DOE/RL-2009-54
Revision 0

Proposed Plan for Amendment of 100-NR-1/ NR-2 Interim Action Record of Decision

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

U.S. DEPARTMENT OF ENERGY Richland Operations Office

P.O. Box 550
Richland, Washington 99352

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U.S. Department of Energy, Richland Operations Office
U.S. Environmental Protection Agency
Washington State Department of Ecology

Department of Energy Hanford Site June 2010

Public Comment Period

June 21 – July 22, 2010

How You Can Participate:

Read this Proposed Plan and review related documents in the Administrative Record.

Comment on this Proposed Plan by mail or e-mail, on or before July 22, 2010.

See page 27 for more information about public involvement and contact information.

Inside this Plan

Figure 1. 100-N Area (2008)

INTRODUCTION

This Proposed Plan describes the rationale for amending the 1999 EPA/ROD/R10-99/112, *Interim Remedial Action Record of Decision for the 100-NR-1 and 100-NR-2 Operable Units, Hanford Site, Benton County, Washington* (**interim action ROD**). The 100-NR-1 and NR-2 **Operable Units (OU)** are located on the Hanford Site in south-central Washington State. The following changes to the interim action ROD are proposed:

- Construct a subsurface **permeable reactive barrier (PRB)** to immobilize strontium-90 (Sr-90) present in soil and groundwater, thus reducing its **flux** to the Columbia River through groundwater flow.
- Decommission the existing pump-and-treat system's treatment facility and conveyance piping.

As described in the Evaluation of Alternatives section of this Proposed Plan, five remedial action alternatives were evaluated with the overall goal of reducing the Sr-90 flux to the Columbia River.

Interim Action ROD

Interim Remedial Action Record of Decision for the 100-NR-1 and 100-NR-2 Operable Units, Hanford Site, Benton County, Washington

OU

Operable Unit. Generally, a discrete geographic portion of a larger Site.

PRB

Permeable reactive barrier. Placement of reactive materials in the subsurface to intercept a contaminant plume, provide a flow path through a reactive media, and immobilize or transform the contaminant(s) into environmentally acceptable forms to attain remediation concentration goals on the downgradient side of the barrier.

Flux

A term that describes the mass of contaminant that moves past a boundary per unit time. Typical units include kilograms (pounds) per day.

MCL

Maximum contaminant level. The maximum concentration of a contaminant allowed in water delivered to public drinking water systems.

Lead Regulatory Agency

The lead regulatory agency is that agency (Ecology for the 100-N Area) that is assigned regulatory oversight responsibility with respect to actions under the Tri-Party Agreement regarding a particular OU, Treatment, Storage or Disposal Unit; or Milestone pursuant to Section 5.6 of the Tri-Party Agreement Action Plan.

Non-Lead Regulatory Agency

The non-lead regulatory agency (EPA for the 100-N Area) provides the lead regulatory agency with technical support associated with review of Tri-Party Agreement primary documents. The non-lead regulatory agency also provides concurrence on decision documents.

These alternatives included: the No-Action Alternative, Alternative 1—Institutional Controls and Monitored Natural Attenuation, Alternative 2—Resume Operation of Existing Pump-and-Treat System, Alternative 3—Impermeable Barrier, and Alternative 4—Apatite Permeable Reactive Barrier (PRB). Under Alternative 4 (the preferred alternative), the apatite PRB would be extended from its current length of 90 meter (m) (300 feet [ft]) to approximately 760 m (2,500 ft) to span the width of the area where Sr-90 concentrations in groundwater exceed the U.S. Environmental Protection Agency (EPA) 8 picocurie per liter (pCi/L) drinking water standard, which is also known as the **maximum contaminant level (MCL)**. The 8 pCi/L Sr-90 drinking water standard is also protective of aquatic biota present in the Columbia River because this concentration corresponds to a radiation dose that is 90,000 times more conservative than DOE's aquatic animal radiation dose limit of 1.0 rad per day.

The extended PRB will provide increased protection for the Columbia River by immobilizing Sr-90 across a broad section of the shoreline to reduce the amount of Sr-90 that reaches the river. The Sr-90 will remain bound within the PRB's apatite matrix, where it will naturally decay to concentrations that reduce the threat to human health and the environment. Concurrent or following construction of the apatite PRB, DOE will decommission the treatment components of the existing 100-NR-2 OU groundwater pump-and-treat system, which was placed in standby mode in 2006.

Three government agencies are involved in 100-N Area cleanup activities. DOE is the lead agency responsible for performing the interim remedial action. The Washington State Department of Ecology (Ecology) is the **lead regulatory agency**, while EPA is the **non-lead regulatory agency**.

DOE, Ecology and EPA (Tri-Parties) are seeking public input on the remedial action alternatives considered and the preferred alternative recommended for implementation in this Proposed Plan. The public is encouraged to review the key documents identified in the Sidebar and References section of this Proposed Plan to gain a more comprehensive understanding of the 100-N Area. These documents are available in the Hanford Site Administrative Record or at the public information repositories identified in the Community Participation section of this Proposed Plan.

After considering public comments, the Tri-Parties will select a remedial action alternative and prepare an amendment to the interim action ROD. The Tri-Parties will provide a response to public comments on this Proposed Plan in the responsiveness summary included in the interim action ROD amendment. Information concerning how the public can provide input on the preferred remedial action alternative, or any of the other identified alternatives, is provided in the Community Participation section of this Proposed Plan.

This Proposed Plan is being issued to fulfill the requirements of Section 117(a) of the ***Comprehensive Environmental Response, Compensation, and Liability Act*** **(CERCLA)** and Section 300.430(f)(2) of the **National Oil and Hazardous Substances Pollution Contingency Plan (NCP)** (40 Code of Federal Regulations [CFR] 300). This Proposed Plan also fulfills DOE's policy to consider values identified in the ***National Environmental Policy Act*** **(NEPA)** when evaluating proposed CERCLA remedial actions.

SITE BACKGROUND

The Hanford Site encompasses approximately 1,517 square kilometers (km^2)(586 square miles [mi^2]) in the Columbia Basin of south-central Washington State (Figure 2). In 1942, the area was selected for plutonium production as part of the Manhattan Project because of the abundant water available from the Columbia River, and the availability of electricity from the Bonneville and Grand Coulee Dams. Originally designated as the Hanford Works, and later the Hanford Nuclear Reservation, the Hanford Site occupies parts of four counties (Benton, Franklin, Grant, and Adams) located north of Richland, Washington. In July 1989, the Hanford Site was placed on the CERCLA **National Priorities List (NPL)** (40 CFR 300, Appendix B) as four separate NPL sites comprising the 100 Area, 200 Area, 300 Area, and 1100 Area.

100-N Area Description

The 100-N Area is located in the northern part of the Hanford Site along the Columbia River (Figure 2). Nine plutonium production reactors were built and operated between 1943 and 1986 in six geographic areas identified as the 100-B/C, 100-K, 100-N, 100-D, 100-H, and 100-F Areas.

The 100-N Reactor was constructed between 1958 and 1963. The reactor began producing plutonium in April 1964 and began generating steam for electricity at the Washington Public Power Supply System Hanford Generating Plant in 1966. Both uses of the reactor continued until 1986, when the reactor was placed in a stand-down status. In 1988, DOE placed the reactor in cold standby. In 1991, DOE issued an order to prepare the 100-N Reactor for decontamination and decommissioning (DOE/RL-97-1047).

The 100-N Reactor was unique in its use of a heat-exchange cooling system to reduce contaminant discharge to the environment, in comparison with other 100 Area reactors that used a single-pass cooling water design. The primary coolant (deionized water) was passed through the reactor multiple times (roughly 100 cycles, based on a 1 percent continuous bleed rate [PNNL-SA-39495]), which resulted in higher concentrations for some radionuclides in the cooling water relative to Hanford's single-pass reactors.

CERCLA

Comprehensive Environmental Response, Compensation, and Liability Act (42 USC 9601, et seq.)

NCP

National Oil and Hazardous Substances Pollution Contingency Plan (Implementing CERCLA, 40 Code of Federal Regulations Part 300)

NEPA

National Environmental Policy Act (42 US Code Section 4321, et seq., implemented at 40 Code of Federal Regulations Part 1500, et seq.)

100-NR-1/NR-2—Key Documents

National Oil and Hazardous Substances Pollution Contingency Plan

Limited Field Investigation Report for the 100-NR-1 Operable Unit

Limited Field Investigation Report for the 100-NR-2 Operable Unit: Hanford Site, Richland, Washington

Qualitative Risk Assessment for the 100-NR-2 Operable Unit

Corrective Measures Study for the 100-NR-1 and 100-NR-2 Operable Units

Interim Remedial Action Record of Decision for the 100-NR-1 and NR-2 Operable Units, Hanford Site, Benton County

Evaluation of Strontium-90 Treatment Technologies for the 100-NR-2 Groundwater Operable Unit Letter Report

Strontium-90 Treatability Test Plan for the 100-NR-2 Groundwater Operable Unit

NPL

National Priorities List (Code of Federal Regulations, Title 40, Part 300, Appendix B)

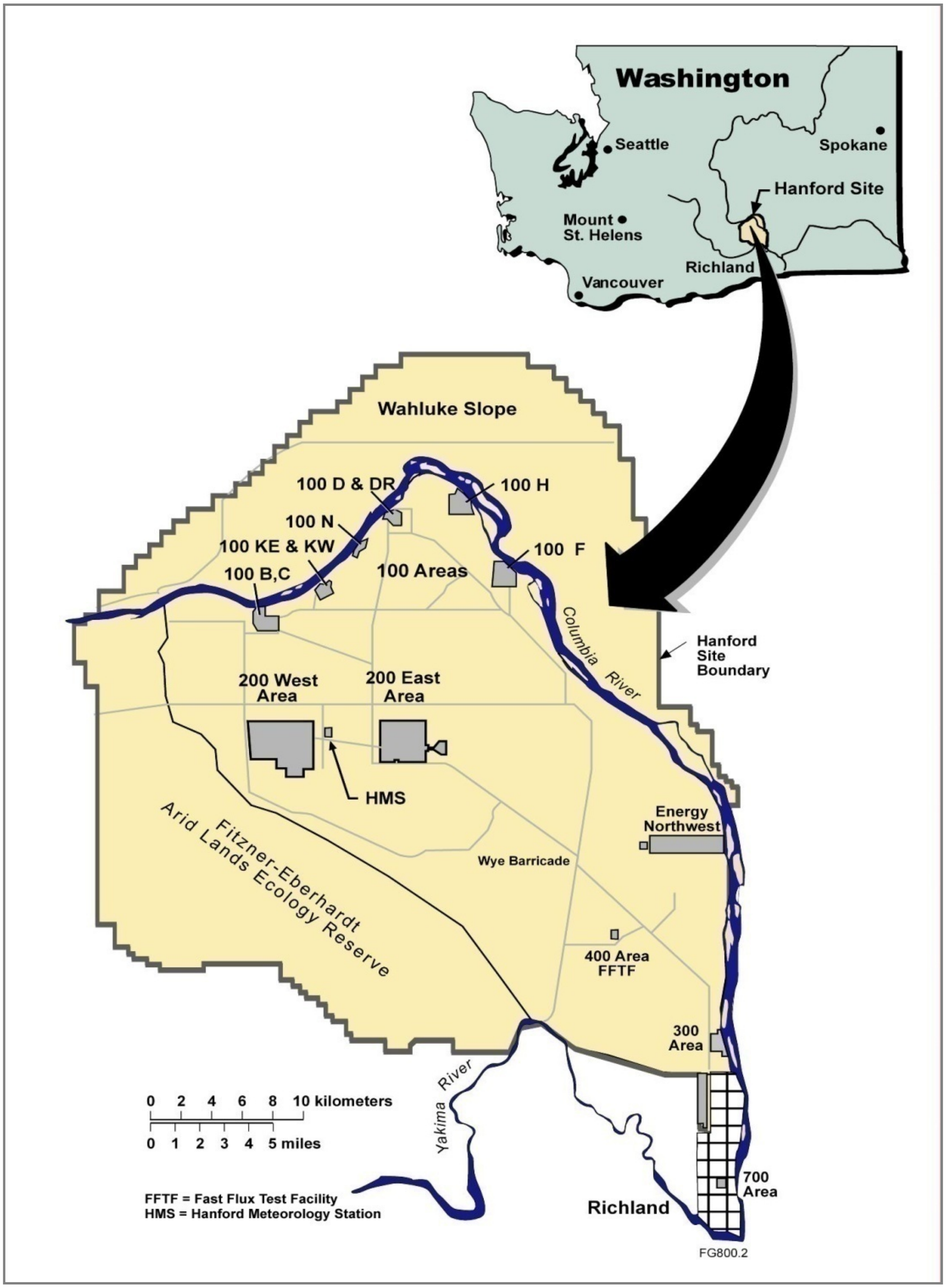

Figure 2. Hanford Location and 100 Area Site Map

The 100-N Area (Figure 3) includes two OUs. The 100-NR-1 OU spans an area of approximately 405 hectares (ha) (1,000 acres [ac]). The 100-NR-2 OU includes contaminated groundwater beneath and in proximity to the 100-NR-1 OU. A separate interim action ROD, identified as the treatment, storage, and disposal (TSD) ROD, addresses 100-NR-1 OU contaminated soil, structures, and pipelines associated with the 116-N-1 and 116-N-3 liquid waste disposal facilities (LWDF).

What media are contaminated at the site?

The primary media addressed by this Proposed Plan is groundwater contaminated with Sr-90. Other radionuclide and chemical contaminants have been detected in groundwater in the 100-N Area, and in groundwater upwelling samples collected along the Columbia River shoreline.

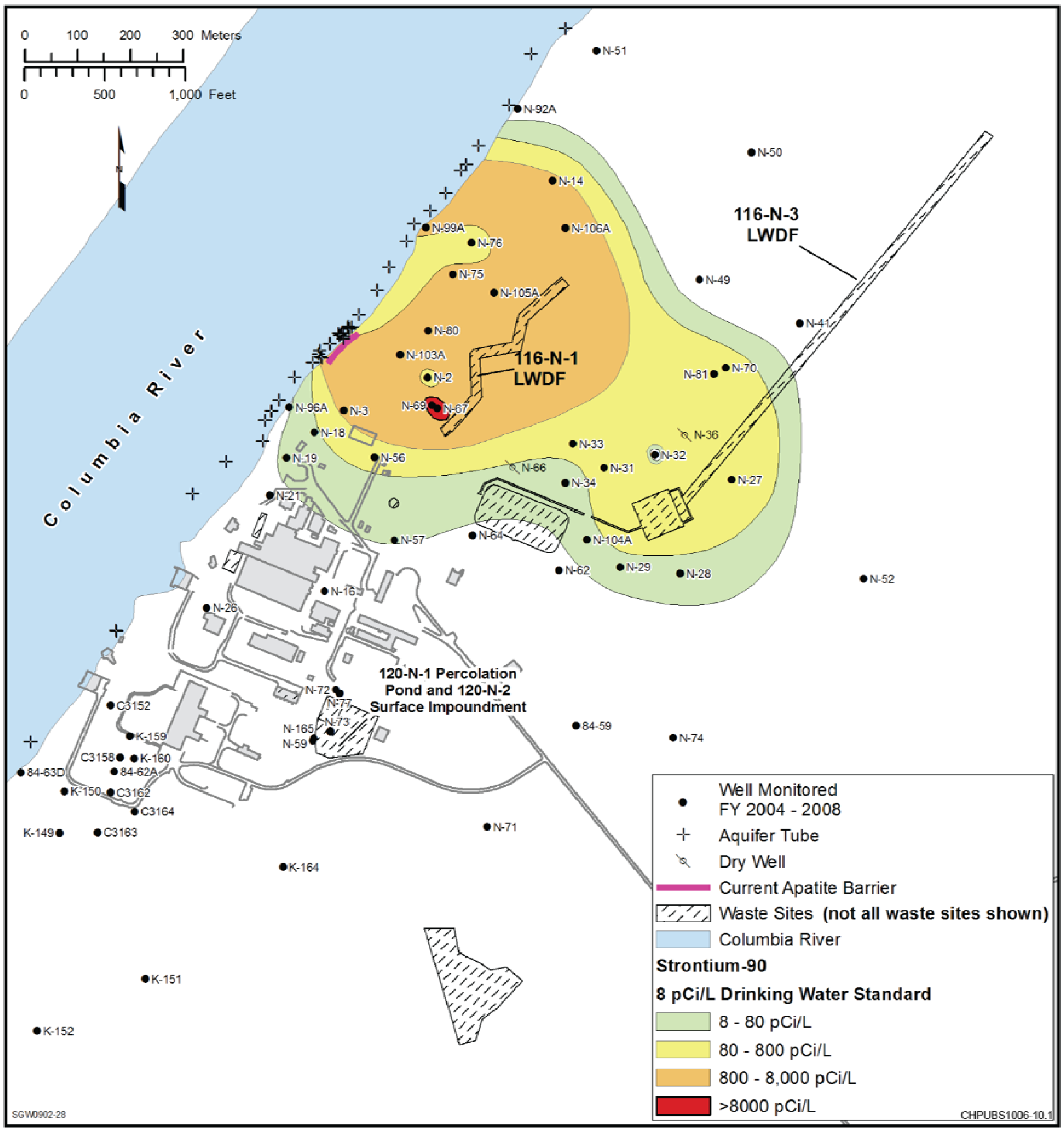

Figure 3. 100-N Area Site Map

RCRA

The Resource Conservation and Recovery Act (RCRA), enacted in 1976, is the principal federal law in the United States governing the disposal of solid waste and hazardous waste.

LFI

Limited Field Investigation. The collection of limited additional site data that are sufficient to support a decision on conducting an expedited response action or interim remedial measure.

ERA

Expedited Response Action. A non-time critical removal action conducted under 40 CFR 300.415 designed to address imminent threats to human health or the environment posed by the actual or potential release of hazardous substances. The 100-N Springs ERA was agreed to by the Tri-Parties on January 8, 1993 to address the presence of strontium-90 in 100-NR-2 groundwater at concentrations up to 750-times higher than the 8 pCi/L MCL.

What caused the current contamination at the site?

100-N Reactor operations and historical waste-handling practices resulted in the contamination of soil and groundwater at the 100-N Area. While the reactor was in operation, large volumes (3,785 L [1,000 gallons (gal.)] per minute) of cooling water were discharged to the soil through the 116-N-1 LWDF (between 1963 and 1983) and the 116 N-3 LWDF (between 1983 and 1991). The liquids percolated through the soil column, where they were transported by groundwater toward the Columbia River (Figure 4). The 116-N-1 LWDF was constructed about 244 m (800 ft) inland from the river. When Sr-90 was detected at the shoreline in 1985, the cooling water was diverted to the 116-N-3 LWDF, which is located farther inland.

The discharges to the LWDFs contained radioactive waste products and undocumented quantities of dangerous waste streams, including corrosive liquids, metals-laden wastes, and other laboratory chemicals as allowed by the ***Resource Conservation and Recovery Act*** **(RCRA)** Part A permit. Historical records indicate sodium dichromate was also used between 1964 and 1973 in the primary (re-circulation) cooling water system and subsequently discharged to the 116-N-1 LWDF. Approximately 65 tons of sodium dichromate was discharged to the 116-N-1 LWDF.

What previous investigations have occurred and what were the results?

A number of investigations have been conducted in the 100-N Area since the Hanford Site 100 Area was placed on the NPL in 1989. This included investigations at both the 100-NR-1 OU and the 100-NR-2 OU. Figure 5 shows a timeline of major 100-N Area activities.

DOE/RL-93-80, ***Limited Field Investigation (LFI)*** *Report for the 100-NR-1 Operable Unit*, and DOE-RL-93-81, *Limited Field Investigation Report for the 100-NR-2 Operable Unit: Hanford Site, Richland, Washington*, provided the first comprehensive assessment of contaminant distribution in soil and groundwater in the 100-N Area. While these investigations detected numerous radionuclide and chemical contaminants in soil and groundwater, Sr-90 has been the primary contaminant of interest as a result of its frequency of detection and the concentrations observed in proximity to the Columbia River. The concentration of Sr-90 detected in groundwater samples collected between 1993 and 1995 from monitoring wells near the river was more than 5,000 pCi/L. Subsequent monitoring has shown similar levels of Sr-90 in 100-NR-2 OU groundwater (Figure 3). Concentrations of Sr-90 in groundwater have remained relatively consistent since 1995.

What has been done to remediate the contamination?

In 1993, the Tri-Parties agreed to implement an **expedited response action (ERA)** to address Sr-90 present in groundwater along the Columbia River

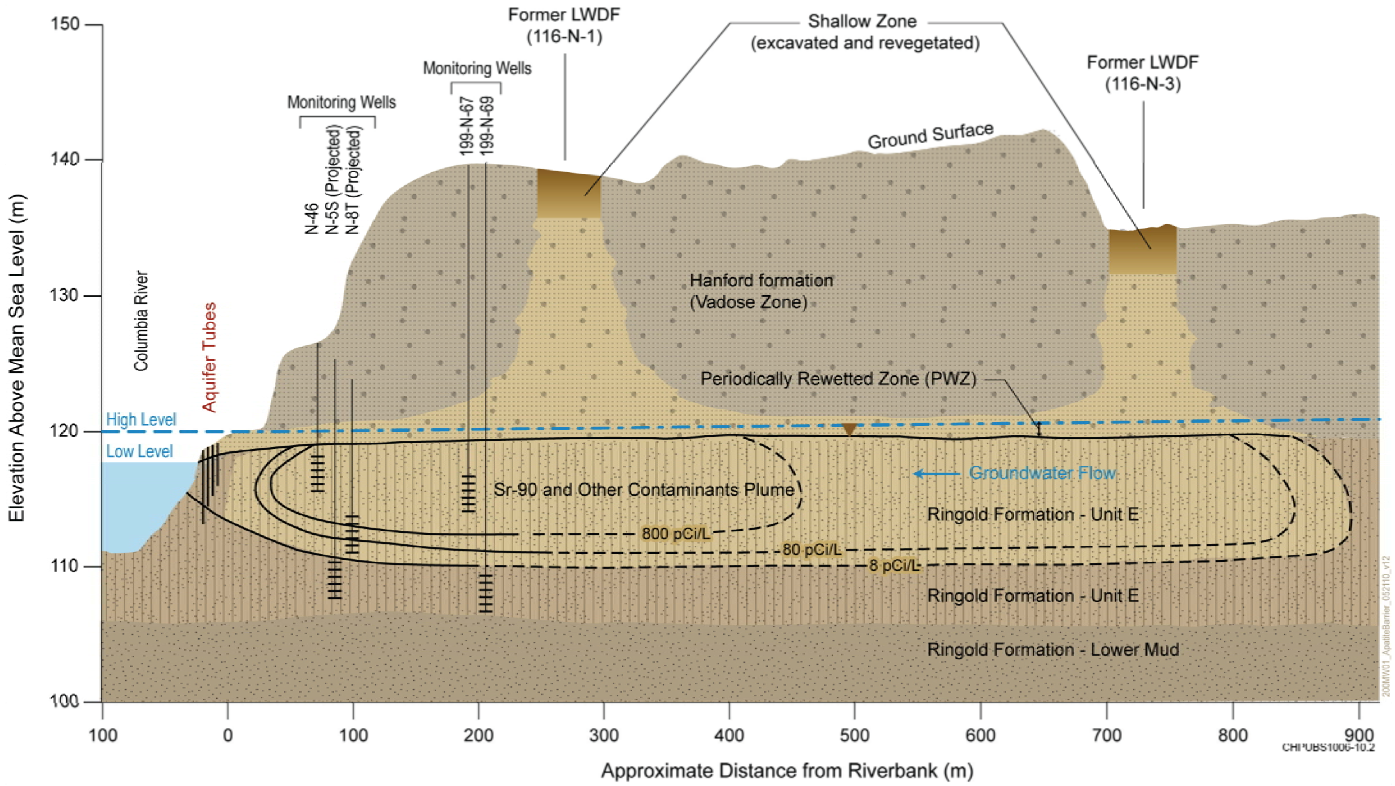

Figure 4. Contaminant Distribution Model for the 100-NR-1/NR-2 OU

shoreline. An action memorandum was issued by Ecology and EPA in September 1994 requiring the design, construction, and operation of a groundwater pump-and-treat system and construction of a sheet pile barrier. The pump-and-treat system included four extraction wells, a treatment system for Sr-90 removal, and two injection wells to return the treated water to the aquifer. The sheet pile barrier was not installed because the sheet piles could not be advanced to the required depth of 15.2 m (50 ft) during the constructability test.

The objectives for the ERA were to substantially reduce the flux of Sr-90 to the Columbia River and to obtain data sufficient to establish final remedial actions. The pump-and-treat system operated from September 1995 through March 2006, treating 1.1 billion L (305 million gal.) of groundwater containing 1.8 **curies (Ci)** of an estimated 1866 Ci (as of 1995) of Sr-90 discharged to the soil column through the 116-N-1 and 116-N-3 LWDFs. The 0.2 Ci removed each year was estimated to be 10 times less than the amount removed by natural radioactive decay (DOE/RL-2004-21). The pump-and-treat system had limited success in removing Sr-90 from the aquifer as a result of its strong affinity for adhering to aquifer sediments. Therefore, the system was placed in a standby mode in March 2006.

Along the shoreline, rip-rap material was placed over portions of the riverbank to reduce the potential for human and ecological receptor contact with contaminated groundwater seeps and springs.

Ci

Curie. A unit of radionuclide activity measurement.

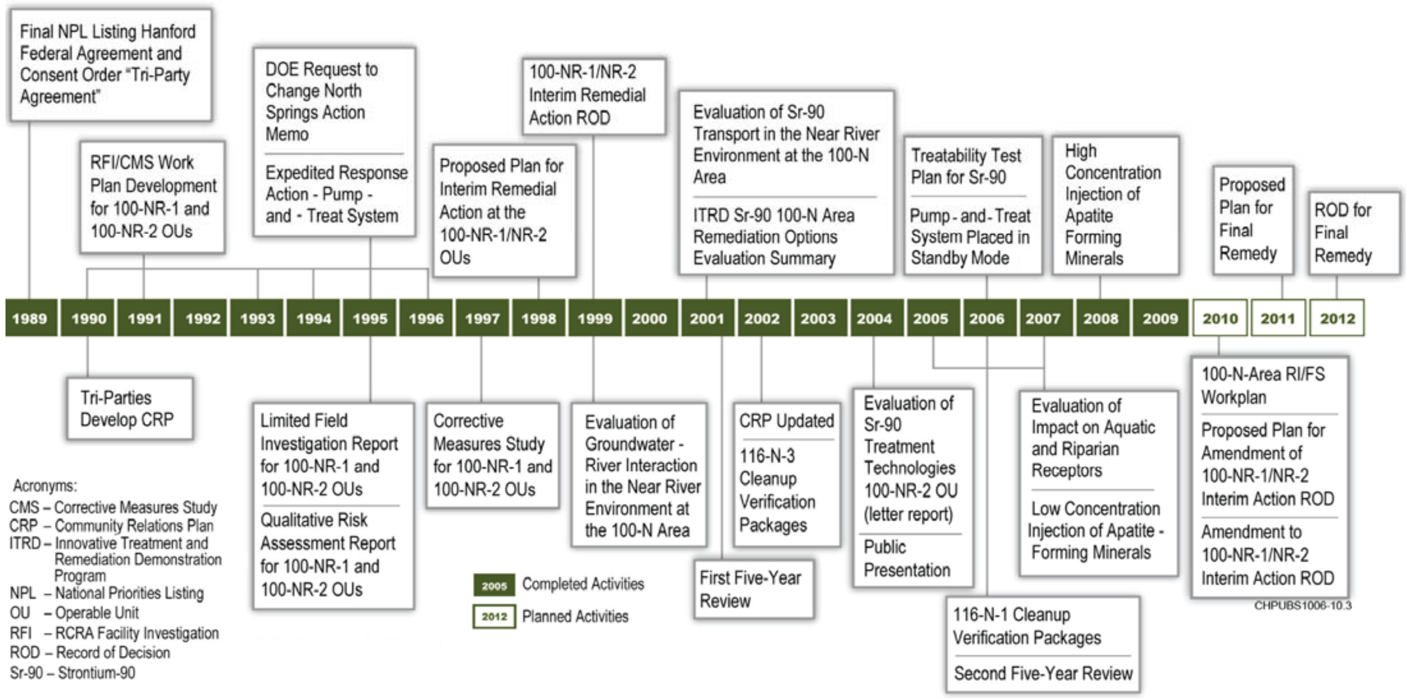

Figure 5. Timeline of Major Activities for the 100-N Area

Apatite Sequestration
An exchange process where Sr-90 and other divalent ions substitute for calcium in the apatite crystal matrix.

At the time of the ERA in 1993 and interim action ROD in 1999, insufficient information was available to select a final remedy for the 100-NR-2 OU. Therefore, the interim ROD required DOE to evaluate other technologies for Sr-90 treatment.

Interim actions were also taken to address soil contamination. As specified in the 100-NR-1 TSD interim ROD, the top 4.6 m (15 ft) of contaminated soil was removed at the 116-N-1 and 116-N-3 LWDFs and transported to the 200 Area for disposal at the Environmental Restoration Disposal Facility (ERDF). As of March 2010, approximately 522,200 tons of contaminated soil and debris has been removed from the 100-N Area. Approximately 250,000 and 154,600 tons of this material was associated with the 116-N-1 and the 116-N-3 LWDFs, respectively.

What is the status of the 5-year review action items?

The second CERCLA 5-year review was published in November 2006 (DOE/RL-2006-20). The review identified two issues pertaining to the 100-N Area and two follow-up actions that included:

- Implementing the treatability test plan for a PRB utilizing **apatite sequestration** as described in the *Strontium-90 Treatability Test Plan for the 100-NR-2 Groundwater Operable Unit* (DOE/RL-2005-96) and issuing a treatability test report. In 2006-2008, workers injected apatite-forming chemicals into shoreline wells to create a 90-m (300-ft) long barrier.

- Collecting additional data to support risk assessment and obtaining additional pore water data from the Columbia River shoreline. Additional data has been collected and is summarized further in the Summary of Site Risks section of this Proposed Plan.

The CERCLA 5-year review for the 100-NR-2 OU concluded that remedial action objectives for Sr-90 in groundwater are not being met. The determination for long-term protectiveness for human health and the environment is being deferred until a final remedy is selected through the CERCLA **remedial investigation and feasibility study (RI/FS)** process.

What previous efforts have been made by the Tri-Parties to involve the public in matters related to site cleanup?

The Tri-Parties developed the first **Community Relations Plan (CRP**) (Ecology et al., 2002) in 1990 as part of the overall Hanford Site restoration effort. The CRP and its subsequent revisions were used as the basis for public involvement efforts associated with the 100-N Area. The Proposed Plan that led to develop of the interim action ROD for the 100-NR-1/NR-2 OUs in 1999 was provided to the public for review and comment in 1998.

SITE CHARACTERISTICS

The 100-N Area extends across an approximate 4 km^2 (1.6 mi^2) area, located along the Columbia River shoreline between the 100-K and 100-D Areas.

What are the physical characteristics of the site?

The topography in the 100-N Area is relatively gentle but marked by the presence of a steep bluff approximately 21 m (70 ft) high along the river shoreline. The 100-N Area is also characterized by the presence of numerous small rolling hills known as Mooli Mooli (Little Stacked Hills), which formed as a result of the cataclysmic flooding that occurred at the end of the Pleistocene Era, approximately 10,000 years ago.

What roads, buildings, and land uses are present on the site?

The 100-N Area initially contained 232 facilities comprising the reactor building, water treatment plant, generating plant, storage buildings, offices, maintenance shops, and other supporting infrastructure. Many of these structures have been deactivated, decommissioned, and demolished.

Current land use in the 100-N Area consists of facilities support, remediation activities, and undeveloped land. Facilities support includes maintenance of existing structures, roads, and grounds. Remediation activities include ongoing investigation and cleanup actions to address the

RI/FS

The remedial investigation (RI) is a process undertaken to determine the nature and extent of the problem presented by a hazardous substance release. The RI emphasizes data collection and site characterization. It is generally performed concurrently and in an interactive fashion with the feasibility study (FS). The RI includes sampling and monitoring, as necessary, and includes the gathering of sufficient information to determine the necessity for remedial action and to support the evaluation of remedial alternatives. The FS is a study undertaken to develop and evaluate options for remedial action. The findings of the RI and FS are presented in the RI/FS report.

CRP

Community Relations Plan (Hanford Community Relations Plan) potential threats that may arise from exposure to contaminants present in soil and groundwater. Undeveloped land comprises a large portion of the open space in the 100-N Area. The undeveloped areas are the least disturbed and contain minimal infrastructure.

The Columbia River adjacent to the 100-N Area is used for recreational activities such as hunting, fishing, and boating, and supports a large variety of aquatic and riparian animals.

What geographic, topographic, or other factors had a major impact on remedy selection?

The presence of Sr-90 in groundwater that naturally upwells into the Columbia River was a major factor in the decision to implement the ERA and other interim remedial actions in the 100-N Area. The Hanford Reach (65 FR 37253) is a valued ecological area and was declared a national monument in 2000. Additionally, important cultural resource sites are present in the 100-N Area, some of which date back 9,000 years.

During 100-N Reactor operations, a groundwater elevation mound formed beneath the 116-N-1 and 116-N-3 LWDFs. The mound was approximately 6 m (20 ft) high and created large hydraulic gradients that increased groundwater flow rates toward the river. While the 100-N Reactor was operating, riverbank seepage was pronounced. Following shutdown of the LWDFs, the number of seeps and springs and their discharge volume has decreased.

River level fluctuations along the 100-N Area shoreline have a significant influence on the Sr-90 flux to the river. These fluctuations, which result from hydroelectric dam operating schedules and natural seasonal variations, create groundwater elevation changes in the shoreline environment. These changes, in turn, reverse the hydraulic gradient, resulting in the temporary inland flow of water from the river to the aquifer instead of the natural flow direction where groundwater flows into the river. During high river levels, surface water moves into the river bank and mixes with groundwater. During low river levels, the water drains back into the river, as evidenced by the seeps and springs present along the riverbank. The zone where surface water and groundwater mixing occurs under high river level conditions is located within tens of meters of the shoreline. As a result of the frequency of these gradient reversals, the volume of water that is exchanged between the river and the river bank is estimated to be 10 times greater than the volume of groundwater upwelling into the river as a result of the natural hydraulic gradient (DOE/RL-95-110, *N-Springs Expedited Response Action Performance Evaluation Report*). Seeps, springs, and subsurface groundwater upwelling are the primary pathway for Sr-90 entry into the Columbia River.

How much and what type of contamination is present?

The radionuclide and chemical contaminated zones underlying the 116-N-1 and 116-N-3 LWDFs resulted from 30 years of wastewater discharge. The contaminated zones include portions of the **vadose zone** that were wastewater-saturated during 100-N Reactor operations, and the underlying groundwater extending from the LWDFs to the Columbia River (Figure 4).

Vadose zone
The subsurface zone above the regional water table.

It is estimated that about 7,873 Ci (as of 1995) of radionuclides were discharged to these LWDFs (DOE/RL-95-110). Of the total radionuclide inventory, Sr-90 accounted for 1,866 Ci (24 percent); tritium (H-3) for 2,224 Ci (28 percent); cobalt-60 (Co-60) for 1,511 Ci (19 percent); and cesium-137 (Cs-137) for 2,248 Ci (29 percent). The remaining inventory includes ruthenium-106 (Ru-106), cesium-134 (Cs-134) and plutonium-239 (Pu-239), which account for less than 1-percent of the total.

As a result of its frequency of occurrence in soil and groundwater, Sr-90 has been the primary contaminant of interest in the 100-N Area and the major focus of groundwater interim action. The majority of the 1,500 Ci (as of 2003) of Sr-90 remaining in the 100-N Area resides in the vadose zone (DOE/RL-2004-21). Of the 72.8 Ci of Sr-90 present in the aquifer, an estimated 72 Ci are sorbed to the aquifer solids and approximately 0.8 Ci is present in groundwater.

The Sr-90 groundwater plume is estimated to be approximately 760 m (2,500 ft) wide at the river's edge (Figure 3) and extends inland approximately 900 m (3,000 ft). Concentrations greater than the 8 pCi/L interim action ROD remedial action goal occur across an estimated 100 ha (250 ac) area. Areas of groundwater upwelling exist in the near-shore river sediments. Preliminary results from years 2009–2010 pore water samples taken in these sediments have shown detectable levels of Sr-90 at a few locations, although samples from most locations were non-detect. Additional evaluation of the pore water sampling information will be performed for the upcoming RI/FS.

Because Sr-90 has a much greater affinity for vadose zone soil and aquifer solids, its rate of transport in groundwater to the river is much slower than the actual groundwater flow rate. The relative velocity of Sr-90 to groundwater is approximately 1:100 (DOE/RL-2005-96). Under current conditions, the estimated annual Sr-90 flux to the river from the 100-N Area is 0.1 Ci per year.

A majority of the Sr-90 remaining in the soil and groundwater is not expected to reach the Columbia River. As a result of its low mobility, a majority of the Sr-90 present in the inland portions of the 100-N Area will naturally decay before it reaches groundwater and the river. With a half-life of 28.6 years, it will take approximately 300 years for the 72.8 Ci of Sr-90 currently present in the aquifer at the 100-N Area to decay to a concentration less than the 8 pCi/L remedial action goal.

Hyporheic Zone
The subsurface zone adjacent to a river channel where groundwater and surface water mixing occurs.

Other contaminants currently monitored in groundwater include nitrate, tritium, sulfate, petroleum hydrocarbons, manganese, iron, and chromium. Nitrate concentrations greater than the 45 mg/L drinking water standard have been observed in groundwater samples collected from monitoring wells located in the vicinity of the 116-N-1 and 116-N-3 LWDFs, 120-N-1 Percolation Pond, and 120-N-2 Surface Impoundment. Tritium, sulfate, petroleum hydrocarbons, manganese, iron, and chromium present in groundwater at concentrations greater than their primary or secondary drinking water standards generally occur in much smaller areas. Petroleum hydrocarbons, iron, manganese, and chromium have been detected in several monitoring wells near the river shoreline. Hexavalent chromium detected in the southwestern portion of 100-N Area groundwater is associated with and being addressed through 100-KR-4 OU interim actions.

SCOPE AND ROLE

A primary objective for the Hanford Site cleanup mission is protection of the Columbia River. Interim and final remedial actions undertaken by DOE in the Columbia River corridor play an important role in realizing this objective. At the 100-N Area, DOE has committed to meet the 8 pCi/L drinking water standard for Sr-90 in the **hyporheic zone** and river water column by December 31, 2016 (TPA Milestone M-016-110-T03 [Ecology et al., 1989a]). The 8 pCi/L drinking water standard is also protective of aquatic life in the river, as described in Appendix A.

The 100-NR-2 OU is one of five groundwater OUs in the Hanford Site 100 Area. In addition to the 100-NR-2 groundwater OU, two other groundwater OUs, 100-KR-4 and 100-HR-3, have active interim remedies to address hexavalent chromium contaminated groundwater. The 100-NR-2 OU is the only groundwater OU where an interim action was implemented for Sr-90-contaminated groundwater. In conjunction with the existing and proposed interim remedial actions underway in the 100-N Area, final RI/FS planning for the 100-N Area is underway through the 100 Area integrated RI/FS process. This effort is expected to produce a final FS report and Proposed Plan for the 100-N Area by 2011 (TPA Milestone M-015-62-T01 [Ecology et al., 1989a]).

SUMMARY OF SITE RISKS

As described in DOE/RL-91-40, interim remedial actions for source and groundwater OUs were designed to address threats posing a near-term risk to public health and the environment. The 100-NR-1/NR-2 OU interim remedial actions were implemented to reduce the likelihood of exposure to Sr-90 and other hazardous substances, and to reduce the flux of Sr-90 to the Columbia River.

Qualitative Risk Assessments (QRA) were conducted to support interim action decision making and to identify high-priority sites for interim remedial action. The QRAs evaluated risk for a predefined set of human and environmental exposure scenarios. If the estimated risk exceeded certain thresholds, interim remedial actions were considered necessary to protect human health and the environment. The risk evaluations conducted for the 1995 QRAs are still relevant for the remedial action alternatives described in this Proposed Plan.

The QRAs are not intended to substitute for the **Baseline Risk Assessment (BRA)** that will be conducted as part of the 100 Area integrated RI/FS for use in determining final remedial actions for the 100-N Area. The DOE is preparing the River Corridor Baseline Risk Assessment (RCBRA), which is using a multi-step process, in accordance with EPA guidance, to estimate risks to human health and the environment based on current conditions in the 100-N Area. The RCBRA included workshops to solicit and incorporate input from regulatory agencies, the Natural Resource Trustee Council, Tribal Nations, and stakeholders. Based on these discussions, sampling and analysis plans were developed to collect the data needed to address the remaining issues. After the necessary data are collected, current and future risks to human health and the environment will be assessed and characterized as part of the RI/FS report scheduled for completion in December 2011.

Summary of Human Health QRA

The QRA for the 100-NR-2 OU (BHI-00055) considered two human exposure scenarios (frequent- and occasional-use) with three exposure pathways (groundwater ingestion, inhalation of tritium, and dermal absorption of tritium from groundwater use). Currently, there is no resident population, and day use on the Columbia River is allowable below the high-water mark. Because groundwater use does not currently occur, risk that might occur for humans under frequent- and occasional-use were included to provide upper and lower estimates of risk to a reasonable maximum exposure individual. The inhalation pathway was only evaluated in the frequent-use scenario because it was assumed that exposures to volatile contaminants would occur during residential water use, and would not be expected to occur in an occasional-use scenario. The dermal exposure pathway was evaluated because of the somewhat high concentrations of tritium-contaminated groundwater present in the 100-NR-2 OU.

The QRA determined that groundwater ingestion would be the major pathway of exposure, even though groundwater is not currently being used. Sr-90, tritium, and arsenic were determined to be the major contributors to incremental excess cancer risk in the drinking water groundwater use scenarios. Arsenic, cadmium, chromium, fluoride,

QRA

Qualitative Risk Assessment. A QRA is a judgment not based solely on quantification, agreed to by the parties, based on available site data regarding the threat posed by site contamination.

BRA

A Baseline Risk Assessment is an assessment conducted before cleanup activities begin at a site to identify and evaluate the threat to human health and the environment. After remediation has been completed, the information obtained during the BRA can be used to determine whether the cleanup goals were reached.

manganese, and nitrate were determined to be the primary contaminants contributing to non-cancer (hazard index) health effects for the defined groundwater exposure scenario.

Summary of the Ecological Risk Assessment

The 1995 ecological QRA presented in BHI-00055 focused on the hypothetical effects of contaminants on selected aquatic organisms in or near the Columbia River. The scope of this assessment was limited; therefore, the interim action ROD included a provision for a more thorough evaluation of impacts to ecological receptors in the shoreline area. Cadmium, lead, and zinc were identified in the QRA as contaminants of potential ecological concern.

The more comprehensive assessment of potential ecological impacts concluded that Sr-90 concentrations in Asiatic clams in the 100-N Area were elevated relative to the upstream Vernita reference area (DOE/RL-2006-26). However, the estimated radiological dose for all biota evaluated were well below DOE's radiation dose limit of 1.0 rad per day for aquatic animals (DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota).* Additionally, there was little indication of adverse effects from Sr-90 in the health status indicators surveyed during these sampling efforts. The concentrations of lead and other metals present in river substrate pore water exceeded ecological benchmarks in a localized area along the shoreline. Interim and final petroleum hydrocarbon remedial actions are expected to address these metals. Soil concentrations for several metals in the Sr-90 plume area exceeded thresholds developed for birds.

Indicators of potential adverse effects were identified along a section of the shoreline (approximately 150 m [492 ft] long) located in the vicinity of a diesel spill that occurred in 1966. Water quality sampling data performed beneath the riverbed indicate that the impacted area contains low dissolved oxygen concentrations and elevated levels of dissolved iron and manganese that exceed water quality benchmarks for the protection of aquatic life. Low dissolved oxygen concentrations in combination with elevated iron and manganese levels suggest that microbial decomposition of petroleum hydrocarbons is occurring. Additional follow-up sampling is planned during the 100 Area integrated RI/FS.

Need for Action

Based on the findings of the QRA and the additional information developed since issuance of the interim action ROD, it is the Tri-Parties' judgment that the preferred alternative identified in this Proposed Plan, or one of the other active measures considered in the Proposed Plan, is necessary to protect public health or welfare or the environment from the actual or potential release of Sr-90 into the environment. Successful implementation of the preferred alternative supports the goal of reducing the Sr-90 flux to the Columbia River.

REMEDIAL ACTION OBJECTIVES

The remedial action objectives (RAO) presented in the interim action ROD are sufficient to evaluate, recommend, and implement the proposed interim action remedy modifications described in this Proposed Plan. Therefore, no changes to the RAOs are required. Appendix A provides the RAOs presented in the interim action ROD for the 100-NR-2 OU, and also presents the regulatory and technical basis for the 8 pCi/L remedial action goal for Sr-90.

SUMMARY OF ALTERNATIVES

As required by the interim action ROD, DOE conducted a comprehensive review of Sr-90 treatment technologies to complement the existing interim remedial actions. This review was commissioned under DOE's Innovative Treatment and Remediation Demonstration program and culminated with the *Hanford 100-N Area Remediation Options Evaluation Summary Report* (ITRD, 2001) in November 2001. Based on the evaluation presented in this document, the Technical Advisory Group recommended that **monitored natural attenuation (MNA)**, soil flushing, phytoextraction, stabilization by phosphate injection, impermeable barriers (sheet pile and cryogenic), and treatment barriers be evaluated further for Sr-90 remediation.

Subsequent evaluations and/or field trials led to the elimination of soil flushing and sheet pile barriers as viable technologies for the 100-NR-2 OU. Based on the findings presented in the letter report by Fluor Hanford/CH2M HILL (2004), the following remedial action alternatives were assembled for evaluation in this Proposed Plan:

- No Action
- Alternative 1—Institutional Controls and Monitored Natural Attenuation
- Alternative 2—Resume Operation of Existing Pump-and-Treat System
- Alternative 3—Impermeable Barrier
- Alternative 4—Apatite Permeable Reactive Barrier

Based on the evaluation presented in the Evaluation of Alternatives section of the Proposed Plan, the Tri-Parties are recommending Alternative 4—Apatite Permeable Reactive Barrier as the preferred alternative.

No-Action Alternative

The No-Action Alternative represents a scenario where no restrictions, controls, or active remedial actions are applied to a site. Under this alternative, the flux of Sr-90 to the Columbia River would not be reduced

MNA

Monitored natural attenuation. MNA is the reliance on natural processes, within the context of a carefully controlled and monitored cleanup, to reduce the mass, toxicity, mobility, volume or concentration of contaminants in affected media.

IC
Institutional control, an administrative tool used to restrict access to or limit activities in identified areas of soil and groundwater contamination to prevent human exposure.

and Sr-90 concentrations in groundwater will remain above the 8 pCi/L remedial action goal for about 300 years. Sr-90 concentrations in the hyporheic zone may also exceed 8 pCi/L, but concentrations within the river water column are expected to be less because of the mixing that occurs in the river.

The No-Action Alternative was developed per NCP requirements (40 CFR 300.430(e)(6)), and was previously rejected in the interim action ROD as not meeting CERCLA requirements. Therefore, this alternative is not evaluated further in this Proposed Plan because the No-Action Alternative was previously rejected in the interim action ROD as not protective of human health and the environment.

Alternative 1—Institutional Controls and Monitored Natural Attenuation

This alternative consists of maintaining existing **institutional controls (ICs)** for the 100-N Area, while relying on MNA to reduce Sr-90 concentrations to the 8 pCi/L remedial action goal. The existing ICs include entry restrictions (security), escorts and badging of site visitors, excavation permits, surveillance, posted signs, and deed notifications that restrict land and groundwater use. DOE is responsible for enforcing ICs and reporting on their effectiveness in annual reports.

MNA is an important component of this alternative. MNA is the reliance on natural processes, within the context of a carefully controlled and monitored cleanup, to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in affected media. A majority of the Sr-90 present in the aquifer will naturally attenuate through radioactive decay before it reaches the river. Natural attenuation can reduce Sr-90 concentrations to protective levels in the inland areas of the 100-N Area that are far enough away from the river such that enough attenuation time is available.

MNA requires periodic sampling to verify that contaminant concentrations are declining in accordance with expectations and to ensure that contaminants remain isolated from potential points of exposure. MNA activities include periodic sampling and analysis of groundwater samples as described in the existing interim action ROD. MNA requires an extended timeframe before Sr-90 concentrations decrease to protective levels; therefore, ICs must be maintained for up to 300 years.

Under this alternative, DOE would also maintain the existing rip-rap cover that was placed over the groundwater seeps and springs along the shoreline, and maintain the existing pump-and-treat system in a standby mode to supplement MNA if warranted by future groundwater monitoring results.

Many of the elements contained within this alternative, including ICs and groundwater monitoring, have already been implemented. Therefore, this alternative could be implemented within a relatively short timeframe of 12 to 18 months. The estimated timeframe to achieve the Sr-90 8 pCi/L remedial action goal in groundwater throughout the aquifer and in the hyporheic zone is estimated at 300 years. The total net present value cost to implement this alternative is estimated at $3.6 million.

Alternative 2—Resume Operation of Existing Pump-and-Treat System

This alternative would resume operation of the existing pump-and-treat system until 100-NR-2 OU RAOs are achieved. The existing system consists of four extraction wells (N-75, N-103A, N-105A, and N-106A), two injection wells (N-29 and N-104), a treatment plant, and the supporting equipment, such as piping, electrical equipment, instrumentation, and tanks.

Sr-90-contaminated groundwater would be pumped from the extraction wells, at a total average rate of approximately 190 L/min (50 gal./min), to the treatment plant where Sr-90 is removed from groundwater. The treated water would be returned to the aquifer through the injection wells.

Periodic monitoring of the pump-and-treat system would be performed to track operations and obtain data to evaluate overall system performance. The scope of this monitoring program would be similar to that performed between 2001 and 2005 while the system was in operation.

It would take approximately 18 months to implement this alternative. The estimated timeframe to achieve the Sr-90 8 pCi/L remedial action goal in groundwater throughout the aquifer and in the hyporheic zone is estimated at 300 years. The total net present value cost to implement this alternative is estimated at $47.3 million.

A groundwater pump-and-treat alternative was previously evaluated and selected in the interim action ROD. However, subsequent evaluations demonstrated that pump-and-treat was ineffective in controlling the Sr-90 flux to the river. Therefore, an expansion of the existing pump-and-treat system was not developed for inclusion in this Proposed Plan. Full-scale pump-and-treat technology will be evaluated in the proposed plan for the "final" record of decision scheduled to be published December 2011.

Alternative 3—Impermeable Barrier

This alternative would consist of constructing an impermeable barrier along the shoreline to re-direct groundwater flow and Sr-90 transport. The barrier would be constructed to divert groundwater flow such that the length of the flowpath that Sr-90 follows as it moves from the aquifer to the river is increased. The lengthened flow path would translate into increased travel times to enable radioactive decay to lower concentrations before Sr-90 enters the river.

Under this alternative, an estimated 550-m (1,800-ft) long impermeable barrier would be constructed by injecting bentonite grout through an array of specially designed injection wells. The well casing design allows the injected grout to move into the aquifer's natural void spaces and into new void spaces created by the injection process. The bentonite grout solidifies in place, forming an impermeable barrier without the need for trenching. This alternative assumes that sufficient injections could be performed to achieve an 11-centimeter (cm) (4.5-inch [in.]) thick grout barrier. Placement of the grout would be monitored using an active resistivity imaging method to ensure that a continuous barrier free of voids and other discontinuities is constructed. The ability to achieve a continuous solid barrier is the greatest uncertainty with this alternative. Field testing would be needed to select the optimum spacing between injection wells.

It is assumed that the impermeable barrier would be installed from ground surface to a depth of 9.1 m (30 ft) below ground surface (bgs) to prevent groundwater flow over the top and beneath the barrier as a result of the groundwater elevation mound that would form upgradient.

This alternative also includes (a) decommissioning of the existing treatment components of the 100-NR-2 groundwater pump-and-treat system, (b) MNA, (c) ICs, and (d) maintenance of the rip-rap cover along the shoreline, as described under Alternative 1.

The timeframe required to implement this alternative is estimated at 3 years. The estimated timeframe to achieve the Sr-90 8 pCi/L remedial action goal in the hyporheic zone is estimated to range from 3 to 5 years after the barrier has been fully constructed. The timeframe required to achieve the 8 pCi/L remedial action goal in groundwater throughout the aquifer is estimated at 300 years. The total net present value cost to implement this alternative is estimated at $17.7 million.

Alternative 4—Apatite Permeable Reactive Barrier

A PRB is a subsurface treatment zone that immobilizes or transforms target contaminants as they are transported by natural groundwater flow through a reactive media. Under this alternative, apatite-forming minerals would be injected into the subsurface in a liquid or powder form. The reactive media, apatite, is a natural calcium phosphate mineral occurring in the earth's crust as phosphate rock, and is a primary component in the teeth and bones of animals. The apatite PRB immobilizes Sr-90 in vadose zone soil, aquifer solids, and groundwater by sequestering the strontium into the apatite's molecular structure via calcium substitution while the groundwater flows through the barrier.

This innovative technology has been under evaluation in the laboratory and in the field at the 100-N Area since 2005. In 2006 and 2007, a pilot study was implemented using a low-concentration, apatite-forming solution that was injected into 10 wells to create a 90 m (300 ft) reactive barrier in the aquifer (PNNL-17429). The low-concentration injections were followed in 2008 by high-concentration injections to increase the mass of apatite to provide for long-term Sr-90 treatment (PNNL-SA-70033).

The high concentration injections were conducted in 16 wells that are approximately 9.1 m (30 ft) deep. These wells included the original 10 injection wells screened in the Hanford formation and upper contaminated portion of the Ringold Formation, and six new injection wells screened in the Ringold Formation only. Groundwater quality monitoring conducted following the high concentration injections revealed that a 90 percent reduction in Sr-90 concentration was achieved in the vicinity of the injections approximately 1 year after treatment.

Additional field-scale trials are also underway to evaluate vadose zone infiltration of apatite-forming solutions, and jet-injection of apatite-forming solutions and solid phase apatite (PNNL-18303).

Experience gained from the low and high concentration injections, and the infiltration and jet-injection pilot tests, will be used to refine the delivery method and injection solution composition to increase the technology's effectiveness along the extended PRB.

Under this alternative, the existing apatite PRB would be extended from 90 m (300 ft) to a total length of approximately 760 m (2,500 ft). The barrier would initially be extended 90 m (300 ft) to the southeast and 90 m (300 ft) to the northeast, under an Ecology-approved design optimization study to refine the injection well design and apatite solution composition, prior to full-scale build-out. Figure 6 shows the proposed PRB alignment. Figure 7 shows a cross-sectional depiction of the apatite PRB.

Under this alternative, the apatite sequestration technology may be deployed elsewhere within the 100-N Area to treat Sr-90 present in vadose zone soil. Vadose zone application may use different delivery methods such as infiltration and direct (jet) injection. The decision to deploy apatite sequestration at additional locations will be made via an Ecology-approved plan, or through an addendum to DOE/RL-2001-27.

This alternative includes one additional round of injections at a subset of injection well locations within 5 years of completing all apatite injections. This alternative also includes (a) decommissioning of the existing treatment components of the 100-NR-2 groundwater pump-and-treat system, (b) MNA, (c) ICs, and (d) maintenance of and the rip-rap cover along the shoreline as described under Alternative 1.

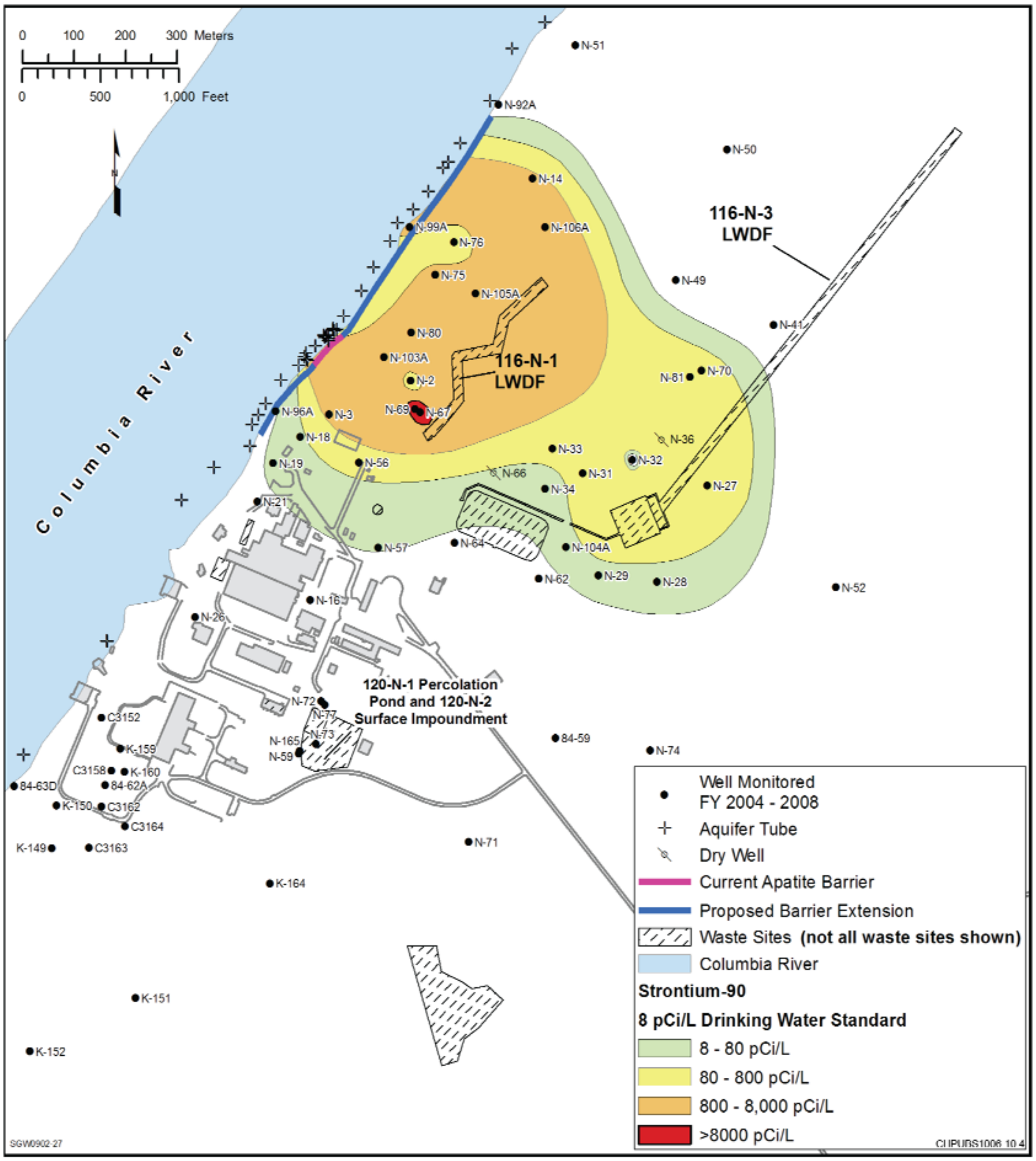

Figure 6. Apatite PRB Location

The timeframe required to implement this alternative is estimated at 2 years. The timeframe required before the Sr-90 8 pCi/L remedial action goal is achieved in the hyporheic zone is estimated at 2 to 3 years after the barrier has been fully constructed. The timeframe required to achieve the 8 pCi/L remedial action goal in groundwater throughout the aquifer is estimated at 300 years. The total net present value cost to implement this alternative is estimated at $20.9 million.

EVALUATION OF ALTERNATIVES

The Tri-Parties evaluate each remedial alternative against nine different CERCLA criteria to identify a preferred alternative. During the evaluation process, each alternative is first assessed individually against the CERCLA criteria, then a comparative analysis is performed to assess the overall performance of each alternative relative to the others. The first two evaluation criteria are threshold criteria. An alternative must meet the threshold criteria or it cannot be selected.

The next five criteria are balancing criteria, which are used to weigh major advantages and disadvantages between the alternatives. Each alternative is assessed in terms of how well it satisfies these criteria. The final two criteria are modifying criteria that factor in State acceptance and community acceptance. From this evaluation, a preferred alternative is identified.

The CERCLA evaluation of alternatives presented in this Proposed Plan focuses on the four 100-NR-2 OU remedial action alternatives. These four alternatives include: Alternative 1—Institutional Controls and Monitored Natural Attenuation, Alternative 2—Resume Operation of Existing Pump-and-Treat System, Alternative 3—Impermeable Barrier, and Alternative 4—Apatite PRB. The No-Action Alternative was not evaluated because it was previously determined in the interim action ROD that the No-Action Alternative is not protective of human health and the environment.

CERCLA Evaluation Criteria

Threshold Criteria

- Overall protection of human health and the environment
- Compliance with applicable or relevant and appropriate requirements

Balancing Criteria

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

Modifying Criteria

- State acceptance
- Community acceptance

The preferred alternative and proposed actions may be modified or changed by the agencies in response to public comment or new information that becomes available after this Proposed Plan is released.

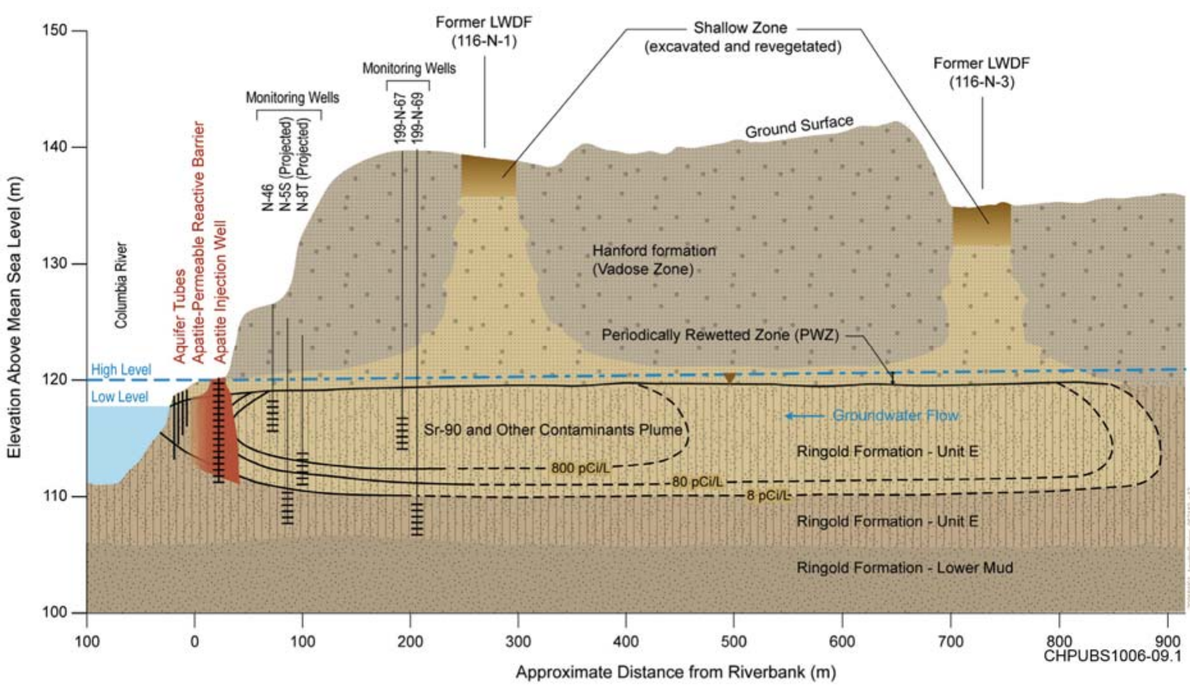

Figure 7. Apatite PRB Cross-Section View

CERCLA Criteria Defined

Threshold Criteria

1. Overall Protectiveness of Human Health and the Environment—determines whether an alternative eliminates, reduces, or controls threats to public health and the environment.
2. Compliance with ARARs—evaluates whether the alternative meets federal and state environmental statutes, regulations, and other requirements that pertain to the site, or whether a waiver is justified.

Balancing Criteria

1. Long-term Effectiveness and Permanence—considers the ability of an alternative to maintain protection of human health and the environment over time.
2. Reduction of Toxicity, Mobility, or Volume through Treatment—evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present.
3. Short-term Effectiveness—considers the length of time needed to implement an alternative and the risks the alternative poses to workers, residents, and the environment during implementation.
4. Implementability—considers the technical and administrative feasibility of implementing the alternative, including factors such as the relative availability of goods and services.
5. Cost—includes estimated capital and annual operations and maintenance costs, as well as net present value cost. Cost estimates are expected to be accurate within a range of +50 to -30 percent.

EVALUATION OF 100-NR-2 OU ALTERNATIVES

The detailed and comparative evaluation of alternatives is generally performed in the FS, and from the FS, a Proposed Plan is prepared to identify the preferred alternative. Although an FS was not specifically prepared to support this Proposed Plan, a large body of existing information is available in the Administrative Record, including that presented in DOE/RL-95-111, *Corrective Measures Study for the 100-NR-1 and 100-NR-2 Operable Units*, which supports the alternative development and evaluation presented in this Proposed Plan. The following summarizes the comparative evaluation of alternatives that was used to identify the preferred alternative.

Overall Protection of Human Health and the Environment. All four alternatives are expected to result in continued exceedance of the 8 pCi/L remedial action goal for Sr-90 in the aquifer. However, the ICs established previously under the interim action ROD protect human health. Therefore, because all four alternatives maintain these ICs, all four alternatives protect human health.

Since there is no established ambient water quality criteria (AWQC) for Sr-90 in surface water, the Tri-Parties have agreed to use the 8 pCi/L remedial action goal for interim actions. This concentration is protective of aquatic animals in the Columbia River because it corresponds to a radiation dose that is significantly less than DOE's radiation dose limit of 1 rad per day. Additional information on the protectiveness of the 8 pCi/L remedial action goal for aquatic receptors is provided in Appendix A.

Alternative 4 provides the highest degree of protection for the environment among the four alternatives considered because Sr-90 is intercepted, removed from groundwater, and immobilized within the apatite crystal matrix, thereby reducing the Sr-90 flux to the river and Sr-90 concentrations within the groundwater treatment zone. Protection against future releases is achieved by injecting a sufficient amount of apatite-forming chemicals to immobilize all Sr-90 that could be transported to the river. It is expected that the apatite barrier will prevent 0.6 Ci of Sr-90 from reaching the river on an annual basis. Depending on the form of apatite used, Sr-90 concentrations may remain elevated in the area between the PRB and the river for a period of time. Un-reacted liquid apatite-forming chemicals could also migrate to the river. Water quality effects from the un-reacted chemicals, if any, are known to be short-lived. Periodic groundwater monitoring will be performed to confirm the apatite PRB's effectiveness until RAOs are achieved.

Alternative 3 protects the environment by increasing the length of the groundwater flowpath, providing additional time for radioactive decay to decrease Sr-90 concentrations to protective levels. Because Sr-90 travels slowly in the aquifer (less than 2 m [6 ft] per year), it is estimated the barrier's 549 m (1,800 ft) length would increase the travel time, between the aquifer and the river, to upward of 300 years. Sr-90 concentrations in groundwater between the impermeable barrier and the river may remain elevated for a period of time following its installation. Periodic groundwater monitoring would be performed to confirm the impermeable barrier's effectiveness.

Alternative 2 does not protect the environment. Prior performance evaluations (DOE/RL-2006-08) of the 100-NR-2 OU pump-and-treat system have shown that it is ineffective in removing Sr-90 from the aquifer, and reducing Sr-90 flux to the river. The pump-and-treat system removed approximately 0.2 Ci of Sr-90 from the aquifer on an annual basis.

Alternative 1 provides the least protection for the environment because the flux of Sr-90 to the river is not decreased until radioactive decay reduces concentrations to protective levels, which may not occur for up to 300 years.

Compliance with Applicable or Relevant and Appropriate Requirements (ARARs). As required by the NCP under 40 CFR 300.430(f)(1)(ii)(B)(2), a new ARARs analysis was conducted to support the development and evaluation of Sr-90 remedial action alternatives for this Proposed Plan. Based on the analysis, the Sr-90 ARAR of 8 pCi/L established in the interim action ROD has not changed. Because there is no AWQC for Sr-90, the Tri-Parties have agreed to use the 8 pCi/L remedial action goal for the hyporheic zone. This concentration is protective of aquatic animals in the Columbia River because it corresponds to a radiation dose that is significantly less than DOE's radiation dose limit of 1 rad per day for aquatic animals.

Alternatives 3 and 4 are expected to meet ARARs in the hyporheic zone by 2016. Alternatives 1 and 2 are not expected to achieve ARARs in the hyporheic zone for up to 300 years. Groundwater protection ARARs will not be achieved by any of the four alternatives throughout the 100-NR-2 OU for up to 300 years. The four alternatives are interim remedial actions designed to reduce the near-term risk.

Long-term Effectiveness and Permanence. The magnitude of residual risk, and the reliability of controls required to manage treatment residuals once the remedial action is complete, are generally comparable among the four alternatives. All four alternatives achieve the Sr-90 remedial action goal throughout the upland portion of the aquifer through natural attenuation within the same timeframe, enabling the existing ICs to be lifted once the remedial action is complete. Alternative 4 is expected to provide a higher degree of long-term effectiveness and permanence over the other three

Modifying Criteria

1. State Acceptance—considers whether the State agrees with the analyses and preferred alternative recommendation presented in the Proposed Plan.
2. Community Acceptance—considers whether the local community agrees with the analyses and preferred alternative recommendation presented in the Proposed Plan.

alternatives because Sr-90 is immobilized within the apatite crystal matrix. Pilot testing work performed to date has not identified any conditions that would enable Sr-90 to be released to groundwater from the breakdown of the apatite. Additionally, because apatite is insoluble, Sr-90 cannot be released to groundwater through dissolution.

Reduction of Toxicity, Mobility, or Volume through Treatment. Alternative 4 is the only alternative that effectively treats groundwater by removing Sr-90 from the groundwater. The Sr-90 is sequestered within the PRB where it will naturally decay. Alternative 2 provides a means of treating groundwater. However, it has been shown in the past to not treat a significant part of the groundwater plume. Alternatives 1 and 3 do not provide any appreciable reduction in toxicity, mobility or volume through treatment.

Short-term Effectiveness. Alternatives 3 and 4 require the installation of a large number of injection wells. This work will generate contaminated soil and well-development water containing hazardous substances. Alternative 2 requires periodic changeout of the ion exchange media, and maintenance and repair of the pump-and-treat system's extraction and injection wells and the treatment system's components. Personnel performing this work and managing investigation-derived waste or remediation waste may be exposed to hazardous substances. However, this risk is minimized through adherence to existing construction and operation and maintenance health and safety protocols. Because Alternative 1 does not employ active measures, workers have much less potential for contaminant exposure.

This criteria also considers the timeframe required before RAOs will be met. The timeframe required to achieve the Sr-90 surface water quality remedial action goal (RAO #1) is expected to be the shortest for Alternative 4, followed by Alternatives 3 and 2, respectively (see Appendix A). Under Alternative 1, Sr-90 surface water remedial action goals may not be achieved for up to 300 years. The groundwater quality remedial goal (RAO #2) for Sr-90 under all four alternatives will not be achieved throughout the 100-NR-2 OU for up to 300 years.

Implementability. All four alternatives are implementable. Alternatives 3 and 4 pose some technical challenges arising from the large volume of bentonite grout and apatite-forming minerals that must be injected along the river shoreline. Successful implementation may require additional injections at one or more locations. Alternative 2 is implementable because the pump-and-treat system's infrastructure is already in place. However, extensive maintenance, repair, and replacement of system components will be required to return the pump-and-treat system to normal operation.

Cost. Estimated design, construction, decommissioning, and operation and maintenance costs were developed for each of the four alternatives. Operation and maintenance costs were estimated based on a 300-year remedial action timeframe, which corresponds to the time required before groundwater protection ARARs are achieved throughout the 100-NR-2 OU.

The total estimated net present value cost is $3.6 million for Alternative 1—ICs and MNA; $47.3 million for Alternative 2—Resume Operation of Existing Pump-and-Treat System; $17.7 million for Alternative 3—Impermeable Barrier; and $20.9 million for Alternative 4—Apatite PRB. Table 1 provides a comparison of the total capital, operations and maintenance, non-discounted, and net present value costs for the four alternatives. An allowance of $683,400 for decommissioning of the treatment components of the existing pump-and-treat system is included in the cost estimates for Alternatives 3 and 4.

The cost estimates presented in this Proposed Plan are based on the best available information regarding the anticipated scope of each remedial alternative. Changes in the scope of the selected remedial alternative identified in the amended interim action ROD are likely to occur as a result of new information obtained during remedial design and construction. These are order-of-magnitude cost estimates that are expected to be within + 50 to -30 percent of the actual project cost.

State Acceptance. Ecology is supportive of this proposed plan. This proposal for treatment of Sr-90 requires a ROD amendment. Under the NCP [40 CFR 300.430(f)(1)(ii)(B)(2)], a new ARARs analysis is required for the portion of the ROD being amended. After completion of the ARARs analysis for Sr-90, the ARARs are unchanged. Ecology will determine final acceptance of the ROD Amendment based on public input on this Proposed Plan.

Table 1. Remedial Alternative Cost Summary Comparison

Cost Element	Alternative 1 ICs and MNA	Alternative 2 Resume Operation of Existing Pump-and-Treat System	Alternative 3 Impermeable Barrier	Alternative 4 Apatite PRB
Capital Cost	$28,300	$275,000	$14,206,000	$16,141,000
Operations and Maintenance Cost (net present value*)	$3,584,0000	$47,050,000	$3,458,000	$4,801,000
Operations and Maintenance Cost (non-discounted cost)	$26,900,000	$387,020,000	$26,163,000	$27,303,000
Total Net Present Value Cost (capital plus net present value operations and maintenance cost)	$3,612,300	$47,325,000	$17,664,000	$20,942,000

Notes:

* Net present value calculation uses a discount rate of 2.8 percent per OMB Circular A-94.

Community Acceptance. Community acceptance is determined in the Responsiveness Summary, which will be provided with the interim action ROD amendment. Additional information is provided in the Community Participation section of this Proposed Plan.

PREFERRED ALTERNATIVE

Based on information currently available, the Tri-Parties believe that the Preferred Alternative, Alternative 4—Apatite PRB, meets the threshold criteria and provides the best balance of trade-offs among the alternatives evaluated with respect to the balancing criteria (Table 2). The preferred alternative satisfies CERCLA 121(b) statutory requirements that require the preferred alternative to: 1) be cost-effective; 2) comply with ARARs (or justify a waiver); 3) utilize permanent solutions and alternative treatment technologies to the maximum extent practicable; and, 4) satisfy the preference for treatment as a principal element. The preferred alternative may change in response to public comment.

Table 2. Summary of Comparative Evaluation of 100-NR-2 Operable Unit Alternatives

CERCLA Criteria	Alternative 1 ICs and MNA	Alternative 2 Resume Operation of Existing Pump-and-Treat System	Alternative 3 Impermeable Barrier	Alternative 4 Apatite PRB
1. Protection of human health/environment	Yes/No	Yes/No	Yes/Yes	Yes/Yes
2. Compliance with ARARs	No	No	Yes	Yes
3. Long-term effectiveness and permanence	◐	◐	◐	○
4. Reduction of toxicity, mobility, or volume through treatment	●	●	◐	○
5. Short-term effectiveness	◐	◐	◐	◐
6. Implementability	○	○	◐	◐
7. Net Present Value Cost (includes capital and O&M)	$3.6 million	$47.3 million	$17.7 million	$20.9 million
8. State Acceptance	No	No	No	Yes
9. Community Acceptance	To Be Determined[a]			

Explanation of evaluation metric:

○ Performs very well against the criteria relative to the other alternatives with no significant disadvantages or uncertainty.

◐ Performs moderately well against the criteria relative to the other alternatives with some disadvantages or uncertainty.

● Performs less well against the criteria relative to the other alternatives with significant disadvantages or uncertainty.

Identifies the preferred alternative.

a. Community acceptance is determined in the Responsiveness Summary, which will be provided with the interim action ROD amendment.

The Tri-Parties believe that Alternative 4—Apatite PRB is the most cost-effective alternative that achieves the RAO of protecting the Columbia River by reducing the Sr-90 flux to the river. Alternative 4 meets the CERCLA preference for treatment by removing Sr-90 from the groundwater before it reaches the Columbia River. This will result in decreased short-term and long-term risk to aquatic receptors present in the river. The preferred alternative is expected to be an important component of the final remedy for the 100-NR-2 groundwater OU that will be announced in a Proposed Plan to be issued in December 2011.

NATIONAL ENVIRONMENTAL POLICY ACT

The NEPA process is intended to assist federal agencies with making decisions that are based on understanding the environmental consequences and taking actions that protect, restore, and enhance the environment. Although CERCLA remedial actions do not require separate NEPA analysis of environmental impacts, Secretarial Policy and DOE Order 451.1B require that DOE CERCLA documents include consideration of NEPA values to the extent practicable to supplement the information available to the public and decision makers. Based on the evaluation presented in this Proposed Plan, the long-term environmental impact of Alternative 4—Apatite PRB will be positive, substantially mitigating Sr-90 contamination in the environment. Short-term impacts during the interim remedial action will be mitigated to stay within standards established under the identified ARARs. The long-term positive environmental impact of remediation clearly outweighs the short-term, limited impacts during remedial construction activities.

COMMUNITY PARTICIPATION

Public involvement is a key element in the CERCLA decision-making process. The public and Tribal Nations are encouraged to read and provide comments on any of the alternatives presented in this Proposed Plan, including the preferred alternative. The public comment period for this Proposed Plan extends from June 21, 2010, through July 22, 2010. Comments on the preferred alternative, other alternatives, or any element of this Proposed Plan will be accepted through July 22, 2010. Comments may be sent to:

Paula Call, U.S. Department of Energy, via:

Mail: P.O. Box 550, A7-75
Richland, WA 99352
Email: 100NRPP@rl.gov

Following the public comment period, a decision will be made after considering comments on the Proposed Plan. The preferred alternative may be modified or another alternative selected based on the comments received and information gathered during the public comment period. DOE will then prepare an amendment to the 100-NR-1/NR-2 interim action ROD. The interim action ROD amendment will identify the alternative chosen and include agency responses to the comments received during the public comment period in a responsiveness summary.

JUNE-JULY 2010 Public Comment Period						
SUN	MON	TUE	WED	THU	FRI	SAT
20	21	22	23	24	25	26
27	28	29	30	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24

Location of Public Information Repositories

Hanford Public Information Repository Locations
Administrative Record and Public Information Repository:
Address: 2440 Stevens Center Place, Room 1101, Richland, WA.
Phone: 509-376-2530
Web site address: http://www2.hanford.gov/arpir/

Portland
Portland State University
Bradford Price and Millar Library
1975 SW Park Avenue
Attn: Claudia Weston (503) 725-4542
Map: http://www.pdx.edu/map.html

Seattle
University of Washington
Suzallo Library
Government Publications Division
Attn: David Maack (206) 543-4664
Map: http://tinyurl.com/m8ebj

Richland
U.S. Department of Energy Public Reading Room
Washington State University, Tri-Cities
Consolidated Information Center, Room 101-L
2770 University Drive
Attn: Janice Parthree (509) 372-7443
Map: http://tinyurl.com/2axam2

Spokane
Gonzaga University Foley Center
East 502 Boone
Attn: Linda Pierce (509) 323-3834
Map: http://tinyurl.com/2c6bpm

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APPENDIX A. 100-NR-2 OU REMEDIAL ACTION OBJECTIVES AND REMEDIAL ACTION GOALS FROM 1999 INTERIM ACTION ROD

REMEDIAL ACTION OBJECTIVES

1. Protect the Columbia River from adverse impacts from the 100-NR-2 groundwater so that designated beneficial uses of the Columbia River are maintained. Protect associated potential human and ecological receptors using the river from exposure to radioactive and nonradioactive contaminants present in the unconfined aquifer. Protection will be achieved by limiting exposure pathways, reducing or removing contaminant sources, controlling groundwater movement, or reducing concentrations of contaminants in the unconfined aquifer.

2. Protect the unconfined aquifer by implementing remedial actions that reduce concentrations of radioactive and nonradioactive contaminants present in the unconfined aquifer.

3. Obtain information to evaluate technologies for Sr-90 removal and evaluate ecological receptor impacts from contaminated groundwater (by October 2004).

> This objective was achieved with issuance of *Evaluation of Strontium-90 Treatment Technologies for the 100-NR-2 Groundwater Operable Unit Letter Report*, (Fluor Hanford/CH2M HILL, 2004) and DOE/RL-2006-26, *Aquatic and Riparian Receptor Impact Information for the 100-NR-2 Groundwater Operable Unit*.

4. Prevent destruction of sensitive wildlife habitat. Minimize the disruption of cultural resources and wildlife habitat in general and prevent adverse impacts to cultural resources and threatened or endangered species.

Remedial Action Goals

A remedial action goal of 8 pCi/L was established in the interim action ROD as the allowable concentration of Sr-90 in groundwater and surface water that is protective of human health and the environment. The remedial action goal for Sr-90 corresponds to the 8 pCi/L federal remedial action goal based on a 4 millirem per year annual dose.

There is no federal or state ambient water quality standard for Sr-90. Therefore, the Tri-Parties agreed to adopt the remedial action goal for radionuclides. For strontium-90, the remedial action goal is 8 pCi/L. This concentration, if consumed by the standard man (150 lb) at a rate of 2.0 L/day, would correspond to a dose of 4 millirem per year to the critical organ (bone) or 0.011millirem per day. With a relative biological effectiveness factor of 1.0 for beta radiation, an 8 pCi/L concentration is essentially 90,900 times more conservative than the DOE radiation dose limit of 1.0 rad per day for aquatic organisms and 9,900 times more conservative than the radiation dose limit of 0.1 rad per day for terrestrial and riparian animals. One reason for the large difference between the human and animal radiation dose limits is that the biota dose levels are based on protection of animal populations rather than protection of the most sensitive human individual. The 0.011millirem per day dose associated with the 8 pCi/L remedial action goal is very conservative and protective compared to established radiation dose limits for aquatic organisms.