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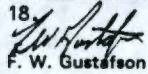

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7. Abstract

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This project plan describes the process by which an Expedited Response Action will be proposed for controlling the flux of Strontium 90 from a groundwater plume into the Columbia River via N-Springs

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1.0 INTRODUCTION

Since the signing of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) in 1989 (Ecology et al. 1989), the parties to the agreement have recognized the need to modify the approach to conducting investigations, studies, and cleanup actions at Hanford with a goal of maximizing efficiency, optimizing use of limited resources, and achieving cleanup in the earliest possible time frame. To implement this approach, the parties have jointly developed the *Hanford Site Past Practice Strategy* (DOE-RL 1991a). The principles of the strategy are embodied in the *Hanford Federal Facility Agreement and Consent Order Change Package*, (Ecology et al. 1991).

The strategy provides new concepts for undertaking expedited response actions (ERA) and/or interim remedial measures (IRM), as appropriate, to either remove threats to human health and the environment, or to reduce risk by reducing toxicity, mobility, or volume of contaminants. In accordance with this strategy, the U.S. Department of Energy (DOE) proposes to conduct an ERA at the N Springs, located in the Hanford 100-N Area, to eliminate or reduce the strontium-90 transport into the river through the groundwater pathway.

1.1 BACKGROUND

The N reactor, located in the 100-N Area of the Hanford Site, was operated as a dual production reactor (plutonium and byproduct steam for electricity generation) from 1963 until 1987. Since 1987, the reactor has been taken through progressive stages of shutdown and will eventually be completely decommissioned. Low-level radioactive liquid effluents from reactor operations were disposed in the 1301-N and 1325-N cribs (116-N-1 and 116-N-3) and associated overflow trenches (Figure 1-1). Liquid effluent discharges to the soil have essentially ceased as shutdown and reactor decontamination operations have progressed.

Liquid effluents discharged to the two cribs in the 100-N Area created a significant groundwater mound, altering the normal groundwater flow patterns in the area. The soil column underlying the cribs and trenches provided for a significant degree of sorption and retardation of radionuclides contained in the water. However, after extended operation, the soil adsorption capacity became saturated for some contaminants, allowing radionuclides to reach the Columbia River. The area along the southern bank of the river where the contaminated groundwater discharges into the river is known as N Springs. Sampling of the N Springs in 1991 (DOE-RL 1992a) showed the principal radionuclides in the groundwater reaching the river to be strontium-90 at concentrations as high as about 3,200 pCi/L. This significantly exceeds the drinking water Maximum Contaminant Level (MCL) of 8 pCi/L (40 CFR 141). The rate of radionuclides release to the river is slowly diminishing because of lower groundwater flows as a result of the N reactor shutdown (WHC 1991) and radioactive decay.

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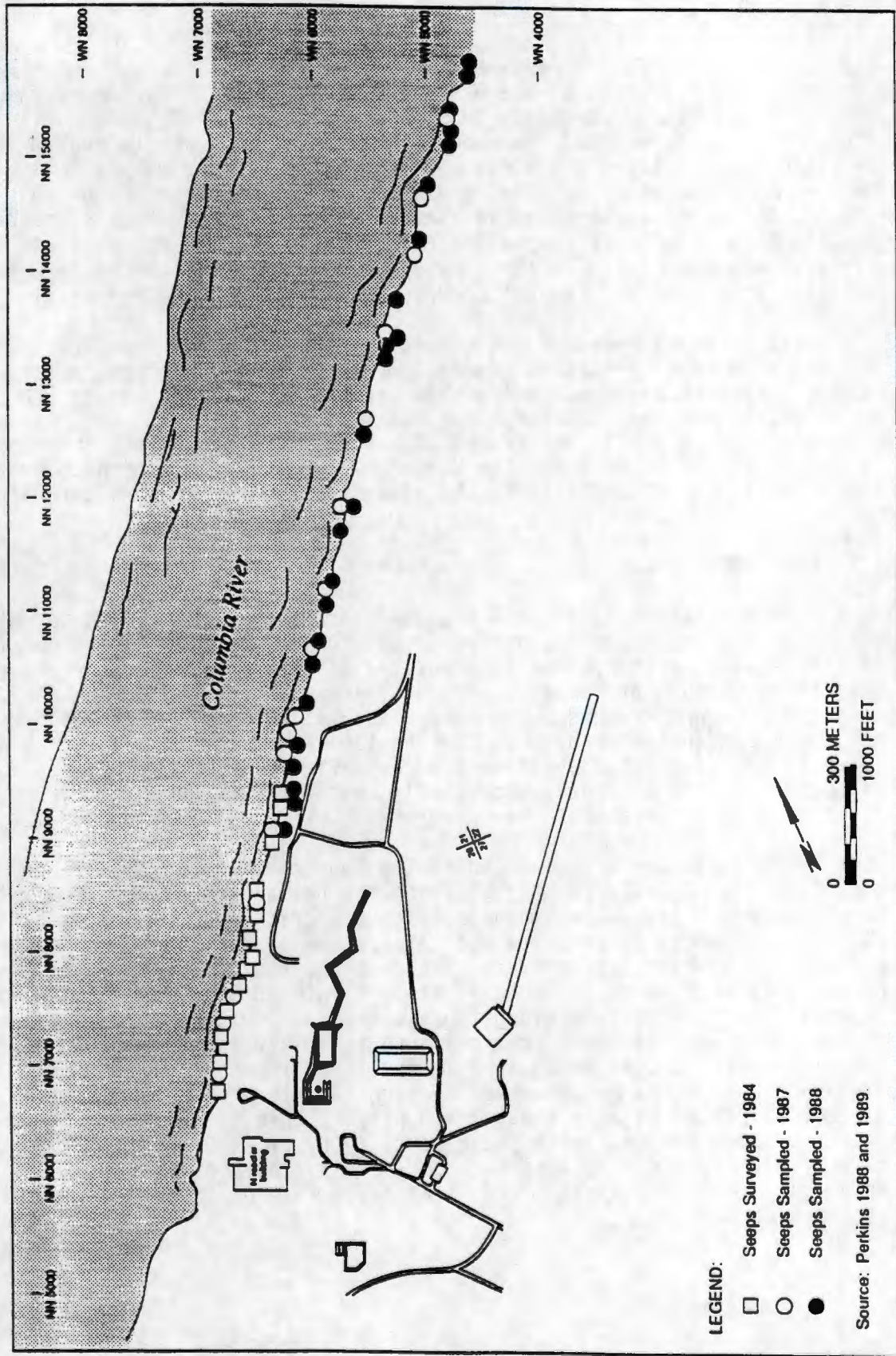


Figure 1-1. Locations of N Springs (DOE-RL 1991b).

1.2 PURPOSE AND OBJECTIVES

Since the N Springs represent a significant pathway for contamination releases into the river, DOE proposes to conduct an ERA to eliminate or restrict the flux of strontium-90 migration into the river through the groundwater pathway. This ERA meets the criteria as defined by DOE-RL (1991a) and as detailed in Gustafson (1991). The ERA will be conducted as a non-time-critical removal action under the regulatory authority as defined in 40 CFR 300.415.

In accordance with the past practice strategy and the requirements of removal actions under 40 CFR 300.415, the ERA does not necessarily constitute the final remedial action for the site, but shall, to the extent practicable, contribute to the efficient performance of any anticipated long-term remedial actions with respect to the contaminant release(s). In accordance with 40 CFR 300.415(i), removal actions shall to the extent practicable, considering the exigencies of the situation, attain applicable or relevant and appropriate requirements (ARAR).

In accordance with these requirements, the principal objective of the N Springs ERA Proposal will be to evaluate alternatives and recommend a single alternative that best meets the selection criteria as prescribed by Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), including a demonstration of cost effectiveness. Since complete remediation of the contaminated groundwater beneath 100-N is not a principal objective of the ERA, there is some flexibility in the scope of the ERA and the degree to which groundwater remediation is achieved. It is intended that the Engineering Evaluation/Cost Analysis (EE/CA), which will be conducted as part of the ERA Proposal preparation, attempt to identify an ERA system that optimizes the benefit produced for the costs incurred.

1.3 SCOPE

This document presents the project plan for implementing the ERA. The project plan describes the tasks needed to complete the ERA proposal and consists of the following elements:

- A description of site characteristics
- Identification of tasks necessary for completing the ERA proposal
- Identification of critical design and implementation tasks
- A description of the alternative screening process and the alternatives that will be considered for performing the ERA
- A project schedule.

The ERA proposal is a primary document subject to U.S. Environmental Protection Agency (EPA) approval and Washington State Department of Ecology (Ecology) review. Following EPA approval of the ERA proposal, it will be issued for public comment. Following the public comment period and comment incorporation, a Tri-Party Agreement Action Memorandum will be issued and the ERA implemented.

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2.0 SITE CHARACTERISTICS

2.1 DISCHARGE HISTORY

The primary sources for groundwater contamination, which contribute to N springs, are the 1301-N and 1325-N cribs. The following is a brief description of the discharge histories for each facility and was taken primarily from DOE-RL (1991b).

2.1.1 1301-N

The 1301-N crib and trench was a major contributor of contaminants to the groundwater. The facility is a liquid waste disposal facility (LWDF) that used the properties of the underlying soil column as a filtration and ion exchange system to remove radioactive material from the waste water. The facility operated from 1964 to 1985 with an estimated average flow rate of 8,000 L/min. The LWDF received liquid radioactive wastes from N reactor, including effluents from the reactor coolant system, fuel storage basin, periphery coolant systems, and other radioactive drain systems. The facility was also used for disposal of chemicals. Estimates of radionuclides and chemical wastes discharged to the LWDF are shown in Table 2-1.

The 1301-N crib and trench is a dangerous waste disposal facility under RCRA interim status. The DOE has prepared a draft closure and post-closure plan (WHC 1987a) for submittal to Ecology in accordance with WAC 173-303-610, *Dangerous Waste Regulations*. A new closure and post-closure plan (superseding the above plan) is to be submitted in May 1994 to fulfill Tri-Party Agreement Milestone M-20-31 (Ecology et al. 1990).

2.1.2 1325-N

The 1325-N crib and trench is located approximately 300 m east of the 1301-N LWDF. The function of the LWDF was the same as 1301-N. The 1325-N crib was constructed in 1983 as a replacement for the 1301-N LWDF. 1325-N began receiving N reactor flow in 1983, and was put into full service in 1985. Between 1983 and 1985 both LWDF received wastes from N reactor. The average flow rate from 1983 to 1986 was approximately 1,400 L/min. Discharges were reduced in 1987 when the N reactor was placed on standby status. Currently, the trench is not receiving liquid wastes. The 1325-N LWDF received similar wastes as 1301-N. Estimates of radionuclides and chemical wastes disposed to the LWDF are shown in Table 2-2.

The 1325-N crib and trench is a dangerous waste disposal facility under RCRA interim status. The DOE has prepared a draft closure and post-closure plan (WHC 1987b) for submittal to Ecology in accordance with WAC 173-303-610. A new closure and post-closure plan (superseding the above plan) is to be submitted in May 1994 to fulfill Tri-Party Agreement Milestone M-20-31 (Ecology et al. 1990).

Table 2-1. Radionuclides/Chemical Wastes Disposed to 1301-N.

Radionuclides	Cumulative inventory ^a (Ci)
cobalt-60	3,800.0
strontium-90	1,800.0
ruthenium-106	120.0
cesium-134	51.0
cesium-137	2,300.0
plutonium-239	18.0
Chemical waste	Disposal rate (lb/yr)
hydrazine test solution	6,100.0
ammonia test solution	6,100.0
chloride test solution	7,800.0
fluoride test solution	3,900.0
lead-acid battery fluid	630.0 ^b
nickel-cadmium battery fluid	270.0 ^b
hydrazine (injection system)	350.0

^aAccounting for decay to September 1985.

^bActual amount is not available, but amount shown is possible because of common floor drains.
Source: DOE-RL 1991b.

Table 2-2. Radionuclides/Chemical Wastes Disposed to 1325-N.

Radionuclides	Cumulative inventory ^a (Ci)
cobalt-60	1,300.0
strontium-90	200.0
ruthenium-106	66.0
cesium-134	14.0
cesium-137	350.0
plutonium-239	2.6
Chemical waste	Disposal rate (lb/yr)
hydrazine test solution	6,100.0
ammonia test solution	6,100.0
chloride test solution	7,800.0
fluoride test solution	3,900.0
lead-acid battery fluid	120.0 ^b
nickel-cadmium battery fluid	80.0 ^b
hydrazine (injection system)	10.0

^aAccounting for decay to September 1985.

^bActual amount is not available, but amount shown is possible because of common floor drains.
Source: DOE-RL 1991b.

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2.2 PHYSICAL SETTING

2.2.1 Topography

The topography of the 100-N Area has elevations ranging from approximately 120 m (394 ft) at the Columbia River to approximately 140 m (460 ft) above mean sea level in the eastern portion of the area. Some portions of the area have been reworked as part of construction of 100-N Area facilities. The average elevation above the riverbank is 137 m (449 ft). The slope along the riverbank is approximately 15%.

2.2.2 Geology

The Hanford Site is located in the Pasco Basin, which is within the Columbia-Snake River physiographic province (Hunt 1974). The following is a brief discussion of the geologic characteristics of the 100-N Area. More detailed discussions of the geologic characteristics of the Hanford Site and 100-N Area may be found in DOE (1988), DOE-RL (1991b), and WHC (1987a and b).

The stratigraphy of the 100-N Area is shown on Figure 2-1. Stratigraphically the area is underlain by the Columbia River Basalt Group, the Ringold Formation, and the Hanford formation. Only the Ringold and Hanford formations have direct relevance to this study.

The Ringold Formation unconformably overlies the Saddle Mountains Basalt of the Columbia River Basalt Group in the 100-N Area. The formation is approximately 143 to 146 m (469 to 479 ft) thick in the area. The Ringold has been subdivided into three informal units in the 100-N Area; they are designated as Ringold units 1, 2, and 3 (DOE-RL 1991b).

Ringold unit 3 is a relatively coarse-grained sandy pebbly gravel that may be weakly indurated and contains scattered caliche zones. The unit is 5.5 to 20 m (18 to 65 ft) thick in the 100-N Area.

Ringold unit 2 overlies Ringold unit 3 and is approximately 115 m (377 ft) thick. The Ringold unit 2 is further subdivided into subunits a, b, c, which are differentiated based on lithology and depositional environment. Ringold unit 2 is comprised of clays, silts, and sands. A detailed description of Ringold unit 2 may be found in DOE-RL (1991b).

Ringold unit 1 consists of light-tan interbedded sands and gravels. The unit is approximately 13 to 20 m (43 to 66 ft) thick. The contact between the Ringold Formation and the Hanford formation is at approximately 120 to 128 m (394 to 420 ft) elevation. Ringold unit 1 can be distinguished from the overlying Hanford formation based on sand composition; Ringold unit 1 sands are tan and are derived primarily from metamorphic rocks, while the Hanford sands are black and derived from basaltic rocks.

The Hanford formation overlies the Ringold Formation and is composed of interbedded sands, gravels, and cobbles. The Hanford formation has a much coarser texture than the Ringold Formation.

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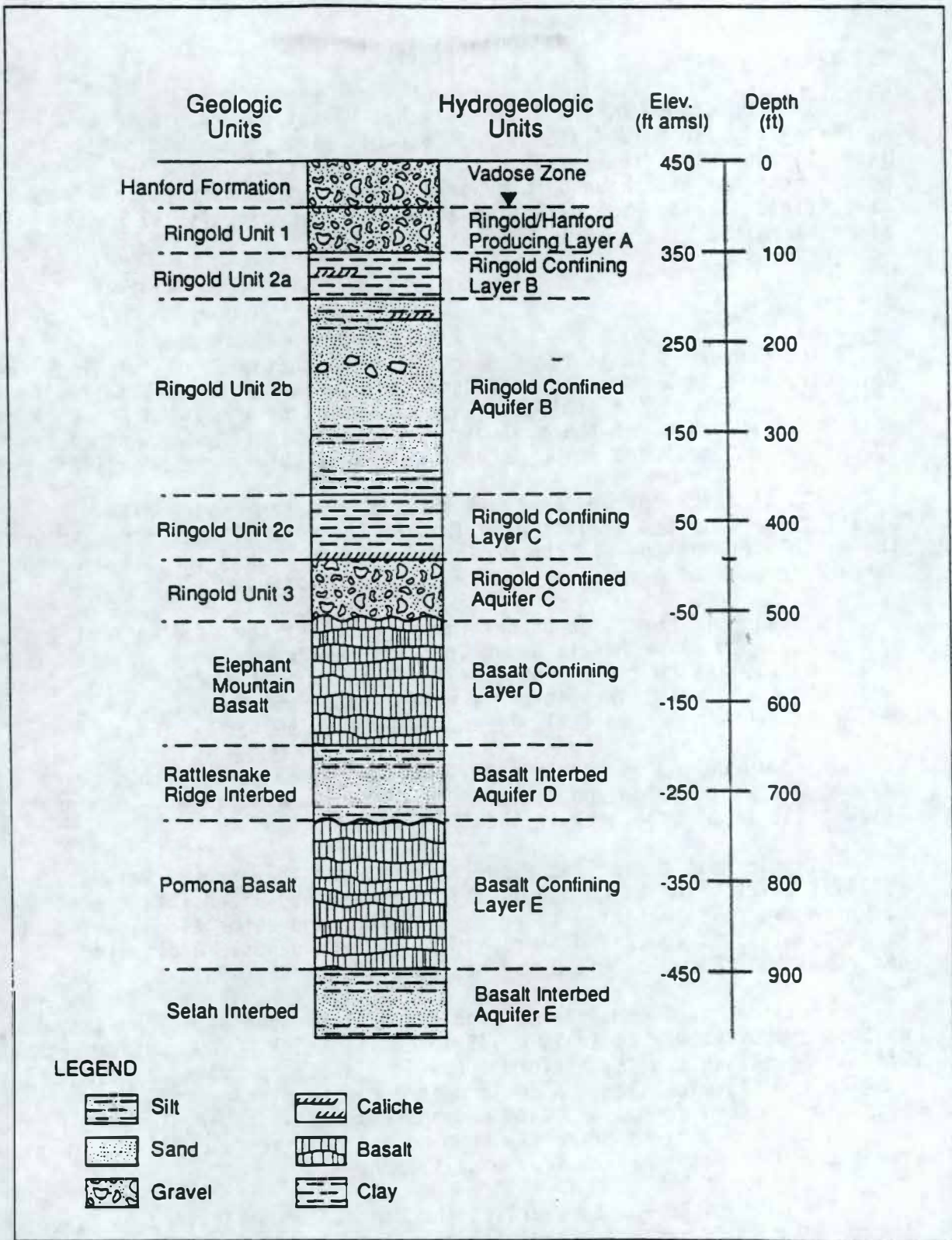


Figure 2-1. Conceptual Geologic and Hydrogeologic Column (DOE-RL 1991b).

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Surficial eolian deposits locally overlie the Hanford formation in the 100-N Area. However these areas are only present where construction activities have not disturbed them.

2.2.3 Hydrogeology

The conceptual hydrogeologic column for the 100-N Area is shown on Figure 2-1. The figure also correlates the geologic unit designations with hydrogeologic units. The hydrogeologic system at the 100-N Area consists of underlying confined aquifers and associated confining layers within the Saddle Mountains Basalt and Ringold Formation, the unconfined aquifer within Ringold unit 1 and Hanford formation, and the vadose zone within the Hanford formation.

2.2.3.1 Ringold Confined Aquifers

The uppermost confined unit is the Ringold Confined Aquifer "B" (Figure 2-1). The unit corresponds to the Ringold Formation unit 2b and ranges in thickness from 53 to 60 m (175 to 200 ft) across the 100-N Area. No site-specific hydrologic data are available for this unit. Reported hydraulic conductivity values for the Ringold Formation range from 3.0×10^{-2} to 2.2×10^{-3} m/d (0.1 to 7,000 ft/d) (DOE-RL 1991b); the lower-end values of this range could be representative of the Ringold Confined Aquifer "B".

The Ringold Confined Aquifer "B" is confined by the Ringold Confining Unit "B". The unit corresponds to Ringold Formation unit 2a and consists of interbedded clay and silt with occasional thin layers of sand. The layer ranges in thickness from 3 to 15 m (10 to 50 ft). No hydraulic data are available for this confining unit.

2.2.3.2 Unconfined Aquifer

The unconfined aquifer, or Ringold/Hanford Producing Layer "A" is located in the silt, sand, gravel, and cobbles of Ringold unit 1 and the lower Hanford formation. The contact between the Ringold Formation and the Hanford formation may be an irregular surface due to erosion from the catastrophic floods that deposited the Hanford formation.

Water levels in the unconfined aquifer have been declining since the end of active operations at N reactor. Water levels for the 100-N Area collected in May 1990 are shown on Figure 2-2. Water levels in the unconfined aquifer are influenced by daily and seasonal fluctuations in river level. During high river stage, such as occurs during the spring months, a reversal of the hydraulic gradient away from the river occurs. Data collected during 1990 show that daily river level fluctuations correlate with water level changes in wells 230 m (750 ft) from the shoreline and seasonal river level fluctuations correlate with water level changes in wells approximately 300 m (1,000 ft) from the shoreline (Gilmore et al. 1991).

Aquifer tests have been completed in 100-N Area wells and results of these tests are summarized in Table 2-4 of DOE-RL (1991b). Estimated transmissivities from wells near the two LWDF range from 536 to 2,506 m^2/d (5,750 to 26,700 ft^2/d).

2.2.3.3 Vadose Zone

The vadose zone in the vicinity of the 100-N Area is within the Hanford formation and the upper portion of Ringold unit 1. The sediment consists of poorly sorted boulders, cobbles, gravels, sands, and silts. Perched water was noted during drilling of one well near 1325-N, but was not noted during drilling of any other wells near 1325-N.

Connelly et al. (1991) collected soil samples from the unsaturated zone for determination of saturated hydraulic conductivity estimates. These estimates ranged from 2.2 to 52 m/d (7 to 170 ft/d). The most representative value was determined to be 20 m/d (65 ft/d). Effective porosities were estimated to range from 9 to 44% (Connelly et al. 1991).

2.2.4 Surface Water Hydrology

The Columbia River forms the northwest border of the N Springs ERA study area. Flow in the Columbia River is relatively swift and straight in the vicinity of the 100-N Area. While the Columbia River is free flowing over this reach, the flow is regulated by the upstream Priest Rapids Dam. River levels may change as much as 1.5 m (5 ft) daily. A more complete description of the surface water hydrology is presented in DOE-RL (1991b).

2.3 CONTAMINATION

2.3.1 Soil

2.3.1.1 Background Soil Quality

Background soil quality has been determined and is discussed in DOE-RL (1991b). Samples contained metals, almost no radionuclides and volatiles, and no semivolatiles.

2.3.1.2 Soil Contamination

Soil contamination data have been collected from wells in the vicinity of the two LWDF. Results show that very low concentrations of radionuclides are present in the soils above the water table, and that very little lateral migration of contaminants occurred in the vadose zone away from the LWDF. Soil samples collected from below the water table show elevated concentrations of radionuclides compared to samples collected from above the water table (DOE-RL 1991b).

2.3.2 Groundwater

2.3.2.1 Background Groundwater Quality

DOE-RL (1991b) states that sufficient data are not available to establish background groundwater quality for the 100-N Area; however, data are available for the Hanford Site in general. Table 2-3 presents the estimated background levels for selected constituents for the Hanford Site.

Table 2-3. Estimated Background Levels for Selected Constituents in Hanford Site Groundwater.

Constituent	Unit	Detection limit	Background concentration ^a
aluminum	µg/L	2 ^b	<2 ^b
ammonia	µg/L	50	<50
arsenic	µg/L	0.2 ^b	3.9 ± 2.4 ^b
barium	µg/L	6	42 ± 20
beryllium	µg/L	0.3 ^b	<0.3 ^b
bismuth	µg/L	0.02 ^b	<0.02 ^b
boron	µg/L	50 ^b	<50 ^b
cadmium	µg/L	0.2 ^b	<0.2 ^b
calcium	µg/L	50	40,400 ± 10,300
chloride	µg/L	500	10,300 ± 6,500
chromium	µg/L	2 ^b	4.0 ± 2.0 ^b
copper	µg/L	1 ^b	<1 ^b
cyanide	µg/L	10	<10
fluoride	µg/L	500	370 ± 100
lead	µg/L	0.5 ^b	<0.5 ^b
magnesium	µg/L	10	11,800 ± 3,400
manganese	µg/L	5	7 ± 5
mercury	µg/L	0.1	<0.1
nickel	µg/L	4 ^b	<4 ^b
nitrate	µg/L	500	<500
phosphate	µg/L	1,000	1,000
potassium	µg/L	100	4,950 ± 1,240
selenium	µg/L	2 ^b	<2 ^b
silver	µg/L	10	<10
sodium	µg/L	10	18,260 ± 10,150
strontium	µg/L	20	236 ± 102
sulfate	µg/L	500	34,300 ± 16,900
tritium	pCi/L	300	<300
uranium	pCi/L	0.5	1.7 ± 0.8
vanadium	µg/L	5	17 ± 9
zinc	µg/L	5	6 ± 2
alkalinity	µg/L	NA	123,000 ± 21,000
pH	unitless	NA	7.64 ± 0.16
total organic carbon	µg/L	200	586 ± 347
conductivity	µmhos/cm	1	380 ± 82
gross alpha	pCi/L	0.5	2.5 ± 1.4
gross beta	pCi/L	4	19 ± 12
radium	pCi/L	0.2	<0.2

^aAverage ± 2 standard errors of the calculated mean.
^bBased on inductively coupled plasma/mass spectrometry data.
 NA = Not Applicable
 Sources: Evans et al. 1989 and Jacquish and Bryce 1990.

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2.3.2.2 Groundwater Contamination

The primary groundwater contamination consists of the radionuclides strontium-90, tritium, iodine-131, and cobalt-60. For this ERA strontium-90 is of primary concern. Strontium-90 activity for the 100-N Area is shown on Figure 2-3, which illustrates that the primary occurrence of strontium-90 is in the vicinity and downgradient of the two LWDF.

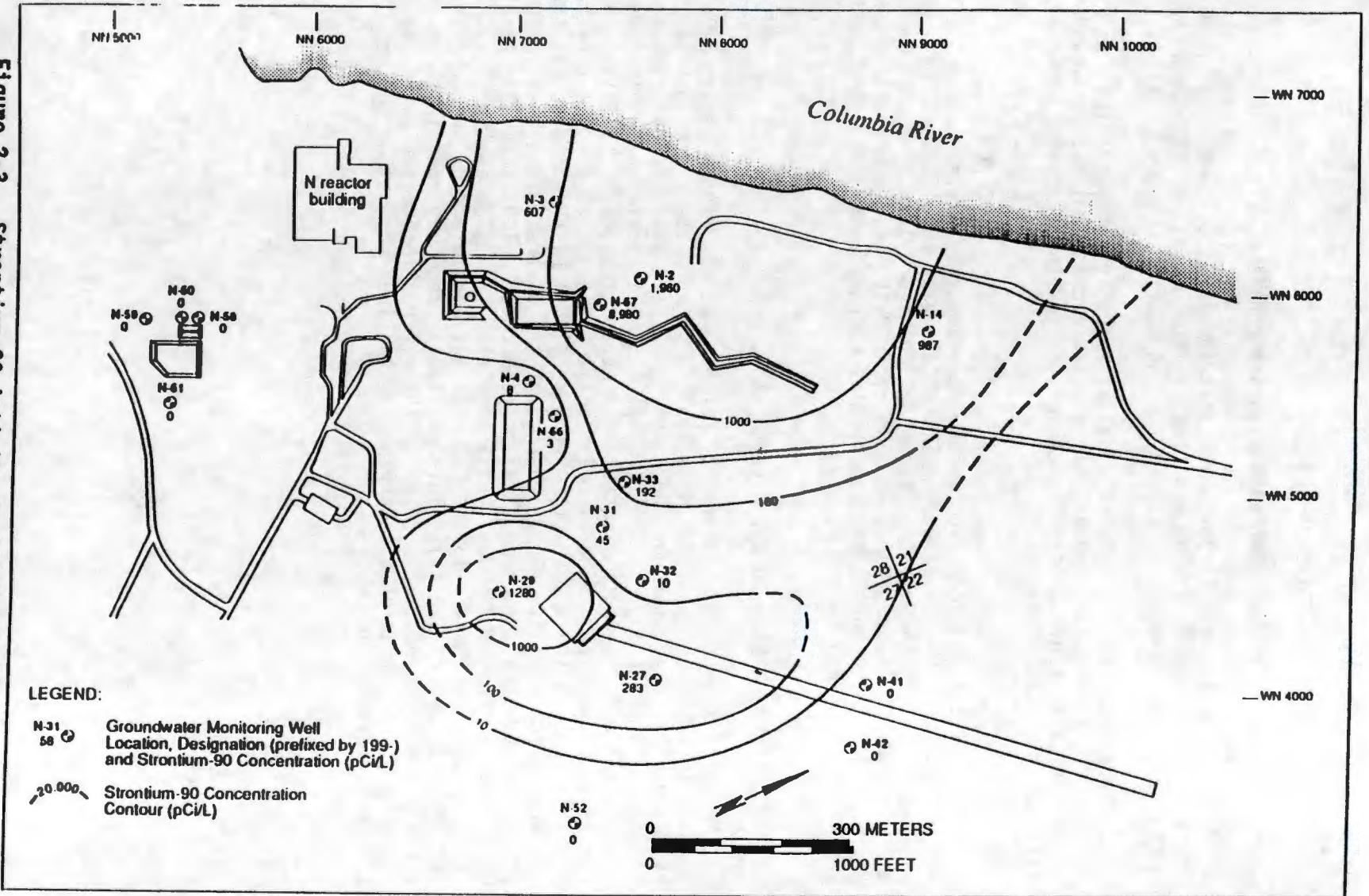
Characterization of the vertical distribution of contamination in the groundwater is limited; however, the available data indicate that much of the contamination is confined to a relatively narrow zone centered around the water table (DOE-RL 1991b).

Spring sampling has been conducted since 1980 as part of the Environmental Surveillance Program and in several separate studies (McCormack and Carlile 1984, Dirkes 1990, and DOE-RL 1992a). Locations of springs and seeps associated with N Springs are shown on Figure 1-1. The maximum value for strontium-90 listed in DOE-RL (1991b) is 8,400 pCi/L. Results from DOE-RL (1992a) show that the maximum value measured was 3,210 pCi/L and was from the same spring location.

2.3.3 Contaminant Flux to the River

Numerical studies conducted by Connelly et al. (1991) and WHC (1991) indicate that the current flux of strontium-90 into the Columbia River is approximately 2 Ci/yr through the N Springs. Data derived from samples collected from N Springs in 1991 (DOE-RL 1992a) indicate that this flux is not evenly distributed along the shoreline. Concentrations of strontium-90 rapidly decrease from a high of 3,210 pCi/L to less than 0.2 pCi/L over a distance of about 105 m (350 ft). Perkins (1989) also indicate that the majority of the strontium-90 discharges at the upstream (southwest) end of the springs (Figure 2-4). Spring sampling conducted in 1991 (Connelly et al. 1991) supports this and shows that a significant portion of the total strontium-90 contribution to the Columbia River also occurs over a distance of approximately 100 m (330 ft). This particular zone may contribute up to 22% of the projected strontium-90 flux to the river. This distribution in contaminant concentration discharging to the river may be due to local hydrogeological influences.

Figure 2-3. Strontium-90 Activity in 100-N Area Groundwater During February 1990 (DOE-RL 1991b)



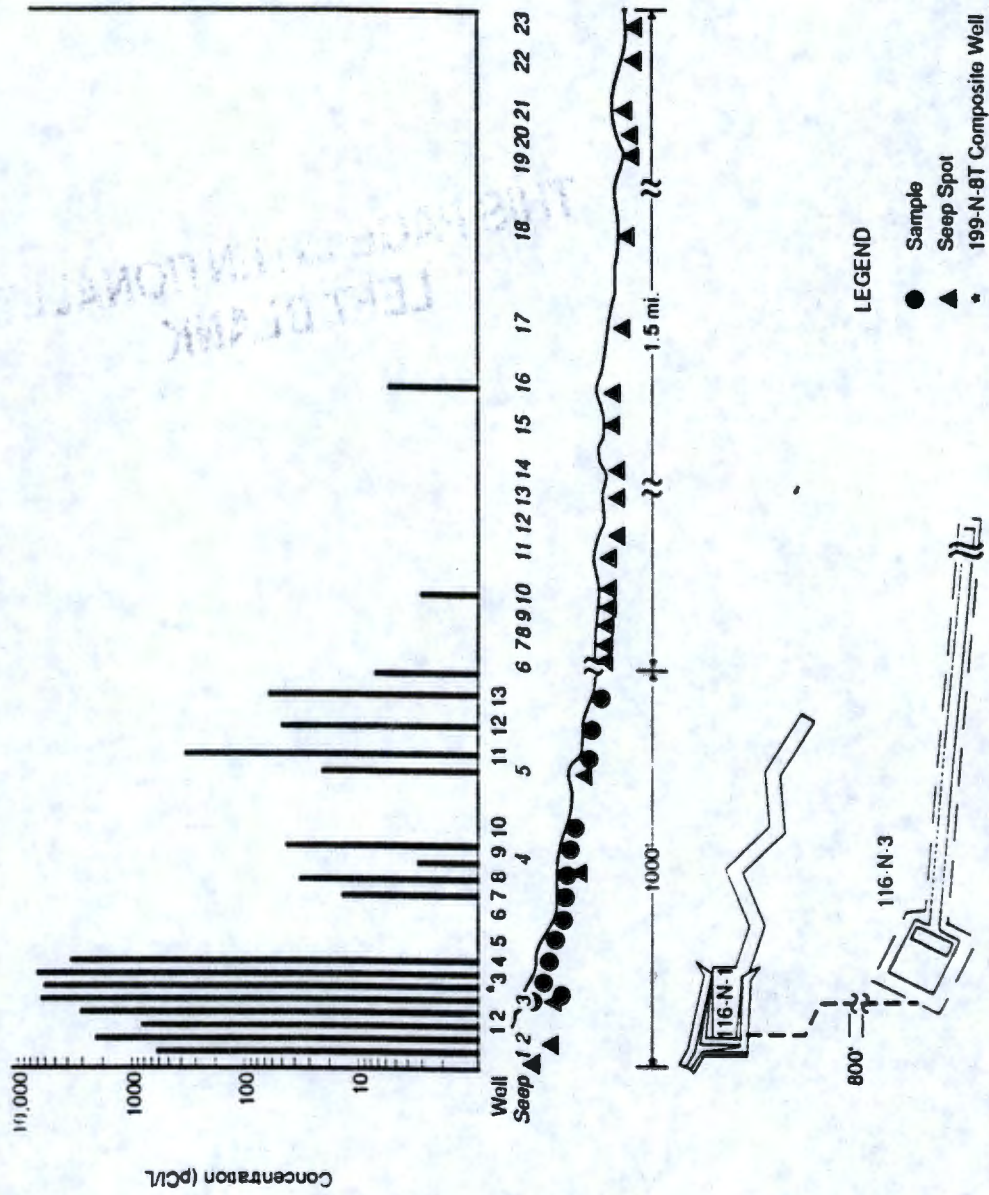


Figure 2-4. Strontium-90 Activity Levels in N Springs During 1988 (DOE-RL 1991b)

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3.0 PROGRAM TASKS

This section briefly describes the tasks to be completed to accomplish the N Springs ERA. Critical schedule elements are identified for each task; the integrated schedule for each of the tasks for the N Springs ERA is given in Section 5.0.

3.1 ERA PROPOSAL

The ERA proposal is a document that proposes and supports the selection of the removal remedy. Since the removal action for N Springs is non-time-critical, an EE/CA must be performed to support the removal action decision. The elements of the EE/CA are listed as follows:

- Description of site characteristics--a summary of what is known about the site and the contamination problems
- Identification of removal action objectives (RAO)--the cleanup objectives that must be met by the removal action
- Identification of removal action alternatives--the technologies that could be used to meet the removal action objectives
- Initial screening of removal action alternatives--evaluation of each alternative against prescribed criteria
- Analysis of remaining removal action alternatives--detailed analysis of screened alternatives with respect to prescribed evaluation criteria
- Comparative analysis of removal action alternatives--a comparison of each alternative relative to the others in meeting the RAO
- Recommended removal action alternatives--selection of the alternative that best meets the evaluation criteria.

The EE/CA process is described in greater detail in Section 4.0. Section 4.0 also describes the initial list of removal action alternatives that will be evaluated in the EE/CA.

Included with the ERA Proposal will be a summary document. This document is similar in scope to a CERCLA Proposed Plan and serves as a vehicle for public involvement in the decision making process.

3.2 TRI-PARTY AGREEMENT ACTION MEMORANDUM

Following completion and approval of the ERA Proposal and summary document, the summary document will be distributed for public comment. At the completion of the public comment period and comment incorporation, a Tri-Party Agreement Memorandum will be prepared that briefly summarizes the ERA Proposal and provides justification for the ERA removal action selected.

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3.3 ERA SYSTEM DESIGN

Following the approval of the N Springs ERA Proposal, system design will begin. System design will be completed to the extent necessary to facilitate competitive bidding of the construction contract. The critical tasks that are necessary for completion of ERA design include:

- Additional data needs--collection of any critical design data that were identified in the EE/CA
- Treatability testing--optional treatability testing to optimize the treatment process
- Modeling/analysis--numerical modeling and analysis of the selected removal action to optimize the system
- System design--equipment/system design and specification in sufficient detail such that equipment procurement and system construction can proceed
- Procurement of construction contractor--a critical path activity because of the long lead time involved.

3.4 ERA CONSTRUCTION/IMPLEMENTATION

Critical tasks for the ERA construction and implementation are:

- Equipment procurement--procurement of all equipment and materials necessary to construct the ERA system
- Field installation--installation of the ERA system ready for shakedown and startup
- Shakedown/startup--ERA system testing and startup.

3.5 SYSTEM OPERATION/ASSESSMENT

System operation and assessment will include the following tasks:

- System Operation and Maintenance
- System Monitoring--monitoring of groundwater contamination levels, contamination levels entering the river, and treatment system effluent
- Performance Assessment/Reporting--assessment of the efficiency of the ERA system in meeting RAO and periodic reporting of the system performance.

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4.0 REMOVAL ALTERNATIVES SCREENING PROCESS

This section describes the process to be used for developing, evaluating, and selecting a preferred removal action alternative for conducting an N Springs ERA. The discussion also provides a description of preliminary removal action technologies that will be considered for evaluation in the EE/CA process.

4.1 ENGINEERING EVALUATION/COST ANALYSIS

The EE/CA is a process used to develop, evaluate, and select the preferred removal action and is required for all non-time-critical removal actions. The EPA guidance document (EPA 1987) provides details on alternative screening for ERA. The basic components of the EE/CA are identified in the following paragraphs.

Site characterization--Includes a site description, site background, analytical data, and site conditions that justify the ERA. A groundwater monitoring system is currently in place in the 100-N Area and it is believed that sufficient data are available such that no additional characterization of the groundwater will be required. However, additional data needs to support the EE/CA will be identified as part of this first step in the EE/CA process.

Identification of RAO--Removal action objectives define the "why", "what", and "when" of a removal action. Development of RAO will include the following:

- Preliminary identification of ARAR
- Determination of ERA scope, i.e., what is to be accomplished by the removal action
- Determination of ERA time frame

Removal action objectives will be developed to delineate the limits of acceptable technical performance and will seek a balance of benefit with cost.

Identification of removal action alternatives--Technologies that potentially meet the RAO will be identified. The identified technologies will consider the contaminants, contaminant levels, and the history of development and field application of the technologies. The initial list of technologies to be considered is discussed in Section 4.2.

Initial screening of removal action alternatives--Identified alternatives will be screened based on the following four factors:

- Timeliness; is the option timely with respect to threat mitigation?
- Protectiveness; is the option protective of human health and the environment?
- Technical feasibility; is the option a viable technology? Is there some technical aspect of this option that would make it inappropriate for use in the ERA? Some of the questions that may be asked when assessing technical feasibility are:
 - Has the technology been proven in large, field-scale applications?

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- Has the technology been used on similar site conditions, media, and contaminants?
- Institutional considerations; are there any overriding institutional considerations that would eliminate the option?

The purpose of the screening is to eliminate technologies that do not meet the screening factors so that they do not have to be carried through the detailed analysis. However, the reasons for eliminating the technology will be clearly documented. This stage of screening will evaluate each technology on a pass-fail basis against the four screening factors listed previously. If a technology fails any one of the factors, it will be eliminated from further consideration in detailed analysis.

Analysis of remaining removal action alternatives--Alternatives that pass initial screening will then undergo a more detailed analysis using the following selection criteria:

- Technical feasibility
 - Effectiveness in reducing toxicity, mobility or volume of the contamination and ability to meet ARAR
 - Demonstrated performance and reliability under similar field conditions
 - Useful life; how long the solution is anticipated to maintain its integrity
 - Environmental effects upon operations
- Cost considerations
 - Capital costs for equipment, construction, engineering, and startup
 - Operation and maintenance costs including performance monitoring
 - Present worth analysis
- Institutional considerations
 - Permitting and other factors affecting implementation time frame
 - Time to complete
 - Safety
- Environmental impacts

Comparative analysis of removal action alternatives--The advantages and disadvantages of each alternative will be compared against those of the other alternatives based on the above evaluation criteria. A scoring process will be used to compare alternatives. In the scoring process, the evaluation criteria will be weighted commensurate with the objectives of the ERA.

Recommended removal action alternative--The recommended removal action alternative will be the best choice based on the comparative analysis. This implies that the alternative that scores highest in the evaluation is the logical choice. However, if two or more scores are very close, other factors, including best professional judgement, may need to be considered.

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4.2 REMOVAL ALTERNATIVE DESCRIPTIONS

This section of the project plan describes the initial technologies that will be evaluated in the EE/CA for the N Springs ERA. The list of technologies and their descriptions are derived from DOE-RL (1992b). Other previous studies considered include WHC (1991) and WHC (1992).

The technologies discussed in the following sections are considered representative of those technologies which, upon consideration of site-specific conditions, are the most likely to meet the removal action objectives at N Springs. Other technologies not included on this initial list may be added during the EE/CA process, if warranted, upon further analysis of site data.

4.2.1 No Action

The no-action option implies no remedial action at N Springs. Institutional controls (such as groundwater and surface water monitoring, access restrictions, and administrative controls) would continue to be maintained. Additional monitoring capability may be provided to enhance existing systems, if necessary. This alternative will not reduce or restrict the flow of contaminants to the river through the springs; however, because the contamination consists primarily of radionuclides, contamination will eventually attenuate through radioactive decay. Contamination migration to the river will also decrease to some extent as a result of the cessation of flow to the 100-N Area cribs and trenches.

Inclusion of this option in the evaluation satisfies the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) requirement that a no action alternative be evaluated as a baseline to which all other alternatives are compared.

4.2.2 Vertical Barriers

The objectives of vertical barriers at N Springs are:

- Inhibit the flow of contaminated groundwater into the river
- Enhance the effectiveness of other alternatives, such as pump and treat, when used in combination with those alternatives

Vertical barriers act as an obstruction to the groundwater pathway of contaminant migration. The flow of contaminants at N Springs is generally from the 1301-N and 1325-N cribs toward the river. A vertical barrier placed between these contaminant sources and the river may eliminate or substantially restrict the movement of contaminants to the river. A vertical barrier would have to be designed to minimize the tendency for the groundwater to channel around the barrier. To be effective, it is also possible that the vertical barrier might have to be combined with other options such as groundwater pumping.

Three types of vertical barriers will be considered, slurry walls, grout curtains, and freeze walls. These are described in the in the following sections.

4.2.2.1 Description

Slurry walls are the most common form of vertical subsurface barriers. Slurry walls are constructed in the following manner:

- A vertical trench is excavated in an appropriate configuration and depth. The bottom of the trench is keyed into a relatively impermeable confining layer below the contaminated groundwater.
- A slurry is introduced into the trench. Materials such as soil-bentonite and cement-bentonite mixes may be used to construct slurry walls.

This slurry accomplishes the following:

- It provides a relatively impermeable barrier to groundwater movement
- It shores the trench walls to prevent collapse
- It reduces fluid losses into the surrounding soils during excavation through formation of a filter cake on the trench walls.

Factors affecting performance of slurry walls include soil characteristics, contaminant compatibility, wall uniformity, and soil shear strength.

Grout curtains are formed by pressure injection of grout through pipes, augers, or beams that are inserted using crane and hammer or drill rigs. The curtain is developed one "post" at a time along the containment boundary. A secondary line of grout posts may be arranged behind the primary curtain to fill any gaps by the primary curtain. The chief advantage of grout curtained relative to slurry walls is that no soil excavation is required. However, the grout curtain may not be as effective as a slurry wall because of the difficulty in placing a gap-free barrier. It may be difficult to control the flow of grout and prevent gaps, especially in highly porous Hanford soils.

Freeze walls use a refrigerant to convert the interstitial water to ice, bonding together adjacent soil particles and rock, forming a relatively impermeable barrier to groundwater flow. The system is created and maintained by circulating refrigerant through pipes embedded in the soil. Standard drilling techniques are used for installing the pipes.

4.2.2.2 Data Requirements/Variables Definition

Data required for evaluation of vertical barriers includes:

- Vertical extent of contamination
- Depth to the bottom confining layer

- Groundwater chemistry
- Extent and center of mass of the contaminant plume
- Soil characteristics, such as grain size, uniformity, mineralogy, porosity, and permeability.

Variables that need to be defined for slurry walls and grout curtains include:

- Slurry wall configuration and depth
- Slurry composition
- Possible interactions between slurry and soils
- Possible interactions between slurry and groundwater
- Equipment requirements for wall or curtain construction.

Variables to be defined for freeze walls include:

- Freeze pipe spacing, configuration, construction, and installation method
- Refrigerant type and system configuration.

4.2.3 Pump and Treat

The objectives of a pump and treat system at N Springs are:

- Reduce the mass of strontium-90 in the contaminant plume
- Minimize groundwater discharges to the river
- Change the groundwater flow gradients to reduce the continual flushing of the contaminated zone due to river stage fluctuations.

The size of the pump and treat system will depend on the extent to which the plume was contained. That is, a pump and treat system whose principal objective was contaminant mass reduction would be a much smaller system than one whose principal objective was total isolation of the plume from the river. The EE/CA will evaluate these tradeoffs and attempt to define a system that optimizes the costs and benefits of a pump and treat system. The principal elements of the pump and treat system are described in the following sections.

4.2.3.1 Description

A pump and treat system combines the general response actions of removal, treatment, and disposal. Water is removed through extraction wells, treated using technologies specific to the contaminants and site conditions, and appropriately disposed according to applicable regulations and considering residual contaminants. Treatment processes that will be considered include

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ion exchange, reverse osmosis, and chemical precipitation. The three technologies were considered as Best Available Technology (BAT) for this application in WHC (1991). The technologies are briefly described as follows:

Ion exchange--Ion exchange is a well developed technology which has seen broad applicability in wastewater treatment and site remediation for removing a wide range of chemical and radioactive constituents from water. Ion exchange has been used extensively at Hanford for a wide variety of applications in production and waste management operations.

The ion exchange process binds ionic contaminants in exchange for mobile ions of similar charge that are contained on organic resin beads or powders (such as polystyrene) or on inorganic materials (such as zeolites). Both anions (chromate, nitrates) and cations (heavy metals, radionuclides) can be removed from solution by use of an appropriate ion exchange resin. Configurations and combinations of ion exchangers containing either cation or anion resins can operate in parallel or in series to treat specific contaminants. Resins may be regenerated using concentrated salt or acid solutions; this regeneration requires secondary waste treatment to reduce the volume of the residual liquid wastes which require disposal. Resins that are selective for strontium-90 and other radionuclides are available. The technology is applicable to treatment of N Springs groundwater either as a standalone treatment or in combination with pretreatment processes such as reverse osmosis or chemical precipitation.

Reverse osmosis--Reverse osmosis is used to treat low concentrations of inorganic contaminants in water. The technology, which is more commonly used in seawater desalinization and domestic water conditioning, has been applied as both a pretreatment and a primary treatment in wastewater treatment applications.

The process consists of applying high pressure to a concentrated solution thereby forcing solvent (water) through a semipermeable membrane (EPA 1987) that filters contaminants from the waste stream. This separation process removes all suspended solids and most dissolved minerals in the solution (Moghissi et al. 1986). For the N Springs application, reverse osmosis could potentially be used as a standalone treatment or as a pretreatment for ion exchange. Reverse osmosis produces a concentrated waste stream that requires secondary treatment for volume reduction prior to disposal.

Chemical precipitation--Chemical precipitation is a commonly used technology in wastewater treatment and site remediation applications. In chemical precipitation, heavy metals in dissolved ionic form (including radionuclides) are reacted with added chemical reagents to form insoluble precipitates that are subsequently removed by gravity settling and/or filtration. The selection of chemical reagents depends on the specific constituents, constituent concentrations, and effluent quality requirements. Chemical precipitation produces secondary wastes that would require additional treatment prior to disposal.

For all of the technologies listed previously, the composition of the groundwater may require pre-treatment steps to remove solids (e.g., filtration) or dissolved minerals that could potentially affect the primary treatment system. For example, carbonates and sulfates, if present in

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sufficient concentrations, can foul the reverse osmosis membrane and may require removal prior to treatment by reverse osmosis.

Secondary waste treatment systems, such as evaporation and stabilization/solidification may be required for treatment of residual waste streams. Other options for secondary treatment include the use of existing Hanford waste management systems.

Pretreatment and secondary treatment options will be considered in the screening and analysis of alternatives.

4.2.3.2 Disposal Options

Options for treated water disposal include direct discharge to the river or reinjection into the groundwater through injection wells, cribs, or trenches (if contaminant levels are below regulatory standards).

Liquid wastes may need further treatment prior to disposal. Solid wastes would be disposed in Hanford burial grounds, if disposal requirements were met.

4.2.3.3 Data Requirements/Variables Definition

Data required for evaluation of a pump and treat system include:

- Extent and center of contaminant plume
- Contaminant concentrations
- Chemistry of groundwater
- Existing well construction and locations
- Geologic and hydrogeologic data.

Variables that would need to be defined include:

- Extraction well pattern and spacing
- Extraction rates
- Treatment system type, configuration, and capacity
- Disposal options for treated water or residual streams
- Equipment requirements.

4.2.4 Hydraulic Control

The objectives of hydraulic control are to:

- Minimize contaminated groundwater discharges to the river

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- Change the groundwater flow gradients to reduce the continual flushing of the contaminated zone due to river stage fluctuations.
- Enhance the effectiveness of other alternatives, such as pump and treat, when used in combination with those alternatives.

Hydraulic control at N Springs would reduce the discharge of contaminants to the river by providing and maintaining either a net groundwater flow away from the river or a static groundwater system with no net flow in any direction. This alternative would not reduce the level of the contaminants, but would help contain the contaminants while allowing for natural decay of the radionuclides.

4.2.4.1 Description

Groundwater extraction wells or extraction drains/trenches are used to withdraw, and occasionally, isolate contaminated groundwater by manipulation of the hydraulic gradient (RAAS 1991). The extraction system design may include a single well or an extraction drain/trench for the withdrawal or containment of an isolated plume or it may include multiple wells or drains/trenches to control a larger or more dispersed plume. The complexity of the design depends on the nature of the transporting medium, the depth of penetration of the contaminants, and the complexity of the geologic stratigraphy. Some water extracted for hydraulic control might be clean water not requiring treatment. However, any contaminated water extracted would require treatment prior to its disposal.

Injection wells use similar construction but operate in an opposite manner from extraction wells. Extraction drains/trenches include any type of buried conduit, equipped with pumps, or belowgrade trenches used to direct and collect contaminated groundwater by gravity flow (Freeman 1989). Drains and trenches are generally limited to shallow contamination zones but may be applicable under specific circumstances at N Springs. Applicability will be further addressed in the EE/CA.

4.2.4.2 Data Requirements/Variables Definition

Data requirements and variables are generally the same as described for the pump and treat option discussed previously.

4.2.5 Permeable Treatment Beds

The objective of permeable treatment beds is to intercept the flow of contaminated groundwater and remove strontium-90, thus reducing the concentration of this contaminant in the groundwater discharging to the river.

4.2.5.1 Description

A permeable treatment bed is constructed by excavating a trench to a natural confining layer. The trench is then backfilled with a porous treatment media that reacts with or adsorbs the groundwater contaminant(s), in this case strontium-90. An example of treatment media includes a strontium-90 specific ion exchange resin. The permeable treatment bed would be placed downgradient of the contaminant plume and adsorbs the contaminant(s) as the

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groundwater flows through the treatment media. Upon saturation (loading) with contaminant(s), the treatment bed would require excavation, replacement, and disposal of the spent treatment media.

4.2.5.2 Data Requirements/Variables Definition

Data required for evaluation of permeable treatment beds include:

- Extent and center of contaminant plume
- Contaminant concentrations
- Chemistry of groundwater
- Geologic and hydrogeologic data
- Depth of contamination
- Depth to confining layer
- Soil properties.

Variables that need to be defined include:

- Type and quantity of treatment media
- Trench construction methods
- Treatment media configuration and installation methods
- Treatment media replacement requirements and methods
- Treatment media disposal requirements.

4.2.6 Combinations of Alternatives

The possible benefits of combining the options described previously will be addressed. For example, a pump and treat system combined with a vertical barrier may provide more protection and better control of contaminant migration. The use of a vertical barrier might also substantially reduce the quantity of water requiring extraction, thus resulting in a smaller pump and treat system and less secondary waste generation. Alternative combinations would be screened using the process described previously and in the EPA guidance document (EPA 1987). Combinations for consideration include:

- Pump and treat combined with vertical barriers
- Pump and treat combined with hydraulic control
- Pump and treat combined with additional treatment technologies to address specific groundwater quality conditions
- Vertical barriers combined with hydraulic control.

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5.0 SCHEDULE

The attached schedule (Figure 5-1) was developed with the anticipated ERA proposal preparation start date of October 1, 1992, and the Tri-Party Agreement commitment that ERA implementation will begin during fiscal year 1994. Key schedule controlling tasks for the ERA proposal and implementation are the required regulatory review cycles and the construction contractor and equipment procurement cycle.

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Figure 5-1. N Springs ERA Proposed Schedule.

Task Name	Duration (Days)	1992			1993												1994					
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
ERA PROPOSAL	295	[Solid bar from Oct 1992 to Jun 1993]																				
ERA PROPOSAL PREPARATION	160	[Solid bar from Oct 1992 to Feb 1993]																				
EPA/ECOLOGICAL REVIEW	45	[Solid bar from Mar 1993 to May 1993]																				
INCORPORATE COMMENTS	50	[Solid bar from Apr 1993 to May 1993]																				
ERA PROPOSAL APPROVAL	0	[Triangle marker in May 1993]																				
PUBLIC COMMENT	50	[Solid bar from May 1993 to Jun 1993]																				
INCORPORATE COMMENTS	50	[Solid bar from Jun 1993 to Jul 1993]																				
ERA TPA ACTION MEMORANDUM	0	[Triangle marker in Jul 1993]																				
ERA DESIGN	330	[Solid bar from May 1993 to Jun 1994]																				
ADDITIONAL DATA COLLECTION	21	[Solid bar from May 1993 to Jun 1993]																				
TREATMENT TESTING	45	[Solid bar from May 1993 to Jun 1993]																				
MODELING/ANALYSIS	60	[Solid bar from May 1993 to Jun 1993]																				
SYSTEM DESIGN	150	[Solid bar from May 1993 to Sep 1993]																				
CONSTRUCT. CONTRACTOR PROCUREMENT	270	[Solid bar from Aug 1993 to Jun 1994]																				
ERA CONSTRUCT/IMPLEMENTATION	60	[Solid bar from May 1994 to Jun 1994]																				
EQUIPMENT PROCUREMENT	60	[Solid bar from May 1994 to Jun 1994]																				
FIELD INSTALLATION (1)	0	[Triangle marker in Jun 1994]																				
SHUTDOWN/STARTUP (1)	0	[Triangle marker in Jun 1994]																				
SYSTEM OPERATION/ASSESSMENT(2)	0	[Triangle marker in Jun 1994]																				

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1 Durations are unknown, but will be defined in the ERA Proposal.
 2 Dates and durations are unknown, but will be defined in the ERA Proposal.


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Date Received: 9/23/92		INFORMATION RELEASE REQUEST		Reference: WHC-CN-3-4	
Complete for all Types of Release					
Purpose			ID Number (include revision, volume, etc.) WHC-SD-EN-TPP-002, Rev. 0		
<input type="checkbox"/> Speech or Presentation <input type="checkbox"/> Full Paper (Check only one suffix) <input type="checkbox"/> Summary <input type="checkbox"/> Abstract <input type="checkbox"/> Visual Aid <input type="checkbox"/> Speakers Bureau <input type="checkbox"/> Poster Session <input type="checkbox"/> Videotape			<input checked="" type="checkbox"/> Reference <input checked="" type="checkbox"/> Technical Report <input type="checkbox"/> Thesis or Dissertation <input type="checkbox"/> Manual <input type="checkbox"/> Brochure/Flier <input type="checkbox"/> Software/Databases <input type="checkbox"/> Controlled Document <input type="checkbox"/> Other		
			List attachments.		
			Date Release Required 9/25/92		
Title N Springs Expedited Response Action Project Plan			Unclassified Category UC-		Impact Level 4
New or novel (patentable) subject matter? <input checked="" type="checkbox"/> No <input type="checkbox"/> Yes If "Yes", has disclosure been submitted by WHC or other company? <input type="checkbox"/> No <input type="checkbox"/> Yes (Disclose No(s)).			Information received from others in confidence, such as proprietary data, trade secrets, and/or inventions? <input checked="" type="checkbox"/> No <input type="checkbox"/> Yes (Identify)		
Copyrights? <input checked="" type="checkbox"/> No <input type="checkbox"/> Yes If "Yes", has written permission been granted? <input type="checkbox"/> No <input type="checkbox"/> Yes (Attach Permission)			Trademarks? <input checked="" type="checkbox"/> No <input type="checkbox"/> Yes (Identify)		
Complete for Speech or Presentation					
Title of Conference or Meeting NA			Group or Society Sponsoring NA		
Date(s) of Conference or Meeting NA		City/State NA		Will proceedings be published? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
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Classification/Unclassified Controlled Nuclear Information	<input type="checkbox"/>	<input checked="" type="checkbox"/>			
Patent - General Counsel	<input checked="" type="checkbox"/>	<input type="checkbox"/>	SW BERGIN	<i>Sw Berlin</i>	9/23/92
Legal - General Counsel	<input checked="" type="checkbox"/>	<input type="checkbox"/>	BD Williamson	<i>BD Williamson</i>	9/24/92
Applied Technology/Export Controlled Information or International Program	<input type="checkbox"/>	<input checked="" type="checkbox"/>			
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Other Program/Project	<input type="checkbox"/>	<input checked="" type="checkbox"/>			
Information conforms to all applicable requirements. The above information is certified to be correct.					
References Available to Intended Audience <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No			INFORMATION RELEASE ADMINISTRATION APPROVAL STAMP		
Transmit to DOE-HQ/Office of Scientific and Technical Information <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No			Stamp is required before release. Release is contingent upon resolution of mandatory comments.		
Author/Requestor (Printed/Signature) F.W. Gustafson <i>[Signature]</i> Date 9/23/92					
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Responsible Manager (Printed/Signature) G.C. Henckel <i>[Signature]</i> Date 9/23/92			Date Cancelled		
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Project Title/Work Order:

N-Springs Expedited Response Action Project Plan

EDT No.: 159748

ECN No.:

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M.R. Adams	H4-55	X		
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R.G. Bauer	H4-55	X		
T.L. Bennington	H4-16	X		
T.A. Demitruk	A3-11	X		
J.J. Dorian	B2-16	X		
J.G. Field	G2-02	X		
K.A. Gano	X0-21	X		
E.G. Hess	R3-09	X		
D.O. Hess	L6-57	X		
B.J. Hobbs	N3-06	X		
A.L. Langstaff	H4-55	X		
M.J. Lauterbach	H4-55	X		
F.V. Roeck	H4-55	X		
A.R. Schade	B1-35	X		
F.A. Schmorde	L6-57	X		
M.V. Shultz	H0-31	X		
W.E. Taylor	N1-75	X		
M.D. Zentner	H0-31	X		
J.J. Zimmer	N1-83	X		
Central Files(2)	L8-04	X		
EDMC (2)	H4-22	X		

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