieve Remedial Action Objectives that are based upon CLUP Industrial land use exposure scenarios** • Cleanup based on conservative Industrial land use (assumes receptor underground in building and outdoor exposure all at same time). • Achieves 15 mrem/yr (3x10-4 risk based on EPA guidance) and 1x10-5 risk from other contaminants. • Assumed to be protective of ecological resources. • No decay of radionuclides. • Excavate waste sites to at least 15 feet depth – based on future industrial excavations - and dispose at ERDF. • Return ground water to beneficial drinking water use, based on 4	• Cleanup based on Industrial land use exposure scenarios with limited excavation. • No ground water use for drinking water or irrigation (the 300 Area is connected to the City of Richland water supply). • Meet CERCLA risk range (10-4 to 10-6 risk) for radionuclides and other contamination and protect ecological resources for CLUP land uses. • Radionuclide decay assumed. • Containment and/or monitoring of some waste sites/burial grounds instead of excavation. • No further degradation of ground water.	• 195 waste sites including 13 solid waste burial grounds associated with 300 Area. • 68 waste sites and 5 burial grounds excavated so far under a final and an interim action Record of Decision. • Over 600,000 tons excavated for approximately $60.5 M. • 33,000 truckloads of waste have been disposed at ERDF. • Transportation risk calculated to be 6.6×10^{-3} fatalities – for 100 and 300 Area campaigns so far: no fatalities; 1 significant transportation incident and 40 events involving movement of material and equipment. Under current and planned actions: • 120 more waste sites and 8 burial grounds are expected to require excavation. Cost estimates of $450M for burial grounds and waste sites. 618-7, 10 and 11	Barriers to Achieving RBES similar to Variance 1 above.	Recommendations similar to Variance 1 above.

Variance Number	Current Baseline	RBES Vision	Impacts (scope, cost, schedule, risk)	Barriers to Achieving RBES	Recommendations
	mrem/yr (MCL) for radionuclides, if practicable.	● Restore ground water to beneficial drinking water use if practicable.	estimated to cost $325M. ● Cost estimate does not include on site disposal costs. ● Requires removal of 150 buildings over 40 of the waste sites. A total of 220 facilities must be properly dispositioned. Under the RBES Vision: ● Lower worker and transportation risks for containment vs. excavation. ● Costs could increase for long term monitoring and maintenance and periodic review to determine continuing remedy protectiveness. ● Characterization costs could be significantly higher than excavation cost for some sites. ● The buildings over waste sites are still anticipated to be demolished in the RBES Vision, but complete removal may not be needed.		

Variance Number	Current Baseline	RBES Vision	Impacts (scope, cost, schedule, risk)	Barriers to Achieving RBES	Recommendations
3	**Cleanup the Central Plateau Waste Sites to achieve Remedial Action Objectives that are based upon CLUP Industrial Exclusive and Conservation/Preservation land use exposure scenarios.** ● Industrial land use and Conservation/Preservation land use for the Central Plateau inside/outside Core Zone, respectively. ● Possible animal intruder and human intruder after 150 years. ● No ground water use for drinking water or Industrial use - incidental contact only. ● Protect ecological resources for this land use. ● 15 mrem/yr from radionuclides (3x10-4 risk based on EPA guidance). ● 1x10-4 to 1x10-6 risk from other contaminants. ● Meet DOE performance assessment criteria - 100 mrem/yr in unrestricted areas (near boundary of waste disposal site). ● Radionuclide decay assumed. ● Remove treat and dispose for	● Core Zone Industrial Exclusive land use for radiation workers, industrial workers, and authorized visitors. ● Outside Core Zone, same as 100 Area Conservation and Preservation land use exposure scenarios - excluding fishing, and adding mining for borrow soil. ● No ground water use for drinking water or irrigation. ● Meet CERCLA risk range of 10-4 to 10-6 risk for radionuclides and other contaminants. Protect ecological resources for CLUP land uses. ● Radionuclide decay assumed. ● Small isolated waste sites may	● Central Plateau is approximately 75 square miles. ● 25 square mile Core Zone contains the 200 Area - reserved for waste management and disposal. ● Approximately 1000 waste sites including 132 burial grounds/landfills/dumps within the Central Plateau. 69 waste sites including 29 landfills/dumps are outside the Core Zone. ● 15,000 cubic meters of suspect transuranic waste stored in retrievable trenches. About 8,600 cubic meters of TRU/M and MLLW stored at CWC. ● One waste site remediated within the Core Zone and no interim action or final RODs for the Central Plateau waste sites. Under current and planned actions: ● Assumes 32% of the waste sites will have surface barriers (Modified RCRA C or Hanford Barrier) ● 40% of the waste sites removed and disposed. ● 28% under natural attenuation or no action. ● Cost estimate of these actions is over $1.5 billion. Under the RBES vision: ● Use Evaporative Transport Barriers for 32% of waste sites with expected cost savings of 25% or more. ● Fewer waste sites will require	Barriers to Achieving RBES similar to Variance 1 above including: ● The level of regulator and stakeholder acceptance of a Zone Based Strategy that enables the RBES Vision may be low.	● Obtain Integration Strategy agreement to expedite development of overall Central Plateau Regulatory and ROD Strategy. ● Only pursue interim actions based on current, not future, ecological or human health risks and River water quality protection. ● Implement February 2004 "Hanford Site Groundwater Strategy" for the ground water protection, monitoring and remediation aspects of this Variance. ● Expedite development of the risk assessment methodology and Sampling and Analysis Plans (SAPs) for the development of the final RODs. ● Implement this Variance and Variances 5 and 6 consistent with Integration Strategy for 200 Area zones.

Variance Number	Current Baseline	RBES Vision	Impacts (scope, cost, schedule, risk)	Barriers to Achieving RBES	Recommendations
	some wastes sites, others receive cover only to achieve regulatory compliance. ● TRU Wastes in retrievable storage will be retrieved, treated and shipped to WIPP. ● Prevent ground water degradation, protect the River and return to beneficial drinking water use if practicable. ● Central Plateau Core Zone remain under DOE control for waste management activities for the foreseeable future	be removed and consolidated to optimize placement of surface barriers. ● Containment and/or monitoring of some waste sites instead of excavation. ● TRU Wastes in retrievable storage will be retrieved, treated and shipped to WIPP. ● Ground water degradation is adequately controlled to protect the River and to return to beneficial drinking water use if practicable. ● Use Integration Strategy to optimize and prioritize cleanup activities within discreet 200 Area zones (e.g., Canyon Zones). ● Ground water points of compliance set at points where ground water treatment and restoration is determined to be practicable and to monitor progress towards protection and restoration goals of CERCLA, RCRA and AEA. ● Institutional controls to prevent intrusion or modification to caps. ● Central Plateau Core Zone remain under DOE control for waste management activities for the foreseeable future	remove, treat, and dispose, and more sites will be addressed by natural attenuation or no action. ● Lower worker and transportation risks for containment vs. excavation. ● Costs for long term monitoring and maintenance and periodic review to determine continuing remedy protectiveness could increase. ● Characterization costs could be significantly higher than excavation cost for some sites. ● Risk to future Hanford Site workers and visitors not expected to change. ● Source removal actions taken only if action will significantly improve ground water quality or the practicability of treatment. ● Contaminants are not expected to significantly impact River water quality or pose an unacceptable risk in the 100 or 300 Area.		
4	**Stabilize high radioactivity material in the 200 Area onsite and allow radioactive decay prior to final disposition** ● Land use, exposure scenarios and risk goals same as variance 3	● Land use, exposure scenarios and risk goals same as variance	● Approximately 2000 cesium-137 and strontium-90 capsules stored in a Central Plateau pool. ● Capsules have high radiation levels making near term disposition uncertain. ● K-Basin sludge is highly	● The level of regulator and stakeholder acceptance of the CLUP identified land uses as the basis for final remedy decisions is low. ● Regulator and stakeholder preferences for institutional and	● Factor this Variance into the current Tri Party discussions related to these decisions. ● Discussions must include consideration of final disposal for capsules in the 200 Area Core Zone.

Variance Number	Current Baseline	RBES Vision	Impacts (scope, cost, schedule, risk)	Barriers to Achieving RBES	Recommendations
	●Ship approximately 2000 metal capsules of cesium-137 and strontium-90 to a geologic repository by 2020. ● Continued capsule storage under water until disposition. ● Central Plateau Core Zone remain under DOE control for waste management activities for the foreseeable future ● Store estimated 50 cubic meters of K Basin radioactive sludge in special containers in 200 Area until shipped to WIPP for disposal. ● Decontaminate the K-Basin as necessary to coincide with	3 ● Place cesium and strontium capsules in dry storage in the 200 Area. ● After 50 years of decay a final disposition pathway will be made. ● Strontium capsules are anticipated to meet onsite disposal criteria prior to the end of the EM cleanup mission. ● Cesium capsule activity is expected to exceed onsite disposal WAC - disposition decision will be made prior to the end of the EM mission. ● Central Plateau Core Zone remain under DOE control for waste management activities for the foreseeable future ● After removal of spent fuel from K-Basin, less than 0.5 cubic meters of fuel pieces will be removed from the sludge, stabilized and stored similar to the fuel. ● Stabilize remaining approximately 50 cubic meters of sludge using in-container solidification processes similar to those used in commercial nuclear power plant waste management operations. ● Directly dispose sludge after stabilization at WIPP or onsite if waste acceptance criteria met. ● Grout remaining equipment	radioactive because it contains less than 0.5 cubic meters of fuel pieces in the sludge. ● 2300 tons of K-Basin highly contaminated fuel packaged and stored in 200 Area. Under current and planned actions: ● Current pool storage of capsules runs about $5M per year. ● Sludge disposal at WIPP is estimated to require 1,000 containers. ● Decontaminating K-Basin and removal of equipment will not occur for 5 or more years. ● Decontaminating K-Basin poses significant worker exposure potential. Under RBES Vision: ● Capsule Storage in 200 Area is consistent with the CLUP exclusive industrial land use. ● Placing capsules in interim dry storage costs about $50M. ● Dry storage maintenance costs estimated at less than $1M per year. ● Long term safe dry storage of the capsules will facilitate future disposition. ● K Basin sludge would not have to be stored in T Plant in special containers for over 10years. ● Grouting sludge will result in much of the sludge and K-Basin equipment being acceptable for either WIPP or onsite disposal. ● Grouting significantly reduces worker risk posed by removing, handling and storing the debris and	other controls for CLUP land uses may differ from DOE's preferences. ● How to balance the remediation risks to workers and risks from transportation with the potential long-term environmental impacts needs to be better understood. ● Capsule disposal at Yucca Mountain repository requires a license application or license amendment. ● Cesium/strontium inventory is regulated under RCRA and is stored in a RCRA facility. Mutual agreement on the conditions of a long term storage permit is not achieved. ● Mutual agreement on grouting, and possible onsite disposal of some K-Basin sludge is not certain.	● Discussions should consider CLUP identified land use scenarios for the 100 Areas and 200 Areas affected, as appropriate, and consider short term risks to workers and risks involved in transportation and disposal activities. ● Evaluate the waste regulatory requirements that apply to capsules. ● Develop permit application for dry storage of capsules.

Variance Number	Current Baseline	RBES Vision	Impacts (scope, cost, schedule, risk)	Barriers to Achieving RBES	Recommendations
	cocooning of reactors in 2012. ● Transfer post remediation 100 Area land to US Fish and Wildlife Service to manage as part of the National Monument	and material in place and then cut up and moved to a disposal facility in the 200 Area. ● Transfer post remediation 100 Area land to US Fish and Wildlife Service to manage as part of the National Monument	untreated sludge. It also lowers transportation risks. ● Stabilized product provides safer handling. ● Avoids extensive deactivation of K-Basin. ● K basin removal could occur earlier than the cocooning of the K reactors, ● Consistent with Industrial Exclusive land use for the 200 Area. ● Risk to future Hanford Site workers and visitors and potential groundwater impacts is not expected to change.		
5.	**In-Place disposal via CERCLA of contaminated materials within the Central Plateau Core Zone** ● Inside Core Zone is Industrial land use and outside the Core Zone is Conservation and Preservation land use. ● No ground water use for drinking water or Industrial use - incidental contact only. ● 15 mrem/yr from radionuclides (3x10-4 risk based on EPA guidance) ● 1x10-4 to 1x10-6 risk from other contaminants.	● Core Zone Industrial Exclusive land use for radiation workers, industrial workers, and authorized visitors. ● Outside Core Zone, meet same objectives as 100 Area for Conservation and Preservation land use exposure scenarios - excluding fishing, and with mining for borrow soil. ● No ground water use for drinking water or Industrial use - incidental contact only ● Meet CERCLA risk range of 10-4 to 10-6 risk for radionuclides and other contaminants. Protect ecological resources for CLUP	● About 900 excess facilities inside and outside Core Zone, including 5 canyons and PFP must be properly dispositioned. ● Approximately 17 metric tons of bulk plutonium bearing material from PFP packaged into about 2,200 Specification 3013 containers and approximately 2,400 Pipe Overpack Containers (POCs). Under the current and planned actions: ● Partial demolition of Canyon buildings to canyon deck. Existing contaminated equipment size reduced, placed in canyon cells and grouted or removed to other disposal location. ● PFP removed to slab and equipment, debris and plutonium holdup packaged and disposed at	Barriers to Achieving RBES similar to Variance 3 above including: ● Regulators have expressed a preference to remove, treat and dispose of underground piping. ● Regulator, Tribal and stakeholder acceptance of on-site waste disposal may be low. ● Characterization requirements have not been mutually agreed.	● Obtain Integration Strategy agreement to expedite development of overall Central Plateau Regulatory and ROD Strategy. ● Implement this Variance and Variances 3 and 6 consistent with Integration Strategy for 200 Area zones. ● U Plant Regional Closure project could serve as a prototype to address this approach. Some alignment may be needed to fully incorporate recent risk based opportunities. ● Use lessons learned from the decision process and field work to improve remediation approaches on the remaining canyon facilities. ● Develop sampling approach for underground piping targeted to depth, location and type of

Variance Number	Current Baseline	RBES Vision	Impacts (scope, cost, schedule, risk)	Barriers to Achieving RBES	Recommendations
	● Prevent ground water degradation, protect the River and return to beneficial drinking water use if practicable. ● Protect ecological resources for this land use. ● Radionuclide decay assumed. ● Central Plateau Core Zone remain under DOE control for waste management activities for the foreseeable future	land uses. ● Radionuclide decay assumed. ● Use Integration Strategy to optimize and prioritize cleanup activities within discreet 200 Area zones (e.g.,, Canyon Zones). ● Prevent ground water degradation, protect the River and return to beneficial drinking water use if practicable ● Institutional controls to prevent intrusion or modification to caps. ● Central Plateau Core Zone remain under DOE control for waste management activities for the foreseeable future	WIPP or onsite if meets WAC. Potential subsurface contamination remediated under same approach as adjacent waste sites. ● PUREX tunnels filled with grout. ● Soil surface barrier placed over demolished Canyons to limit infiltration and to prevent human and animal intrusion. ● Large portions of underground piping removed for disposal on site or at WIPP. ● Long term institutional controls may be needed for capped areas and for wastes disposed onsite. Under RBES Vision: ● Less demolition of key facility structures and more contaminated material disposed on-site. ● Contaminated equipment from the Canyon/PFP and additional waste and adjacent facility demolition debris as well as small isolated waste sites disposed within or near the Canyon/PFP facilities to the extent practicable. Grout to fill void spaces. ● Demolish PFP to concrete structures surrounding RMC/RMA glovebox lines and PRF to lower canyon structure. Leave in place PFP equipment and structure lowering costs and shortening schedule. Savings could approach $500M. ● Remove approximately 0.1 metric tons of plutonium hold-up material from PFP. ● Grout contaminated equipment		contaminants carried to identify sections that must be removed.

Variance Number	Current Baseline	RBES Vision	Impacts (scope, cost, schedule, risk)	Barriers to Achieving RBES	Recommendations
			in PUREX Tunnel and leave in place. ● Strategically place surface barriers to provide groundwater protectiveness and prevent human and animal intrusion for a maximum number of facilities/waste sites and most efficient use of raw materials. ● Engineer barrier to minimize or eliminate the need for a surface cap. ● If the canyon footprint is not covered by a surface barrier, 2.3 million cubic meters of borrow source material or ~200,000 truck trips eliminated and avoiding associated ecological and worker risks. ● Up to 35,000 cubic meters of grout or fill material will be needed to fill the additional void space above the canyon deck for each canyon. ● Stabilization and in place disposal of 400 miles of buried pipelines with some sections (hot-spots) removed and disposed onsite as necessary has significant potential cost and schedule savings. ● Significant risk avoidance to the workforce during remediation. ● Risk to future Hanford Site workers and visitors and potential groundwater impacts is not expected to change. ● Institutional controls, long term monitoring, maintenance and		

Variance Number	Current Baseline	RBES Vision	Impacts (scope, cost, schedule, risk)	Barriers to Achieving RBES	Recommendations
			periodic review to determine continuing remedy protectiveness not expected to change.		
6	**Retrieve Tank Waste and Close Tank Farms Based on Risk Consistent with CLUP Industrial Exclusive Land Use and Integration of RCRA and CERCLA** ● Tanks are considered RCRA TSD units. ● TPA requires that waste be retrieved to the extent "technically possible" before considering "risk based" retrieval per TPA criteria. ● Currently assumed that 99% removal is possible. ● High-level waste portion will be stabilized in glass logs and disposed in geologic repository. ● Low-level mixed waste portion stabilized in form approved by State and disposed in 200 Area. ● Remaining residues will be stabilized to meet RCRA LDR delisting criteria and AEA low level waste disposal criteria. ● Fill tank void space to isolate stabilized waste residuals and prevent tank subsidence. ● Remove/demolish ancillary	Same as current endstate except ● Meet criteria for exclusive Industrial land use exposure scenarios for industrial and radiation workers and authorized visitors as described in Variance #3. ● Tank waste retrieved to extent required for closure under RCRA landfill closure and integration with CERCLA requirements.	● 149 single shell and 28 double shell tanks distributed among 18 Tanks Farms. ● 54 million gallons of liquid, sludge and salt cake waste. ● Most tanks beyond design life. ● 67 tanks have leaked one million gallons of waste with some reaching groundwater. ● Additional leaks highly likely. ● Chemical vapors released from tanks potentially exposing workers. ●Potential for significant radioactive airborne releases. RBES Vision compared to current and planned actions: ● Simpler retrieval systems and less waste retrieved. ● Less waste treated and disposed. For example, if 90% of waste retrieved rather than 99%, cost savings would be approximately $3 billion based on: - Less waste retrieved and treated: cost savings ~$1.5-2B - 10% reduction in number of HLW canisters: cost savings ~$0.5 billion for RPP and $0.4 billion repository fee - 10% reduction in ILAW: cost reduction ~ 0.4 billion - Waste treatment completed ~2 years sooner. ●Worker dose is expected to be	Barriers to Achieving RBES similar to Variance 3 above including: ● Stakeholder concerns about waste left in tanks and impact on Columbia River.	● Implement this Variance and Variances 3 and 5 consistent with Integration Strategy for 200 Area zones. ● Obtain agreement on integration strategy. ● Determine impacts of tank waste residuals in concert with expediting the final remediation approach for the Central Plateau. ● DOE studies should include Tank farm closure pathway analysis and exposure factors for CLUP identified land use scenarios: Industrial Exclusive for the 200-Area Core Zone and Conservation/Preservation outside of the Core Zone.

Variance Number	Current Baseline	RBES Vision	Impacts (scope, cost, schedule, risk)	Barriers to Achieving RBES	Recommendations
	facilities to grade and fill void spaces. ● Surface barrier placed over tank farms for long term mitigation of contaminant movement in ground water and human intrusion. ● Barrier construction coordinated with adjacent 200 Area waste site barrier construction. ● Implement effective Institutional Controls and monitoring for indefinite period into future. ● Central Plateau Core Zone remain under DOE control for waste management activities for the foreseeable future	● Central Plateau Core Zone remain under DOE control for waste management activities for the foreseeable future	reduced ~10% (1,100 person-rem). ● Risk to future Hanford Site workers and visitors is not expected to change. ● Risk avoidance to the workforce and would lower transportation risks. ● Sources of ground water contamination will be removed to the extent practicable, but areas and levels of contamination could become higher before attenuation occurs. ● But, protection of River water quality will not change.		
7	**Leave reactor pipelines in the Columbia River and Reactor Cores in place based upon CLUP Conservation and Preservation land use exposure scenarios** ● Allow decay of activation products in covered reactor cores for 75 years. ● Demolish reactors down to shield walls and install 75 year roof ("cocooning"). ● Potentially remove reactor	● Meet criteria for Conservation and Preservation land use exposure scenarios for 100 Area as described in Variance #1. ●Reactor cores decay in place.	● Eight of the Nine reactor facilities along Columbia River will be decommissioned and "cocooned". ● Approximately 2700 meters of large reactor piping in the river bed. Under current and planned actions: ● Pipelines may have to be removed from under the river bed to the deepest part of the river channel. ● Pipeline characterization indicates that contamination within CERCLA risk range for rural resident scenario. ● Reactors would potentially be completely demolished and transported for disposal in 200 Area, in accordance with current EIS.	Barriers to Achieving RBES similar to Variance 1 above.	● Implement in concert with recommended actions for development of expedited ROD in Variance #1. ● Risk assessment should include leaving the reactor cores and piping in place vs. removal.

Variance Number	Current Baseline	RBES Vision	Impacts (scope, cost, schedule, risk)	Barriers to Achieving RBES	Recommendations
	remains after 75 years for disposal in 200 Area Core Zone. ● Institutional controls until removal of reactor cores. ● Engineering evaluation of reactor cooling water discharge pipeline may propose removal and disposal (possibly in ERDF).	● Reactor pipelines left in place and stabilized.	Under the RBES Vision: ● Cost and schedule estimates have not been developed for removal of pipelines but less cost to leave in place. ● Leaving pipelines in place poses lower worker and ecological risks than from removal and waste transportation. ● Leaving reactor cores in place poses lower worker risks than from removal and waste transportation. ● Costs for long term monitoring and maintenance and periodic review to determine continuing remedy protectiveness would continue after 75 years.		

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Appendix A

200 Area Alternatives Considered

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200 Area Alternatives Considered

Alternative 1 - Engineered Surface Barriers With or Without Vertical Barriers

Alternative 1 consists of engineered surface barriers that would be designed to remediate different types of waste. Alternative 1 would provide a permanent cover over the affected area. The cover would accomplish the following: minimize the migration of precipitation into the affected soil and contaminant leaching; minimize the potential for biotic intrusion; reduce the migration of windblown dust that originated from contaminated surface soils; reduce the potential for direct exposure to contamination; and reduce the volatilization of volatile organic compounds (VOCs) to the atmosphere. If vertical barriers were included, they would limit the amount of lateral migration of contaminants and limit the horizontal movement of moisture beneath the surface barrier. An option for dynamic compaction is also included in this alternative for application at solid waste landfills prior to surface barrier construction to reduce settlements and subsidence that may impact the integrity of a surface barrier. This alternative would not reduce the volume or toxicity of the contaminants, and periodic inspections, maintenance, and monitoring would be required for an indefinite period.

Alternative 2 - Excavation and Disposal With or Without Ex Situ Treatment

Radioactive and hazardous soil or solid debris would be excavated using conventional techniques, with special precautions to minimize fugitive dust generation. If needed, several treatment options could be selected from physical, chemical, and thermal ex situ treatment process options. For example, thermal desorption with offgas treatment could be used if organic compounds are present; soil washing or mechanical separation could be used to separate contaminated fine-grained soil particles; and stabilization/solidification could be used to immobilize radionuclides and heavy metals or to satisfy the treatment option for land disposal restricted wastes. The treated soil would be backfilled into the original excavation or landfilled. Soil treatment by-products may require additional processing or treatment.

Both onsite and offsite landfill disposal options are included in the alternative depending on the nature of the waste. The Environmental Restoration Disposal Facility located adjacent to the 200 Areas is the preferred disposal facility because it has been specifically constructed to handle low level radioactive and/or hazardous waste from environmental remediation activities on the Hanford Site. The offsite disposal option is identified as a contingency for waste forms or contaminants prohibited at the Environmental Restoration Disposal Facility.

Alternative 2 would be effective in treating a full range of contamination, depending on the type of treatment processes selected. Attainment of remedial action objectives would depend on the depth to which the material was excavated. If near surface soil or buried waste was treated, airborne contamination, direct exposure to contaminated soil, and bio-mobilization of contamination would be minimized. Because of practical limits on deep excavation, deep contamination may not be removed and would be subject to migration into groundwater. If further degradation of the groundwater were a concern, additional treatment of deep contamination would be needed. For example, Alternative 2 could be used in conjunction with Alternative 4 (in situ grouting or stabilization of soil) to stabilize deep contaminants.

Alternative 3 - Excavation, Ex Situ Treatment, and Geologic Disposal of Material With Transuranic Radionuclides

Certain waste sites in the 200 Areas may contain isolated zones where the concentration of transuranic radionuclides exceeds 100 nCi/g. For Alternative 3, the soil or solids from those isolated zones would be excavated, stabilized or treated, and shipped to an offsite geologic disposal site.

This alternative would use many excavation and treatment technologies that have been only partly demonstrated at industrial sites. Extensive treatability testing would be required for the transuranic-containing soil to develop optimum methods for treating or stabilizing the transuranic radionuclides. Additional treatability studies might be required to support the aboveground treatment of the non-transuranic soil. The use of remotely controlled excavation and material handling equipment may be needed.

Alternative 4 - In Situ Grouting or Stabilization of Soil

Radioactive and hazardous soil would be grouted using in situ injection methods. The end product is monolithic block of contaminated material encapsulated in grout which would significantly reduce the leachability of hazardous contaminants, radionuclides, and/or semivolatile organic compounds from the affected soil. Grouting may also be used to fill voids, such as in timbered cribs, thereby reducing subsidence. Another variation of this alternative would be to stabilize the soil using in situ mixing of soil with stabilizing compounds such as fly ash.

Alternative 4 would provide a combination of immobilization and containment of heavy metal, radionuclide, inorganic, and semivolatile organic compound contamination. Thus, this alternative would reduce migration of precipitation into the affected soil, reduce the migration of windblown dust that originated from contaminated surface soils, reduce the potential for direct exposure to contaminated soils, and possibly reduce the volatilization of VOCs. Because this alternative would not remove the contaminants from the soil, it is likely that institutional controls would be required.

Alternative 5 - In Situ Vitrification of Soil

The contaminated soil in a subject site would be immobilized by in situ vitrification. High-power electrodes would be used to vitrify the contaminated soil under the site to a depth below where contamination is present. Fences and warning signs may be placed around the vitrified monolith to minimize disturbance and potential exposure.

In situ vitrification would be effective in treating radionuclides, heavy metals, and inorganic contamination, and can also destroy organic contaminants. This would reduce the potential for exposures by leaching to groundwater, windblown dust, and direct dermal contact. However, this alternative would not remove metals or radionuclides from the soil and would likely require additional institutional controls. In situ vitrification may be limited to depths of less than about 6 meters (20 feet), which may not be adequate to immobilize deep contamination.

Alternative 6 - In Situ Soil Vapor Extraction for Volatile Organic Compounds

Soil vapor is drawn from wells that are screened in permeable soil zones that contain high organic vapor concentrations. The vented air would be treated to remove water vapor, the organic vapor of concern, particulate radionuclides that might be entrained in the air stream, and volatile radionuclides.

Alternative 6 utilizes proven technologies to remove the volatilized vapors from the vadose zone soil. No additional treatability testing is expected to be needed for this process because it has been successfully implemented in the 200 Areas near Z Plant. Soil vapor extraction would reduce downward and lateral migration of the VOC vapors through the vadose zone, and thereby reduce potential cross-media migration into the groundwater. Soil vapor extraction would reduce upward migration of VOC through the soil column into the atmosphere, and thereby minimize inhalation exposures to the contaminants. In some cases where radionuclides were discharged to the disposal sites with VOCs (e.g., carbon tetrachloride), the removal of VOCs could reduce the mobility of the radionuclides, and thereby reduce the potential for downward migration of the radionuclides. Finally, soil vapor extraction would enhance partitioning of the VOC off of the soil and into the vented air stream, resulting in the permanent removal of the VOC. Alternative 6 may be used in conjunction with other alternatives if contaminants other than VOCs are present.

Alternative 7 - Monitored Natural Attenuation

This alternative includes a variety of contaminant-specific physical, chemical, or biological processes to reduce the mass, activity, toxicity, mobility, volume, or concentration of contaminants in soil or solid debris. The alternative would include sampling and environmental monitoring, consistent with EPA guidance (EPA 1997), to verify that contaminants are attenuating as expected and to ensure that contaminants remain isolated (i.e., will not lead to further degradation of groundwater). As part of the site-specific detailed analysis of this alternative, the hazards and mobility of the possible transformation or daughter products must be addressed.

Sampling activities would include:

- Sampling contaminated materials and the soils below the sites to verify the nature and extent of contamination
- Verify the hydrogeologic, geochemical and/or biological properties of the vadose zone important to the attenuating processes
- Serve as a monitoring baseline
- Support predictive modeling, if needed.

Environmental monitoring (e.g., vadose zone and/or groundwater) would be conducted to ensure waste containment is achieved and no further degradation of groundwater occurs. The existing network of groundwater monitoring wells in the 200 Areas should be adequate for monitoring most sites. Vadose zone monitoring may be appropriate to verify the effectiveness of attenuating processes and as an indicator of potential future groundwater impacts.

Monitored natural attenuation may be used as a complete remedial alternative, in conjunction with other remedial alternatives, or as a follow-up activity to remedial measures already completed. As a standalone option, monitored natural attenuation is considered most applicable to low-mobility contaminants with limited persistence, where the source is controlled, contaminant plumes that are stable or shrinking, and where potential surface exposure is minimal. If the ability of natural attenuation to meet site-specific RAOs is uncertain, contingency measures (e.g., defaulting to another alternative) should be identified. In any case, institutional controls will likely be necessary to ensure long-term protectiveness.

The preliminary remedial action alternatives identified previously for use in the 200 Areas comprise the complete list of alternatives. However, not all alternatives are applicable to all waste groups. For example, in situ vapor extraction would not be applicable for waste groups that do not have volatile organic soil contamination. Criteria used to evaluate the applicability of alternatives to specific waste groups include:

- Installing engineered surface barriers with or without vertical barriers (Alternative 1) could be used on sites where contaminants may be leached or mobilized by the infiltration of precipitation.

- Excavation and disposal with or without soil treatment (Alternative 2) could be used at most waste sites that contain shallow contamination including; radionuclides, heavy metals, other inorganics compounds, semivolatile organic compounds, and VOCs.

- Excavation, treatment, and geologic disposal of transuranic-containing soils (Alternative 3) could be used only on those sites that contain transuranic radionuclides. Since a geologic repository is likely to accept only transuranic radioactive soils or transuranic/mixed waste, the non-transuranic radioactive soils will not be remediated using this alternative.

- In situ grouting or stabilization (Alternative 4) could be used on waste sites that contains heavy metals, radionuclides, and/or other inorganic compounds. In situ grouting could also be effective in filling voids for subsidence control.

- In situ vitrification (Alternative 5) could be used at most waste sites although this alternative is considered to be most applicable to sites that contain high concentrations of contamination in a small area. Vapor extraction may be needed when VOCs are present. In situ vitrification would not be effective at sites where deep contamination or combustible solid debris is present.

- In situ soil vapor extraction (Alternative 6) could be used on any sites that contain VOCs.

- Natural attenuation (Alternative 7) is applicable at any waste site.

Using these criteria, Table 4.2 in the main text shows preliminary remedial action alternatives that could be used to remediate specific waste groups. A single alternative may not be sufficient to remediate all contamination within a single group. For example, it may be more feasible to place engineered surface barriers at certain waste sites within a group while at other sites excavation and disposal may be more appropriate. Furthermore, some waste sites may require a combination of alternatives. For example, soil vapor extraction to remove organic contaminants could precede in situ vitrification. Detailed feasibility studies will be required to refine and more fully evaluate alternatives as they relate to the specific waste sites.

To date, no final remedial actions have been taken on the 200 Area waste sites. Numerous stabilization actions have been taken to prevent movement of contamination from waste sites, such as applying 46 to 61 centimeters (18 to 24 inches) or more of clean soil over waste sites and controlling animal and plant intrusion. These interim stabilizations provide some protection to human and ecological receptors, but do not necessarily provide a final solution.

Maps A.1 and A.2 show the surface barriers sites in the 200 East and 200 West Areas.

Appendix B

Hanford Advisory Board Advice and Public Comment for Risk-Based End States

To: Mike Thompson

From: Todd Martin

Date: 18 October 2003

Re: HAB advice pertaining to Risk Based End States

Mike, below are some select passages from HAB advice that bear on the RBES discussion. This quick summary comes with a couple of caveats.

First, it is always a bit dicey to take any individual comment out of the context of its original piece of advice. As a result, these are reference points for you on how the Board might lean on any particular issue as opposed to hard, fast stances.

Second, this doesn't represent an exhaustive review of HAB advice and adopted products (such as the Future Site Uses Working Group Final Report). Rather, this is a quick review of input the Board has provided over the last couple years on these topics.

I hope this is useful and don't hesitate to contact me if you have questions (250/362-5629 or toddmartin@telus.net).

Advice #125:

> "Groundwater remains of foremost concern to the Board. The Board encourages the agencies to maintain ongoing successful groundwater remediation actions and pursue more aggressive technology development and treatment activities."
>
> Board advised that 300 Area cleanup should be comprehensive (e.g. include all facilities and waste sites).
>
> "The Board also recommends DOE's approach to cleanup priorities in the 300 Area be based on risks to workers, the public and the environment with appropriate consideration to infrastructure and mortgage reduction issues."
>
> "Consistent with past Board advice, the cleanup goal 'outside the 300 Area fence' should be unrestricted use." The Tri-Party Agreement agencies response to this was essentially, 'it will remain industrial.' This is an example of where the RBES process may bring the 300 Area cleanup closer to HAB values.

Advice #128:

> "The Board advises that a comprehensive risk assessment, including quantitative analyses be developed to guide cleanup decisions."

Advice #129:

> "Any decision to relax current standards to accelerate cleanup and reduce costs must be supported by credible risk assessments, for example, leaving waste in tanks, reclassifying wastes, and possible increases in soil disposal."

Advice #131:

"Currently the Board defines compliance with the Tri Party Agreement (TPA) and its processes as the blueprint for responsible cleanup."

This advice also identified a sort of variance analysis saying that the PMP should, "identify acceleration proposals not in compliance with current orders, rules and laws, or in keeping with the TPA."

Advice #132:

"The Board acknowledges that some waste will remain in the core zone when this cleanup effort is complete. However, the core zone should be as small as possible and should not include contaminated areas outside the 200 Area fences. The waste within the core zone should be stored and managed to make it inaccessible to inadvertent intruding humans and animals."

"A continued human presence in the core zone would provide an ongoing, active institutional interest vested in future management of the risks posed by Hanford waste. One way to ensure this continuous human presence is to maximize the potential for any beneficial use of the accessible areas of the core zone, rather than rely only on long-term government control of these areas."

"Groundwater is a valuable resource with beneficial future uses that must not be restricted outside of the individual waste management unit points of compliance within the core zone."

"For the Central Plateau, the Board advises the agencies to analyze a range of potential human health and ecological risks, including the reasonable maximum risk expected over time. The stakeholder community will use this analysis to advise the agencies on appropriate cleanup decisions. The risk analysis should include: a reasonable maximum exposure to a resident and/or Native American, including groundwater use, in what is currently labeled the buffer zone and in areas freed up for use as the core zone shrinks. For the waste management areas within the core zone, exposure scenarios should include a reasonable maximum exposure to a worker/day user, to possible Native American users, and to intruders."

Advice #135:

"Consistent with its previous advice on risk assessment and exposure scenarios, the Board recommends that a spectrum of analyses and scenarios be run to include tribal use, recreational and rural residential uses in the river corridor. The agencies should consider tribal and recreational use scenarios for all lands within at least one-quarter mile from the river shoreline. In the upland areas of the river corridor, tribal, recreational and rural residential scenarios should be used. Results of risk analyses and exposure scenarios need to be communicated with the public prior to making any decisions based on these efforts."

"Groundwater in the river corridor should be remediated to meet drinking water and ambient water quality standards by the time DOE petitions the EPA to remove the river corridor from the National Priorities List."

Advice #145:

> "Activities must do no further harm to groundwater and groundwater should be cleaned up to its highest beneficial use. The Department of Energy's Hanford site Groundwater Strategy and Groundwater Implementation Plan, and all DOE plans, strategies and actions should reflect that goal."