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Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

MAR 17 1997

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Mr. Dan Haas
National Park Service
Columbia Cascades Systems Support Office
909 First Avenue
Seattle, Washington 98104-1060

Dear Mr. Haas:

REQUEST FOR REVIEW OF PLANNED ACTIVITIES WITHIN ONE QUARTER MILE OF THE COLUMBIA RIVER

This letter is to request National Park Service review of activities planned at the D-Area, within the 100-HR-3 Operable Unit (OU), located on the Hanford Site. Public Law 100-605, Study of the Hanford Reach of the Columbia River, requires coordination with the Nation Park Service to locate any facilities within 1/4 mile of the Columbia River.

Enclosed is a copy of the Record of Decision (ROD), for the 100-HR-3 and 100-KR-4 OUs specifying pump-and treat as the interim action to remove chromium from the groundwater discharging into the Columbia River. This document was transmitted to your office with a letter, dated June 13, 1996, requesting your concurrence on the planned interim action activities. A letter from your office dated July 8, 1996, concurred with the proposed activities.

Because this is an interim ROD, the U.S. Department of Energy has agreed to continue to develop and implement final remedial alternatives for these OUs. One of the remedial action objectives stated in the interim ROD, is to evaluate the effectiveness of other technologies regarding contaminant removal from the aquifer. To accomplish this objective, a treatability test of the In Situ Redox Manipulation (ISRM) technology is planned for the 100-D Area.

Enclosed for your review is the draft version of the Treatability Test Plan for ISRM in the 100-HR-3 OU D-Area. Also enclosed is a concurrence signature page.

If you have any questions please contact me at (509) 373-9631.

Sincerely,

Arlene C. Tortoso

Arlene C. Tortoso, Project Manager
Groundwater Projects

GWP:ACT

Enclosures

cc w/o encls:
R. H. Engelman, RFS
J. S. Fruchter, PNNL
A. J. Knepp, BHI
M. D. McKinney, PNNL

HANFORD REACH REVIEW

I have reviewed the proposed action for the 100 D-Area In Situ Redox Manipulation treatability test as required under Section 2.(a) (4) of the Public Law 100-605, "Study of the Hanford Reach of the Columbia River." I have determined that the proposed action will not have a "direct and adverse effect on the values for which the river segment is under study."

Signature: _____ Date _____

Dan Haas
National Park Service
Columbia Cascades System Support Office

DECLARATION OF THE RECORD OF DECISION

SITE NAME AND LOCATION

USDOE Hanford 100 Area
100-HR-3 and 100-KR-4 Operable Units
Hanford Site
Benton County, Washington

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected interim remedial actions for portions of the USDOE Hanford 100 Area, Hanford Site, Benton County, Washington, which were chosen in accordance with the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), as amended by the *Superfund Amendments and Reauthorization Act of 1986* (SARA), and to the extent practicable, the *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP). This decision is based on the administrative record for this site.

The Washington State Department of Ecology (Ecology) concurs on the selected remedy.

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this Record of Decision (ROD), may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE SELECTED REMEDY

The selected remedy is an interim action that involves removing hexavalent chromium from groundwater that discharges into the Columbia River. To intercept the chromium plumes, groundwater will be pumped from approximately 30 wells located along and inland from the river shoreline. The water will then be treated using an ion exchange treatment technology to remove chromium. The treated effluent will then be returned to the aquifer using injection wells located upgradient of the existing chromium plumes. The interim action includes monitoring of the groundwater near the river and the effluent from the treatment system to determine system performance in meeting the remedial action objectives for protection of the Columbia River. The interim action also involves institutional controls to protect human health from groundwater contaminants.

DECLARATION

This interim action is protective of human health and the environment, complies with Federal and State applicable or relevant and appropriate requirements directly associated with this

action, and is cost-effective. This action utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable, given the limited scope of the action. This remedial action complies with the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume of contaminants as a principal element. Subsequent actions are planned to fully address the threats posed by these operable units.

Because this remedy will result in hazardous substances remaining on-site above health-based levels, a review will be conducted within five years after commencement of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment. Because this is an interim action Record of Decision (ROD), review of these operable units and the remedy will be ongoing as the Tri-Parties continue to develop and implement final remedial alternatives for the operable units and the 100 Area National Priority List (NPL) site.

Signature sheet for the Record of Decision for the USDOE Hanford 100-HR-3 and 100-KR-4 Operable Units Interim Remedial Actions between the United States Department of Energy and the United States Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

John D. Wagoner 4/1/96

John D. Wagoner
Manager, Richland Operations
United States Department of Energy

Date

Signature sheet for the Record of Decision for the USDOE Hanford 100-HR-3 and 100-KR-4 Operable Units Interim Remedial Actions between the United States Department of Energy and the United States Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

Chuck Clarke — 3/26/96

Chuck Clarke
Regional Administrator, Region 10
United States Environmental Protection Agency

Date

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Signature sheet for the Record of Decision for the USDOE Hanford 100-HR-3 and 100-KR-4 Operable Units Interim Remedial Actions between the United States Department of Energy and the United States Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

Michael A. Wilson 3/25/96

Michael Wilson Date
Program Manager, Nuclear and Mixed Waste Program
Washington State Department of Ecology

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DECISION SUMMARY

I. SITE NAME, LOCATION, AND DESCRIPTION

The U.S. Department of Energy's Hanford Site was listed on the National Priorities List (NPL) in November 1989 under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) as amended by the *Superfund Amendments and Reauthorization Act of 1986* (SARA). The Hanford Site was divided and listed as four NPL Sites: the 100 Area, the 200 Area, the 300 Area, and the 1100 Area.

The Hanford Site is a 560-square mile Federal facility located in southeastern Washington along the Columbia River. The region includes the incorporated cities of Richland, Pasco, and Kennewick (Tri-Cities) and surrounding communities in Benton, Franklin, and Grant counties (figure 1). The Hanford Site was established during World War II as part of the "Manhattan Project" to produce plutonium for nuclear weapons. Hanford Site operations began in 1943.

The 100 Area, which encompasses approximately 68 km^2 (26 mi^2) bordering the south shore of the Columbia River, is the site of nine retired plutonium production reactors. The groundwater impacted by operations associated with those 9 reactors has been divided into five operable units. Two of the five groundwater operable units are addressed in this Record of Decision.

Pre-1943 land use at Hanford was primarily grazing and agriculture with some traditional use by Native Americans. Historically groundwater use included domestic consumption, as well as other needs for the small agricultural communities, and by Native Americans. Currently groundwater is not used but is monitored to assess contaminant conditions. Existing land use in the 100 Area includes facilities support, waste management, and undeveloped land. Facilities support activities include operations such as water treatment and maintenance of the reactor buildings. The waste management land use designation results from former uncontrolled disposal activities in areas now known as "past-practice waste sites" located throughout the 100 Area. Lastly, there are undeveloped lands located throughout the 100 Area that comprise approximately 90 percent of the land area within the 100 Area. These areas are the least disturbed and contain minimal infrastructure.

The Hanford Reach of the Columbia River is the last free-flowing portion of the Columbia River in the United States above Bonneville Dam. The river contains the only remaining spawning habitat for native salmon on the main stem of the Columbia River in the United States. The river and associated riparian and upland areas are valued ecological and recreational resources. The Hanford Reach along the 100-HR-3 and 100-KR-4 Operable Units is currently being used for activities such as hunting, fishing, and water skiing. The Hanford Reach of the Columbia River: Comprehensive River Conservation Study and Environmental Impact Statement has identified much of Hanford Reach, including the 100 Area, for consideration as a designated recreational river under the *Wild and Scenic Rivers Act*.

II. SITE HISTORY AND ENFORCEMENT ACTIVITIES

In anticipation of the NPL listing, DOE, EPA, and Ecology entered into a Federal Facility Agreement and Consent Order in May 1989 known as the Tri-Party Agreement. This agreement established a procedural framework and schedule for developing, implementing, and monitoring remedial response actions at Hanford. The agreement also addresses *Resource Conservation and Recovery Act* (RCRA) compliance and permitting.

In 1988, the Hanford Site was scored using EPA's Hazard Ranking System. As a result of the scoring, the Hanford Site was added to the NPL in November 1989 as four sites (the 100 Area, the 200 Area, the 300 Area, and the 1100 Area). Each of these areas was further divided into operable units (a grouping of individual waste units based primarily on geographic area and common waste sources). The 100 Area NPL site consists of the following operable units for contaminated sources such as soils, structures, debris, and burial grounds: 100-BC-1, 100-BC-2, 100-KR-1, 100-KR-2, 100-NR-1, 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, 100-FR-1, 100-FR-2, 100-IU-1, 2, 3, 4, 5, and 6; and for contaminated groundwater: 100-BC-5, 100-KR-4, 100-NR-2, 100-HR-3, and 100-FR-3. This ROD addresses the chromium contaminated plumes in the 100-HR-3 and 100-KR-4 Operable Units.

The 100-HR-3 Operable Unit is located in the north-central part of the Hanford Site along the Columbia River. This operable unit includes the groundwater underlying the 100-D/DR and 100-H Reactor Areas and a portion of the 600 Area (figure 2). The 100-D/DR Area is the site of two deactivated reactors: the 100-D Reactor, which operated from 1944 to 1967, and the 100-DR Reactor, which operated from 1950 to 1965. The 100-H reactor operated from 1949 to 1965.

The 100-KR-4 Operable Unit is also located in the north-central part of the Hanford Site, upriver of 100-HR-3. The 100-KR-4 Operable Unit includes the groundwater underlying the 100-KR-1 and 100-KR-2 Operable Units (figure 3). The 100-K Area is the site of two deactivated reactors: the 100-K East Reactor, which operated from 1955 to 1971, and the 100-K West Reactor, which operated from 1955 to 1970.

During the years of reactor operations, large volumes of reactor coolant water containing chromium and radionuclides were discharged to retention basins for ultimate disposal in the Columbia River through outfall pipelines. Liquid wastes, containing significant quantities of chromium from reactor operations, were also discharged to the soil column at cribs, trenches, and french drains. Contaminant plumes in groundwater resulted from these former waste disposal practices. Groundwater contaminated with chromium is present beneath the 100-D/DR, 100-H, and 100-K Reactor areas and is migrating toward, and discharging into, the Columbia River. The groundwater upwells into the river through the riverbed with minor contributions from riverbank seepage.

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Figure 1. Hanford Site.

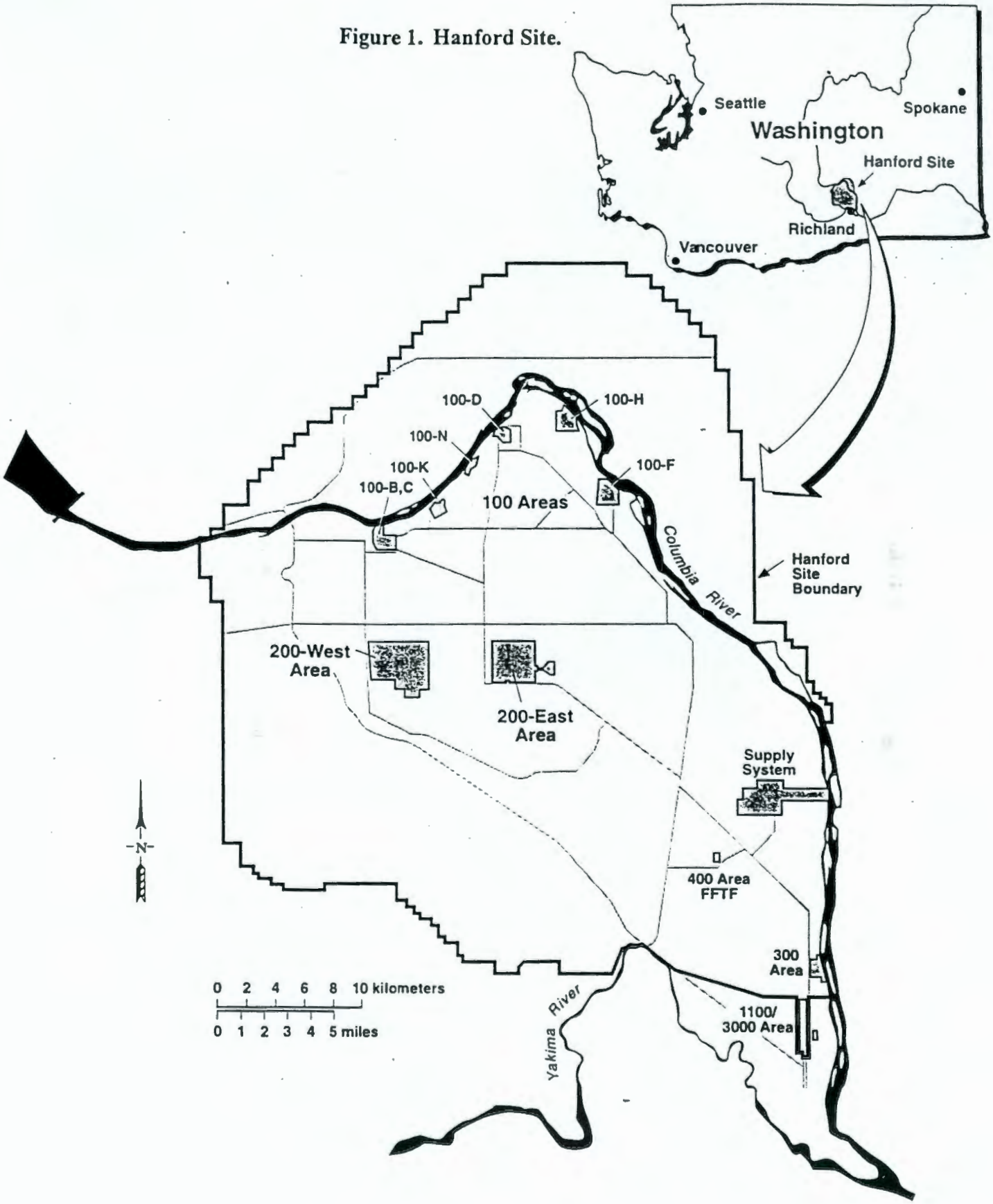

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Figure 2. 100-HR-3 Operable Unit.

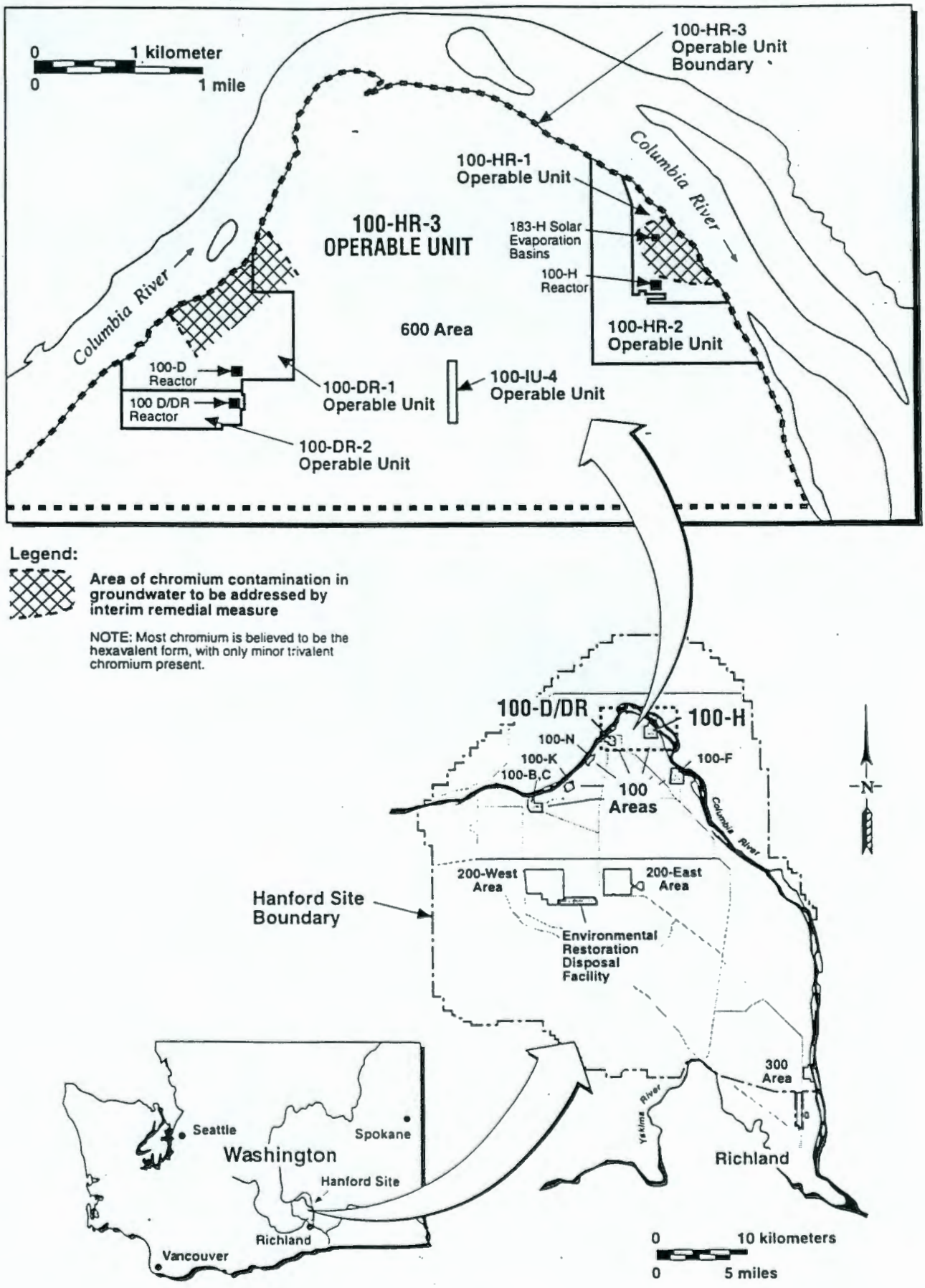

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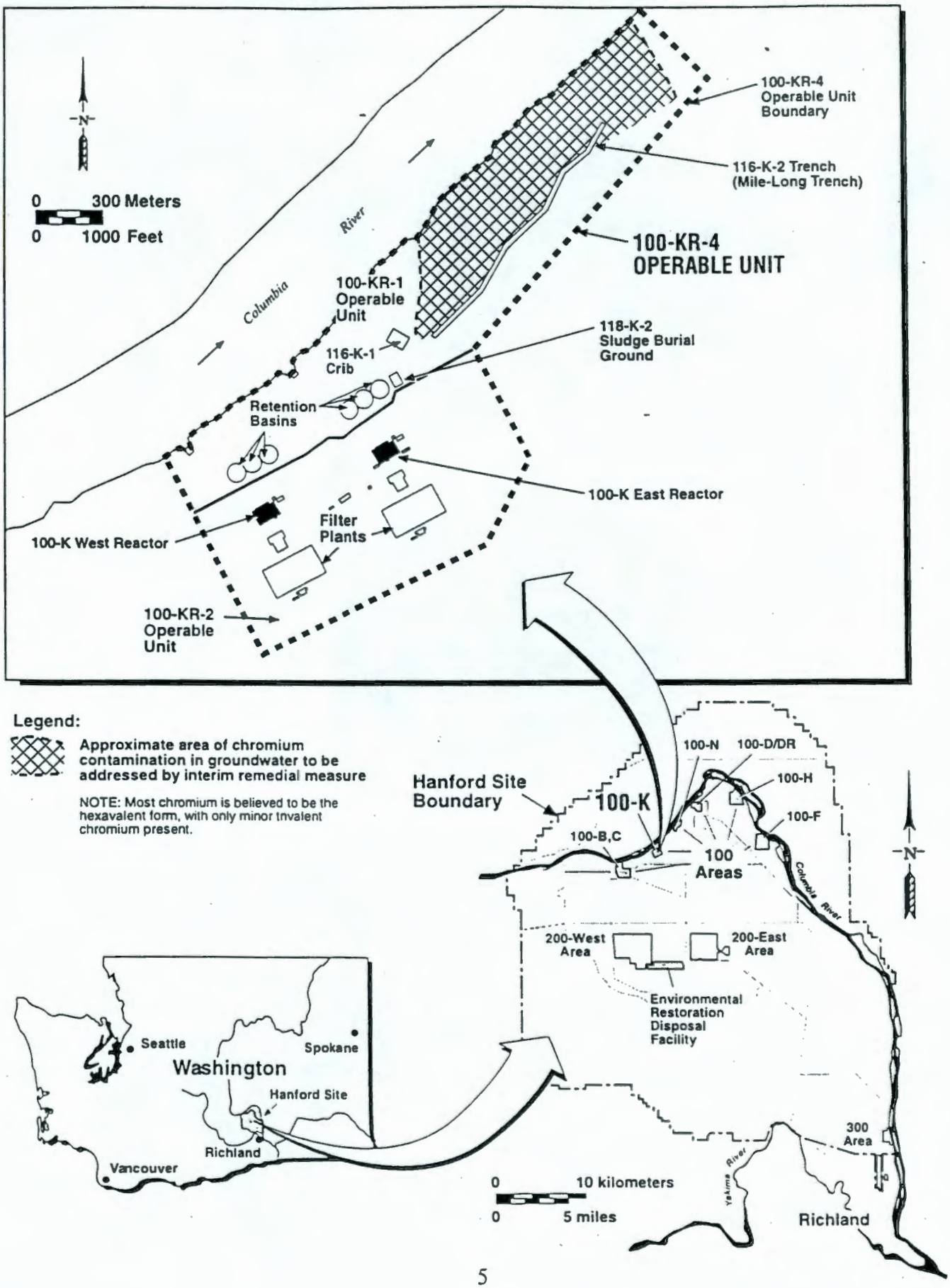
Figure 3. 100-KR-4 Operable Unit.



Prior to starting the "Limited Field Investigation" in 1992 in the 100-KR-4 and 100-HR-3 Operable Units, groundwater monitoring consisted of periodic sampling under programs set up by DOE Order 5400.1. These include the Operational Monitoring program conducted by the Maintenance and Operations contractor for the Site, and the Sitewide Environmental Surveillance program, which is conducted by Pacific Northwest National Laboratory. A limited record exists for groundwater conditions during the reactor operating years. Riverbank seepage monitoring was completed in 1984 and 1988 as part of the Sitewide Environmental Surveillance program. The following three paragraphs identify reactor-area specific activities that add to the data available from these sitewide programs.

At the 100-K Area, groundwater sampling was associated with operations at the 100-K East and 100-K West fuel storage basins. Some post-1959 data from several wells are available to describe conditions downgradient of the 116-K-2 trench used for liquid effluent disposal that included chromium.

For the 100-D/DR reactor area (100-HR-3 Operable Unit), historical data describing conditions during reactor operations are limited to several wells that were constructed in 1960. Quarterly sampling was started in 1991 under the RCRA/Operational program for monitoring liquid effluent discharge to 100-D Ponds. An infiltration experiment was conducted in 1967 that created a groundwater mound in the vicinity of the coolant water retention basins. The results may provide an analog for the unmonitored conditions that prevailed during reactor operating years.

A similar database exists for the 100-H Area (100-HR-3 Operable Unit). Monitoring of the 183-H Solar Evaporation Basins facility occurred between 1973 and 1985, when monitoring was substantially increased under the RCRA/Operational program. A comprehensive database exists to describe the contaminant plume, which includes chromium, associated with the 183-H facility for years after 1985.

The technical information baseline for the RI/FS associated with each operable unit was augmented substantially in 1992 with the installation of new monitoring wells and subsequent quarterly sampling as part of the limited field investigation. A comprehensive riverbank seepage sampling project was completed in late 1991, which helped relate contamination along the shoreline to groundwater contamination underlying the reactor areas. RI/FS characterization activities that followed the four quarters of sampling conducted during the limited field investigation consist of semiannual well sampling, annual riverbank seepage sampling, and periodic Columbia River substrate sampling. Water table elevations were measured at periodic intervals to show the seasonal ranges in flow direction and gradients.

As a result of the discharge of groundwater from the operable units into the river, chromium, a metal that is toxic to aquatic organisms in low concentrations, poses a risk to aquatic organisms in the Columbia River adjacent to the 100-D/DR, 100-H, and 100-K Areas. The most toxic form of chromium, hexavalent chromium, readily dissolves in water and, therefore, moves freely with groundwater. Hexavalent chromium has been detected in groundwater and in the groundwater/river interface where groundwater upwells into the river. Once discharged

to the river, it is easily assimilated by aquatic organisms, some of which are adversely affected. Trivalent chromium is less soluble and less toxic, and is not easily transported by groundwater. Most chromium in groundwater at the Hanford Site is hexavalent chromium, because of the original sources and prevailing geochemical conditions.

In August 1994, a pilot-scale treatability test began at the 100-D/DR Area, to assess the effectiveness of an ion exchange treatment system to remove hexavalent chromium from groundwater. Through July 1995, this pump-and-treat system has extracted more than 4 million gallons (15 million liters) of groundwater and has removed more than 38 pounds (17 kilograms) of chromium. This system is successful in removing chromium from extracted groundwater at 100-D/DR, and indicates that an ion exchange treatment system can be a successful groundwater treatment technology for chromium in the 100 Area.

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III. HIGHLIGHTS OF COMMUNITY PARTICIPATION

The DOE, Ecology, and EPA developed a Community Relations Plan in April 1990 as part of the overall Hanford Site restoration. The Plan was designed to promote public awareness of the investigations and public involvement in the decision-making process. The Plan summarizes known concerns based on community interviews. Since that time several public meetings have been held and numerous fact sheets have been distributed in an effort to keep the public informed about Hanford cleanup issues. The Plan was updated in 1993 to enhance public involvement and is currently undergoing an additional update.

The 100 Area Focused Feasibility Study Document and Proposed Plans for 100-HR-3 and 100-KR-4 were made available to the public in both the Administrative Record and the Information Repositories maintained at the locations listed below. These documents underwent a 45 day public comment period from September 11, 1995 to October 25, 1995.

ADMINISTRATIVE RECORD (Contains all project documents)

U.S. Department of Energy
Richland Field Office
Administrative Record Center
740 Stevens Center
Richland, Washington 99352

EPA Region 10
Superfund Record Center
1200 Sixth Avenue
Park Place Building, 7th Floor
Seattle, Washington 98101

Washington State Department of Ecology
Administrative Record
300 Desmond Drive
Lacey, Washington 98503-1138

INFORMATION REPOSITORIES (Contain limited documentation)

University of Washington
Suzzallo Library
Government Publications Room
Mail Stop FM-25
Seattle, Washington 98195

Gonzaga University
Foley Center
E. 502 Boone
Spokane, Washington 99258

Portland State University
Branford Price Millar Library
Science and Engineering Floor
SW Harrison and Park
P.O. Box 1151
Portland, Oregon 97207

DOE Richland Public Reading Room
Washington State University, Tri-Cities
100 Sprout Road, Room 130
Richland, Washington 99352

Notice of the public comment period and availability of documents for review was published in the Seattle PI/Times, the Spokesman Review-Chronicle, the Tri-City Herald, and the Oregonian on September 10 and 11, 1995. The notice also ran throughout the week of September 10 in the various papers published by the Hood River News. In addition a 2-page focus sheet that summarized the Proposed Plans was mailed to an "interested in Hanford" mailing list of about 4,700. That mailing list included the members of the Hanford Advisory Board (a citizen / stakeholder cleanup advisory board), Native American Tribes with reserved treaty rights to Hanford-related resources, and Natural Resource Trustees. The Proposed Plans were faxed to participants in the Hanford Natural Resource Trustee Council (which includes the Tribes) on August 21-22, 1995. Focus sheets and Proposed Plans were mailed to a number of individuals in response to requests during the comment period. The Proposed Plans and focus sheet identified that a public meeting would be held upon request. Such a request was received from the Columbia River United citizen stakeholder group located in Hood River, Oregon. Per their request, a meeting was held October 18, 1995 that discussed the proposed actions relative to other Hanford groundwater and Columbia River issues. At the meeting, representatives from DOE, EPA and Ecology provided information about this and related projects and answered questions about the projects. A response to the comments received during the public comment period is included in the Responsiveness Summary, which is attached as Appendix A to this ROD. This decision document presents the selected interim remedial action for the groundwater at the 100-HR-3 and 100-KR-4 Operable Units at the Hanford Site in Richland, Washington. The selected interim remedy is chosen in accordance with CERCLA, as amended by SARA, and to the extent practicable, the National Contingency Plan (NCP). The decision for these operable units is based on the Administrative Record.

IV. SCOPE AND ROLE OF RESPONSE ACTION WITHIN SITE STRATEGY

The interim action is expected to provide adequate protection of human health and ecological receptors in the Columbia River and will continue until implementation of the final remedy for the 100-HR-3 and 100-KR-4 groundwater operable units, or until such time that the DOE demonstrates to Ecology and the EPA that no further interim action is required. This interim action is expected to become part of the final remedial action for the 100-HR-3 and 100-KR-4 Operable Units. As with the remedy selection for interim action, final remedy selection will occur only after taking public comment into consideration.

In addition to this action for the 100-HR-3 and 100-KR-4 Operable Units, plans are underway to address waste sites that are the historic sources of groundwater contamination. Surface waste sites that are within operable units 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, 100-KR-1 and 100-KR-2 received wastes during previous operation of the reactors and their support facilities. Cleanup of high priority liquid effluent waste sites in the 100-DR-1 and 100-HR-1 Operable Units were addressed in a September 1995 interim action Record of Decision. The 100-DR-2, 100-HR-2, 100-KR-1 and 100-KR-2 Operable Units will be the subject of future response actions. The 100-IU-4 Operable Unit upgradient of 100-HR-3 includes the former Sodium Dichromate Barrel Landfill, which was previously used to dispose of empty crushed barrels. The 100-IU-4 Operable Unit was remediated in April 1992 through an Expedited Response Action and a no further action final ROD was signed in February 1996.

Because this is an interim action ROD, review of these operable units and the remedy will be ongoing as the Tri-Parties continue to develop and implement final remedial alternatives for the operable units and the 100 Area NPL site. Because this remedy will result in hazardous substances remaining on-site above health-based levels, a review will be conducted within five years after commencement of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

V. SUMMARY OF SITE CHARACTERISTICS

5.1 Site Geology and Hydrogeology

The Hanford Site is located in the Pasco Basin, a topographic and structural basin situated in the northern portion of the Columbia Plateau. The plateau is divided into three general structural subprovinces: the Blue Mountains; the Palouse; and, the Yakima Fold Belt. The Hanford Site is located in the eastern portion of the Yakima Fold Belt.

5.1.1 Geology

The 100 Area is located in the northern portion of the Hanford Site, adjacent to the Columbia River. The geology of the 100 Area is similar to much of the rest of the Hanford Site, which generally consists of three distinct geologic formations. The oldest and deepest formation consists of a thick series of basalt flows and interbeds that have been warped and folded. The top of the basalt in the 100 Area ranges in elevation from 46 m (150 ft) near the 100 H Area to 64 m (210 ft) below sea level west of the 100 K Area. The Ringold Formation overlies the Columbia River Basalts and is up to 185 m (about 600 ft) thick in the Pasco basin. The Ringold Formation is made up of sedimentary deposits which consist of interbedded clay, silt, fine to coarse sand, and gravel. The uppermost formation is referred to as the Hanford Formation. It consists of sand and gravel deposited by catastrophic floods during the last glacial episode. In the 100 Area, the Hanford Formation consists primarily of the Pasco Gravel Facies, with local occurrences of the sand-dominated or slackwater deposits.

The 100 K Area differs geologically from the surrounding area because the Ringold Formation is exposed along the bank of the Columbia River and up to 366 m (1200 ft) inland. Coyote Rapids, immediately upstream of the 100 K Area consists of cemented Ringold material. The contact between the Hanford Formation and the Ringold Formation is generally noted by an iron staining and an increase in cementation. The Hanford Formation underlying the 100 K Area is a wedge that increases in thickness away from the Columbia River. It varies in thickness from 0 to about 37 m (120 ft) near the southwest corner of the K Area. The Hanford Formation in the vicinity of the 100 K Area consists mainly of gravels.

Underlying the 100 H & D Areas, a lacustrine mud unit up to 30 m (100 ft) thick forms the base of the Ringold Formation. Overlying the mud unit, fluvial sands and gravels interbedded with overbank and lacustrine sediments comprise the remaining Ringold Formation. The Ringold/Hanford contact is highest west of the 100 H Area and slopes toward the Columbia River to the east. The Hanford Formation thickness ranges from near 0 to 24 m (80 ft). The unit is thickest in the west central portion of the 100 HR-3 Operable Unit. In this area the Hanford Formation consists of unconsolidated gravels in a matrix of fine to coarse sand.

5.1.2 Hydrogeology

Underlying the 100 Area the uppermost aquifer is referred to as the unconfined aquifer. This aquifer is open to the vadose zone and is hydraulically connected to the Columbia River. Below the unconfined aquifer there exists multiple confined aquifers. The confined aquifers to date have received very little contamination due to an upward hydraulic gradient.

The unconfined aquifer system underlying the 100 K and D Areas is comprised exclusively of Ringold Formation fluvial sand and gravel. Groundwater flow direction is north-northwest towards the Columbia River. The mean hydraulic conductivity of the Ringold Formation is about 32 ft/day. Groundwater elevation across the K Area ranges from about elev. 382 to elev. 392 ft. Across the D Area groundwater elevation ranges from about elev. 381 to elev. 386 ft. In the 100 H Area the unconfined aquifer occurs predominantly in the Hanford Formation. Groundwater elevation ranges from about elev. 374 to elev. 377 ft. The saturated portion of the Hanford Formation is about 13 to 24 ft thick across this area. Flow direction is northeast towards the Columbia River. The mean hydraulic conductivity for the H Area is about 100 ft/day.

5.2 Columbia River Water Quality

Surface water at the 100 Areas of the Hanford Site is limited to the Columbia River and springs along the riverbank. The Columbia River is the second largest river in North America and the dominant surface-water body on the Hanford Site. The existence of the Hanford Site has precluded development of this section of river for irrigation and power, and the Hanford Reach (the free flowing section of the Columbia River beginning at Priest Rapids Dam and ending at Lake Wallula) is now being considered for designation as a National Wild and Scenic River as a result of congressional action in 1988 (*Public law 100-605*).

Washington State has classified the stretch of the Columbia River from Grand Coulee to the Washington-Oregon border, which includes the Hanford Reach, as Class A, Excellent. Class A waters are to be suitable for essentially all uses, including raw drinking water, recreation, and wildlife habitat.

The seepage of groundwater, or springs, into the Columbia River has been known to occur for many years. These relatively small springs flow intermittently, apparently influenced primarily by changes in river level. Hanford-origin contaminants have been documented in these groundwater discharges along the Hanford Reach.

5.3 Groundwater System

Groundwater in the unconfined aquifer at the Hanford Site generally flows from recharge areas in the elevated region near the western boundary of the Hanford Site toward the Columbia River on the eastern and northern boundaries. The Columbia River is the primary discharge area for the unconfined aquifer. Natural areal recharge from precipitation across the entire Hanford Site is thought to range from almost 0 to 10 cm (0 to 4 in.) per year, but is probably less than 2.5 cm (1 in.) per year. Since 1944, the artificial recharge from Hanford Site wastewater disposal operations has been significantly greater than the natural recharge. An estimated 1.68×10^{12} L (4.4×10^{11} gallons) of liquid was discharged to disposal ponds, trenches, and cribs. Now that liquid discharges from reactor processes has stopped, groundwater flow has since returned to its pre-Hanford flow direction and gradient in the 100-HR-3 and 100-KR-4 Operable Units.

5.4 Groundwater Data Summary

The primary purpose of the limited field investigation at the Operable Units was to collect sufficient data to determine if the groundwater is contaminated to the extent that an interim remedial action was warranted. The limited field investigation was designed to augment existing historical groundwater data mentioned in Section II. The data gathered during the limited field investigation were also used to conduct a qualitative risk assessment for human and ecological receptors, and to evaluate remedial alternatives.

As part of the limited field investigation, 22 new groundwater wells were installed (in addition to the existing 42 wells) in the 100-HR-3 Operable Unit and 7 new groundwater wells were installed (in addition to the existing 12 wells) in the 100-KR-4 Operable Unit. These wells were constructed to help define groundwater quality in areas downgradient of the priority waste sites in the area that are sources of the contaminants, and estimate groundwater quality at locations where human and ecological receptors may be exposed to groundwater.

Groundwater samples were collected from these new wells and existing monitoring wells (100-HR-3, figure 4; 100-KR-4, figure 5). A total of 262 samples from 100-HR-3 and 82 samples from 100-KR-4, exclusive of duplicates and splits, were collected over four rounds of sampling (September 1992 to June 1993 for 100-KR-4, and May 1992 to March 1993 for 100-HR-3). These samples were analyzed for organic, inorganic, and radioactive constituents. Soil samples were collected during well-drilling activities and analyzed for physical properties. Tables 1 through 3 (100-HR-3), and table 4 (100-KR-4) present the maximum concentrations of radiological and nonradiological chemicals in groundwater, in springs and seeps, and in the Columbia River within and adjacent to these areas. These maximum concentrations were used to evaluate risks to receptors. Data from near-river wells were used to evaluate ecological risk, and data from all wells were used to evaluate human health risk.

During March of 1995 pore water samples were collected in the river substrate adjacent to the 100-H Area. Results indicated that chromium is present in the river substrate at levels of concern. Similar data are being collected at other reactor areas. Additionally, sampling points are being successfully installed along the shoreline to evaluate the river-groundwater interface. These new data will support the Remedial Design Report/Remedial Action Work Plan (RDR/RAWP).

5.5 Ecological Description

An 18 mile stretch of the Columbia River is located within the 100 Area. The Columbia River corridor is a valued ecological area within the Hanford Site. Semi-arid land with a sparse covering of cold desert shrubs and drought-resistant grasses dominates the Hanford landscape. Forty percent of the area's annual average of six and one quarter inches of rain occurs between November and January. Numerous ecological studies have characterized the biological resources of the Hanford Site, including the terrestrial, riparian, and aquatic habitats.

Because this interim action involves activities located on upland habitat, adjacent to riparian and aquatic areas, and affects the chemical and hydrological regime in the near-river environment, the potential list of species that could be affected includes potentially all species associated with the Hanford site, both resident and migratory. Table 5 lists species of concern found or potentially occurring on the Hanford Site, and table 6 lists known fish species in the Hanford Reach of the Columbia River. Portions of the 100-HR-3 and 100-KR-4 lie within the 100-year flood plain (figure 6). There is a band of wetland habitat adjacent to the Columbia River that varies from very thin in 100-KR-4 to very wide in portions of 100-HR-3.

5.6 Cultural Resources Review

Both 100-HR-3 and 100-KR-4 are in areas rich with cultural resources. The 100-K Area contains a number of archaeological and ethnohistoric sites that range in age from 9,000 years ago to the mid-nineteenth century. The 100-K area is considered extremely sensitive as a Native American-related cultural resource. Two individual sites within the 100-K Area are individually eligible for the National Register of Historic Places while others are included in the Ryegrass Archaeological District. Along the rapids associated with the 100-K Area, Smohalla, Prophet of the Wanapum people performed the first *washat*, the dance ceremony that has become central to the Seven Drums or Dreamer religion. This religion spread to many neighboring Tribes and is currently practiced in some form throughout the interior Northwest. Furthermore, a Wanapum cemetery exists in the 100-K Area.

Surveys for 100-HR-3 have located 25 prehistoric sites and 58 historic sites. Six of the prehistoric sites have been evaluated for and found eligible for listing to the National Register of Historic Places.

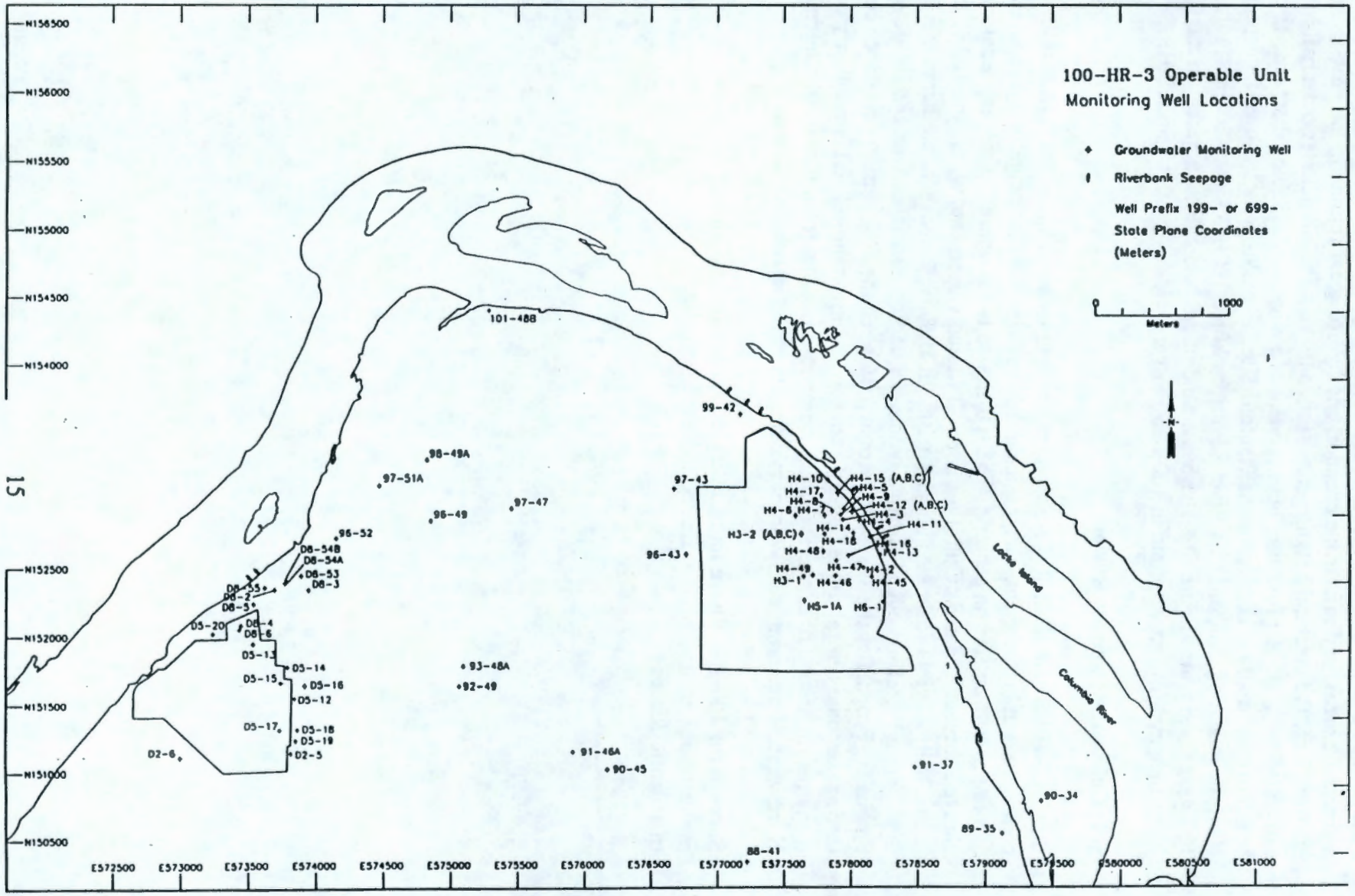

Figure 4. Well Location Map for the 100-HR-3 Operable Unit

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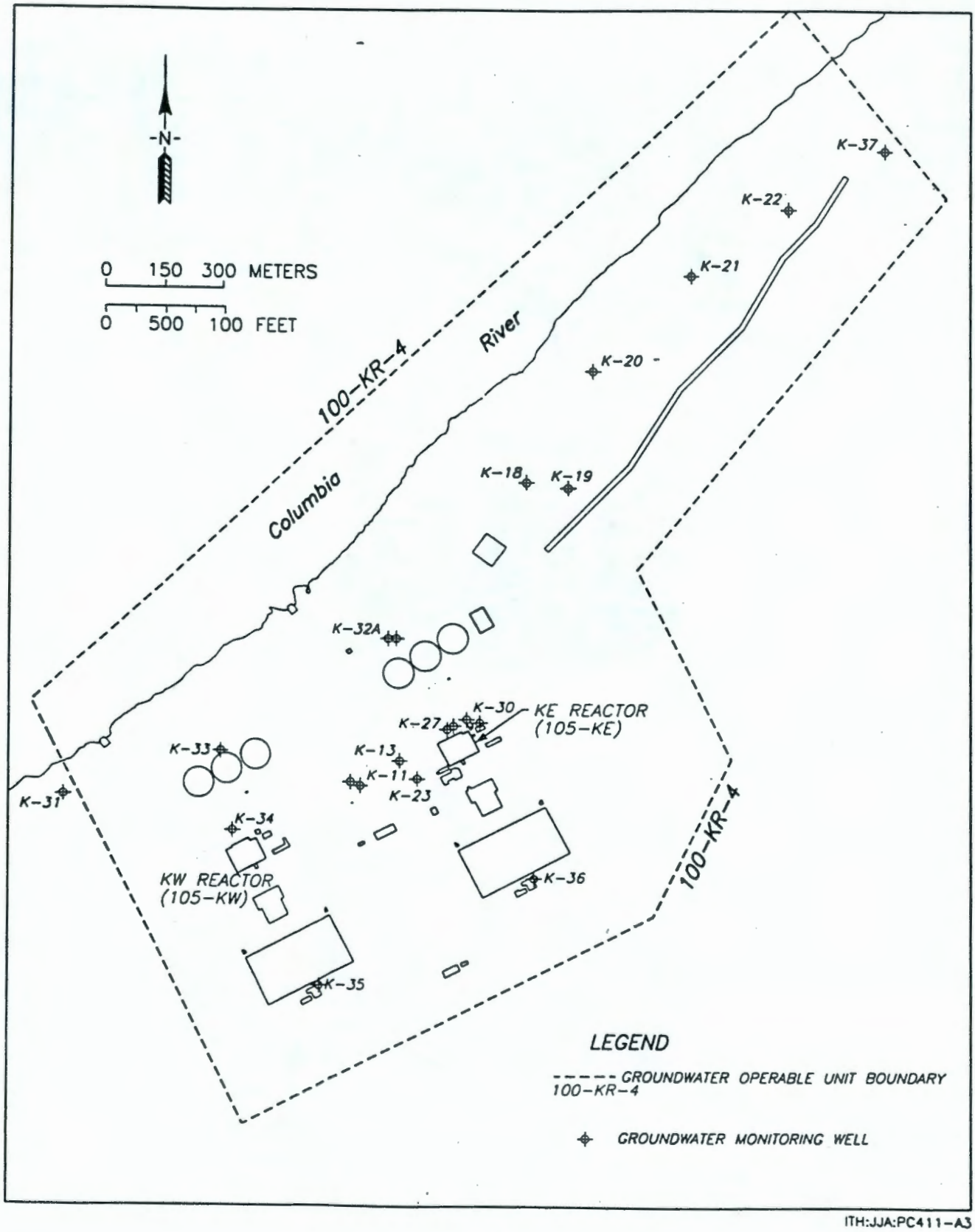
Figure 5. Well Location Map for the 100-KR-4 Operable Unit.



ITH:JJA:PC411-A3

Figure 6. Columbia River Flood Plain.

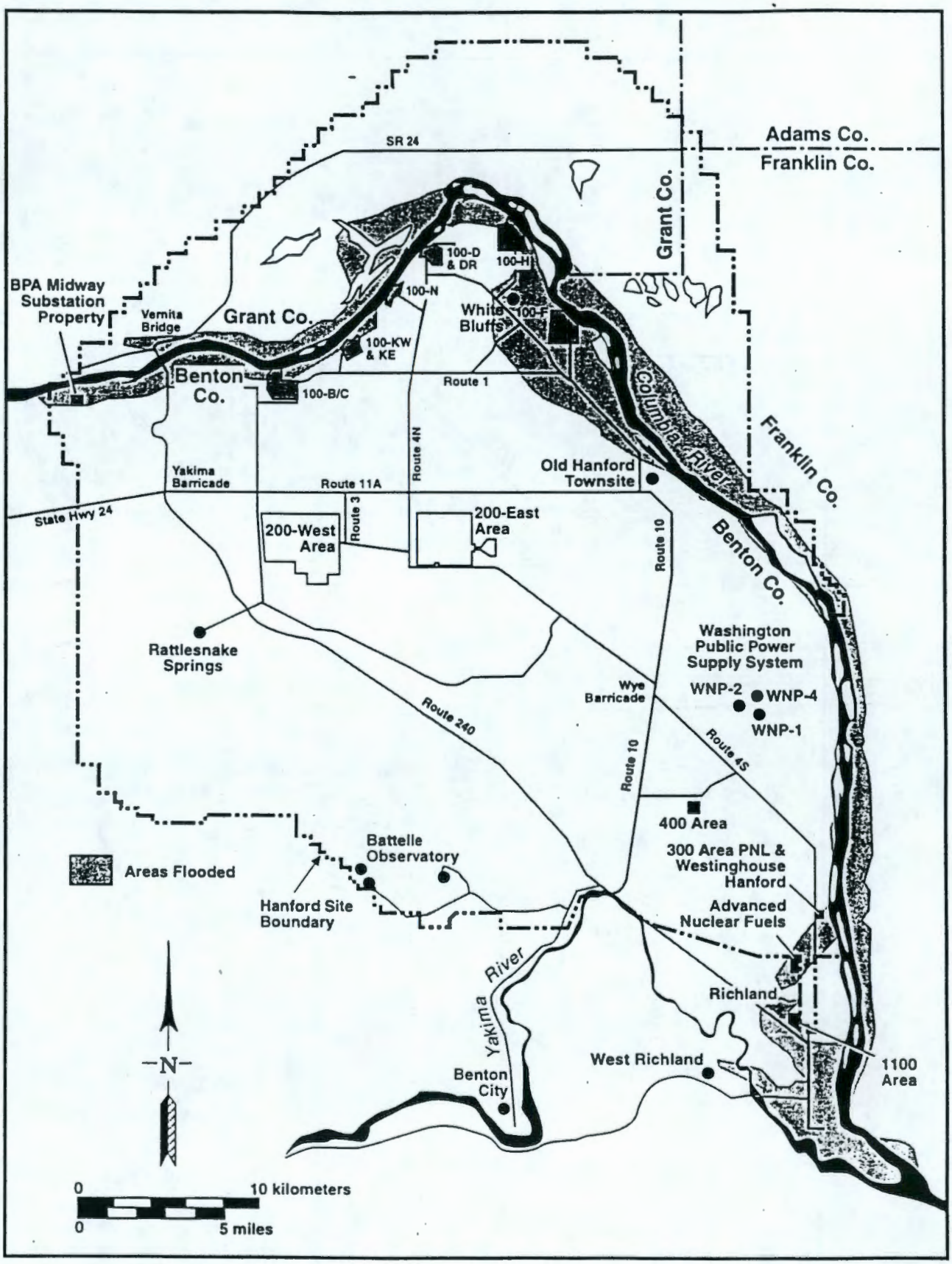


Table 1. Maximum Concentration Summary for Contaminants of Potential Concern in the 100-D/DR Area.

Groundwater Contaminants	All Groundwater Wells	Near-River Groundwater Wells	D/DR Area Springs	D/DR Area Columbia River	MCL (pCi/L or mg/L)
Radionuclides (pCi/L)					
Tritium	78,000	19,000	3,100	<200	20,000[a]
Strontium-90	41(J)	7.6	4.5	<1	8[a]
Uranium 233/234	1.5	1.1	1.0[c]	0.33[c]	NA
Uranium 238	1.4	1.1	1.0[c]	0.33[c]	NA
Inorganics (mg/L)					
Barium	0.164	0.092	0.055	0.026	2.0[a]
Chromium[b]	2.09	0.44(J)	0.12	0.009(U)	0.1[a,b]
Iron	0.550	0.550	0.072	0.102	NA
Manganese	0.19	0.056	0.004(B)	0.007(U)	NA
Vanadium	0.020	0.020	0.005	(U)	NA
Organics (mg/L)					
Bis(2-ethylhexyl)phthalate	0.003	0.003	(U)	(U)	NA
Anions (mg/L)					
Ammonia as N	0.75	0.26	0.1(J)	<0.5(UJ)	NA
Nitrate as N	32.7	14.1	0.68	(U)	10[a]
Sulfide	1	1	(U)	(U)	NA

a 40 CFR 141 (Primary MCL). MCLs presented for comparison purposes.
b Sample Value reported is for total chromium. MCL is for hexavalent chromium.
c Sample Value reported is for total uranium.
(J) Estimated value.
(B) Analyte detected at a concentration below the contract required detection limit, but above the instrument detection limit.
(U) Undetected.
NA Not applicable.
Near-River wells were: 199-D5-20, -D8-4, -D8-5, -D8-53, -D8-54A, -D8-55.

Table 3. Maximum Concentration Summary for Contaminants of Potential Concern in the 600 Area Between the 100-D/DR and 100-H Areas.

Groundwater Contaminants	All Groundwater Wells	Near-River Groundwater Wells	600 Area Springs	600 Area Columbia River	MCL (pCi/L or mg/L)
Radionuclides (pCi/L)					
Tritium	11,000	NA	NA	NA	20,000[a]
Inorganics (mg/L)					
Arsenic	0.012	NA	NA	NA	0.05[a]
Chromium[b]	0.17	NA	NA	NA	0.1[a,b]

a 40 CFR 141 (Primary MCL). MCLs presented for comparison purposes.
b Sample value reported is for total chromium. MCL is for hexavalent chromium.
NA Not Available

Table 4. Maximum Concentration Summary for Contaminants of Potential Concern in the 100-K Area.

Groundwater Contaminants	All Groundwater Wells	Near-River Groundwater Wells	K Area Springs	K Area Columbia River	MCL (pCi/L or mg/L)
Radionuclides (pCi/L)					
Tritium	1,900,000	35,000	8,900	ND	20,000[a]
Carbon-14	23,000	16,000	NA	NA	2,000[a]
Strontium-90	36	36	8.8	0.7(J)	8[a]
Technetium-99	46	11(R)	5.2	2.0	900[d]
Uranium-233/234	3.3	2.3	NA	NA	NA
Uranium-235	0.3	0.2(J)	NA	NA	NA
Uranium-238	2.6	1.9	1.1[c]	0.5[c]	NA
Inorganics (mg/L)					
Aluminum	0.844(J)	0.072(B)	0.225	ND	NA
Arsenic	0.010	0.007(B)	NA	NA	0.05[a]
Cadmium	0.002	0.002(B)	ND	ND	0.005[a]
Chromium[b]	1.95	0.261	0.069	ND	0.1[a,b]
Iron	5.43(J)	1.23	0.243	0.171	NA
Lead	0.008	0.006(J)	NA	NA	0.015[e]
Manganese	0.070	0.070	0.009(B)	0.020	NA
Nickel	0.019	0.010	ND	ND	NA
Silver	0.007(B)	0.005(B)	0.006(B)	ND	0.10[a]
Vanadium	0.024(B)	0.019(B)	0.011(B)	ND	NA
Zinc	0.461(B)	0.461(B)	ND	0.006(B)	NA
Organics (mg/L)					
Chloroform	0.017	0.017	NA	NA	NA
Trichloroethene	0.019	0.019	NA	NA	0.005[a]
Anions (mg/L)					
Chloride	21.6	21.6	6.01	0.86	NA
Nitrate/Nitrite	26	26	1.47(J)	0.5(J)	10[a]

[a] 40 CFR 141 (Primary MCL). MCLs presented for comparison purposes.
[b] Sample value reported is for total chromium.
[c] Value for total uranium reported.
[d] Calculated based on annual average concentration yielding 4 mrem/yr for 2 liter/day daily intake (National Interim Primary Drinking Water Regulations).
[e] Action level per 40 CFR 141, Subpart I.
(B) Concentration below the contract required detection limit but above the instrument detection limit.
(J) Estimated value.
(R) Rejected during data validation due to frequency of instrument calibration.
NA Not Available or Not Applicable.
ND Not detected.
Near-River wells were: 199-K-13, -K-18, -K-19, -K-20, -K-21, -K-22, -K-31, -K-32A, -K-33, -K-34, -K-37.

Table 5. Threatened and Endangered Species Potentially Found on the Hanford Site

Species	Notes
Endangered Vascular Plants	
Persistentsepal yellowcress *(Rorippa columbiae)*	Known to have a scattered distribution because of specialized habitat requirements or habitat loss; generally occurs in marshy places; known to inhabit wet shoreline of Hanford Reach in Benton County.
Northern Wormwood *(Artemisia campertris ssp borealis var workskioldii)*	Rare, local endemic species near the river; not known from Hanford but reported just to the north near Beverly, Grant County.
Threatened Vascular Plants	
Columbia milk-vetch *(Astragalus columbianus)*	Locally endemic to area near Priest Rapids Dam; could potentially occur in Northwest portion of Hanford along the Columbia River.
Dwarf Evening Primrose *(Camissonia (=Oenothera) pygmaea)*	Has been found at Hanford on mechanically disturbed areas.
Hoover's desert parsley *(Lomatium tuberosum)*	Locally endemic to south-central Washington, including Benton County; known to inhabit rocky hillsides.
Endangered Birds	
[1]Aleutian Canada goose *(Branta canadensis leucopareia)*	Only incidental occurrence at Hanford.
American white pelican *(Pelecanus erythrorhynchus)*	Flocks have recently become common in the Columbia Basin during all seasons foraging on fish, amphibians, and crustaceans, and roosting on islands.
[1]Peregrine falcon *(Falco peregrinus)*	Breeds and winters in eastern Washington, inhabiting open marshes, river shorelines, wide meadows, and farmlands; nests on undisturbed cliff faces; an erratic visitor to Hanford.
Sandhill crane *(Grus canadensis)*	Inhabits open prairies, grainfields, shallow lakes, marshes, and ponds; common migrant during spring and fall in Washington; some known and suspected nesting sites in eastern Washington; an occasional visitor at Hanford.
Threatened Birds	
[1]Bald eagle *(Haliaeetus leucocephalus)*	Regular winter visitor to the Columbia River, feeding on spawned-out salmon and waterfowl; they roost in the 100 Areas and nest (unsuccessfully to date) along the Hanford Reach.
Ferruginous hawk *(Buteo regalis)*	Inhabits open prairies and sagebrush plains, usually with rocky outcrops or scattered trees; known to nest in Benton and Franklin Counties, including Hanford; rarely winter in Washington, but are known to occasionally forage on small mammals, birds, and reptiles on sagebrush plains of Hanford.
Threatened Mammals	
Pygmy rabbit *(Sylvilagus idahoensis)*	Inhabits undisturbed areas of sagebrush with soils soft enough to permit burrows; once known to exist at Hanford west of the 200 Areas plateau.

[1]Indicates both state and federal designation.

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Table 6. Fish Species in the Hanford Reach of the Columbia River. (Page 1 of 2)

Common Name	Scientific Name
American Shad	*Alosa sapidissima*
Black bullhead	*Ictalurus melas*
Black crappie	*Pomoxis nigromaculatus*
Bluegill	*Lepomis macrochirus*
Bridgelip sucker	*Catostomus columbianus*
Brown bullhead	*Ictalurus nebulosus*
Burbot	*Lota lota*
Carp	*Cyprinus carpio*
Channel catfish	*Ictalurus punctatus*
Chinook salmon	*Oncorhynchus tshawytscha*
Chiselmouth	*Acrocheilus alutaceus*
Coho salmon	*Oncorhynchus kisutch*
Cutthroat trout	*Oncorhynchus clarki*
Dolly Varden	*Salvelinus malma*
Lake whitefish	*Coregonus clupeaformis*
Largemouth bass	*Micropterus salmoides*
Largemouth sucker	*Catostomus macrocheilus*
Leopard dace	*Rhinichthys falcatus*
Longnose dace	*Rhinichthys cataractae*
Mottled sculpin	*Cottus bairdi*
Mountain sucker	*Catostomus platyrhynchus*
Mountain whitefish	*Prosopium williamsoni*
Northern squawfish	*Ptychocheilus oregonensis*
Pacific lamprey	*Entosphenus tridentatus*
Peamouth	*Mylocheilus caurinus*

Table 6. Fish Species in the Hanford Reach of the Columbia River. (Page 2 of 2)

Common Name	Scientific Name
Piute sculpin	*Cottus beldingi*
Prickley sculpin	*Cottus asper*
Pumpkinseed	*Lepomis gibbosus*
Rainbow trout (steelhead)	*Oncorhynchus mykiss*
Redside shiner	*Richardsonius balteatus*
Reticulate sculpin	*Cottus perplexus*
River lamprey	*Lampetra ayresi*
Sand roller	*Percopsis transmontana*
Smallmouth bass	*Micropterus dolomieui*
Sockeye salmon	*Oncorhynchus nerka*
Speckled dace	*Rhinichthys osculus*
Tench	*Tinca tinca*
Threespike stickleback	*Gasterosteus aculeatus*
Torrent sculpin	*Cottus rotheus*
Walleye	*Stizostedion vitreum vitreum*
White crappie	*Pomoxis annularis*
White sturgeon	*Acipenser transmontanus*
Yellow perch	*Perca flavescens*
Yellow bullhead	*Ictalurus natalis*

VI. SUMMARY OF SITE RISKS

6.1 Qualitative Risk Assessment

A qualitative risk assessment was performed as part of the limited field investigation, and determined the principal risk drivers at the 100-HR-3 Operable Unit and the 100-KR-4 Operable Unit. Another purpose of the qualitative risk assessment was to qualitatively evaluate human health and environmental risks to help determine if the operable units were a candidate for an interim remedial action. The qualitative risk assessment evaluated risks for a predefined set of human and environmental exposure scenarios. If the estimated risks exceeded certain thresholds, interim remedial actions were considered necessary to reduce the risks posed by the contaminants. The qualitative risk assessment is not intended to replace or be a substitute for the baseline risk assessment that will be conducted in association with determining the final action for these operable units. The qualitative risk assessment used the groundwater data from the first four rounds of the limited field investigation sampling. The data were evaluated for consistency and compliance with EPA data management guidance.

6.1.1 Human Health Risks

Human health risks were evaluated for the 100-HR-3 and 100-KR-4 Operable Units to determine whether interim remedial actions were required. The 100-HR-3 and 100-KR-4 Operable Unit Focused Feasibility Studies concluded that there were no current unacceptable human health risks from contaminants in the groundwater, primarily because exposure to groundwater contaminants is precluded by DOE site controls. The interim action is expected to provide adequate protection of human health via institutional controls, and the interim remedial action itself will not pose any unacceptable risks to human health.

6.1.2 Ecological Risks

Ecological risks were evaluated based on the exposure of biological receptors that live in or near the Columbia River to contaminants in surface water, as a result of contaminated groundwater migrating into the river. Plants and animals can also be exposed to contaminants where groundwater surfaces in springs and seeps or where plant roots reach to contaminated groundwater. Most contaminants are also transferred through the food web.

For the purposes of the qualitative risk assessment, maximum concentrations of the contaminants from near-river well samples were used to represent concentrations potentially available to aquatic receptors at the groundwater-river water interface. To estimate ecological risks, the total daily doses to animals in aquatic and riparian habitats from radiological contaminants were estimated using the CRITR2 computer code. These doses were then compared to the DOE benchmark of 1 rad/day (*DOE Order 5400.5*). For the inorganic and organic contaminants, the maximum representative groundwater concentrations from four rounds of limited field investigation sampling were compared to EPA's acute and chronic Ambient Water Quality Criteria (AWQC) for the protection of aquatic organisms. (The EPA's AWQC for hexavalent chromium are numerically equal to the State of Washington's Ambient Water Quality Standards used as an ARAR for this ROD.) If groundwater concentrations

exceeded the 1 rad/day benchmark or the AWQC, an ecological risk was presumed to be present.

6.1.2.1 100-HR-3

The ecological risk analyses for 100-HR-3 indicated that none of the ecological receptors living in or near the Columbia River that were addressed in the qualitative risk assessment (plant, fish , crustacean, plant-eating duck, fish-eating duck, heron) will receive a radiological dose in excess of the 1 rad/day benchmark (table 7). The ecological risk assessment, however, identified inorganic and organic contaminants that exceeded the risk threshold (table 8). These included chromium, sulfide, and bis(2-ethylhexyl)phthalate in the 100-D/DR Area and chromium, iron, and sulfide in the 100-H Area. There are no near-river well data for the 600 Area so comparable analyses are not available (table 3), however extrapolation from surrounding groundwater data does not indicate an ecological risk. Chromium is the most toxic with respect to aquatic receptors, and is the contaminant that has been consistently observed in groundwater in the 100-HR-3 Operable Unit. Chromium (particularly the soluble mobile hexavalent form of chromium) is the most toxic of these four contaminants with respect to aquatic receptors, notably embryonic salmon. Most chromium in groundwater at the Hanford Site is hexavalent chromium, because of the original sources and prevailing geochemical conditions.

The sulfide concentration in most of the groundwater samples were at or below the 1 mg/L level of detection. One sample had a concentration of 26 mg/L, but was determined to be inconsistent with the remaining samples and eliminated from the data set in the limited field investigation. Of 107 samples analyzed for sulfides, 74 were qualified as nondetected. The remaining data were at or below the level of detection. Therefore sulfides are not considered a contaminant of concern.

Analysis of the data for bis(2-ethylhexyl)phthalate indicate that the erratic values that were occasionally obtained for this chemical result from laboratory contamination rather than a contaminant condition in the aquifer. This material, a plasticer, is a common artifact of the sampling/analysis process and is not believed to be a Hanford contaminant.

For iron, only three of the samples collected during 1993-1994 had concentrations above the chronic AWQC of 1,000 μg/L. Each sample was taken from wells constructed with carbon steel casings. After the first few rounds of sampling from these wells, concentrations dropped to several hundred μg/L. The several high concentrations of iron are believe to be an artifact of well construction material.

Table 7. Ecological Risk Summary for Radionuclide Contaminants of Potential Concern in the 100-HR-3 Operable Unit.

Organism	Total Dose to Aquatic and Riparian Receptors, Using Data From Near-River Wells (rad/day)	
	100-D Area	100-H Area
Plant	0.002	0.03
Fish	0.00005	0.002
Crustaceans	0.0001	0.003
Plant-Eating Ducks	0.01	0.06
Fish-Eating Ducks	0.0005	0.008
Heron	0.0003	0.005

Doses are calculated using the sum of all radionuclide concentrations for each area.
All doses are less than the DOE's risk benchmark of 1.0 rad/day.

Table 8. Ecological Risk Summary for Nonradionuclide Contaminants of Potential Concern in the 100-HR-3 Operable Unit.
(Page 1 of 2)

100-D Area

Analyte	Near River Wells Maximum Concentration (unfiltered, μg/L)	AWQC (unfiltered, μg/L)		Exceeds Risk Threshold
		Acute	Chronic	
Bis(2-ethylhexyl) phthalate	3			yes[a]
Barium	91.7			
Chromium (VI)	443	16	11	yes
Nitrate as N	14100	NA	NA	
Manganese	56	NA	NA	
Sulfide	1000			yes[a]
Vanadium	19.6	NA	NA	
Ammonia as N	260			

Table 8. Ecological Risk Summary for Nonradionuclide Contaminants of Potential Concern in the 100-HR-3 Operable Unit.
(Page 2 of 2)

100-H Area

Analyte	Near River Wells Maximum Concentration (unfiltered, in µg/L)	AWQC (unfiltered, µg/L)		Exceeds Risk Threshold
		Acute	Chronic	
Barium	100			
Chromium (VI)	490	16	11	yes
Flouride	80			
Iron	1500	1000		yes[a]
Nitrate as N	32000			
Sulfide	1000			yes[a]
Ammonia as N	29			
Chloroform	31	28900	1240	

NA - No data available
AWQC - Ambient Water Quality Criteria for Protection of Aquatic Life
(B) Concentration below the contract required detection limit but above the instrument detection limit.
(J) Estimated value.
[a] Appears to be an artifact of well construction, sampling, or analysis.
Contaminants of potential concern are contaminants that were detected at concentrations above sitewide background.

6.1.2.2 100-KR-4

The ecological risk analyses for 100-KR-4 indicated that one of the ecological receptors (Table 9, fish-eating ducks) living in or near the Columbia River that were addressed in the qualitative risk assessment will receive a radiological dose in excess of the 1 rad/day benchmark (DOE Order 5400.5). The dose was primarily due to carbon-14. Carbon-14 appears in three 100-K Area wells at elevated concentrations. None of these wells are located within the chromium plume that is the target of the interim action. The source of the elevated carbon-14 appears to be the french drains that received condensate from the inert gas used in 100-K West and 100-K East reactor operations. These contaminant sources will be addressed in the ROD for the 100-KR-2 Operable Unit. The ecological assessment also identified

inorganic contaminants that exceeded the AWQC (Table 10). These included cadmium, chromium, iron, lead, silver and zinc.

Only two samples from one well, 199-K-18, had cadmium concentrations greater than the concentrations associated with the lowest observed effect levels reported in the literature. Several of the samples exceeded EPA's AWQC. These data are believed to be artifacts of the well construction.

One of 25 samples collected from near-river wells during the March 1993 to January 1994 period exceeded EPA's AWQC for iron of 1000 μg/L. The rest of the detectable concentrations were well below this level with many nondetects.

Lead concentrations were all below 5.9 μg/L and appear to represent a background level more than a contaminant plume. Fifteen out of a total 20 samples were below the detection limit. The five detectable concentrations ranged from 3.1 to 5.9 μg/L.

Only one out of 26 samples had a detectable concentration of silver during the January 1993 through January 1994 period.

Zinc is present at a level exceeding the EPA AWQC of 110 μg/L in well 199-K-22 (figure 5). This well is located within the chromium plume that is the target of this interim action. Elevated concentration of zinc in this well are believed to result from a galvanized screen (zinc plated) that was installed in this well, and thus is not representative of a zinc plume.

6.1.3 Risk Summary for 100-HR-3 / 100-KR-4

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment. Groundwater contaminated with chromium is identified in the three reactor areas at concentrations in excess of ecological-based risk thresholds. This groundwater discharges to the Columbia River primarily via upwelling through the river bottom, an environment known to be critical to sensitive ecological receptors such as embryonic salmon. In addition, concentrations of several contaminants exist in groundwater at these operable units that exceed human health levels.

Table 9. Ecological Risk Summary for Radiological Contaminants of Potential Concern in the 100-KR-4 Operable Unit.

Receptor	Estimated Total Dose (rad/day)	Major Contributor
Plant	0.19	Carbon-14
Fish	0.37	Carbon-14
Crustacean	0.37	Carbon-14
Plant-eating Duck	0.33	Carbon-14
Fish-eating Duck	1.1[a]	Carbon-14
Heron	0.70	Carbon-14

[a]Estimated total dose exceeds DOE benchmark of 1 rad/day

Table 10. Ecological Risk Summary for Nonradionuclide Contaminants of Potential Concern in the 100-KR-4 Operable Unit.

Analyte	Near River Wells Maximum Concentration (unfiltered, in µg/L)	AWQC (unfiltered, µg/L)		Exceeds Risk Threshold
		Acute	Chronic	
Aluminum	72.1(B)			
Cadmium	2.2(B)	3.9	1.1	yes[b]
Chloride (mg/L)	21.6	860	230	
Chromium (VI)	261	16	-11	yes
Iron	1230	1000		yes[b]
Lead	5.8(J)	82	3.2	yes[b]
Manganese	69.6			
Nickel	9.9	1400	160	
Nitrate/Nitrite (mg/L)	26			
Silver	5.2(B)	4.1	0.12	yes[b]
Vanadium	19.1(B)			
Zinc	461(B)	120[a]	110[a]	yes[b]
Trichloroethene	19	45000	21900	
Chloroform	17	28900	1240	

a Actual value is hardness dependent. Approximate value using typical Columbia River hardness of 100 mg/l hardness is provided for comparison purposes.

b Appears to be an artifact of well construction, sampling, or analysis.

NA No data available

AWQC Ambient Water Quality Criteria for Protection of Aquatic Life

(B) Concentration below the contract required detection limit but above the instrument detection limit.

(J) Estimated value.

Contaminants of potential concern are contaminants that were detected at concentrations above sitewide background.

VII. REMEDIAL ACTION OBJECTIVES

Remedial action objectives to protect human health and the environment include the following 3 components:

* Protection of aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River.
* Protection of human health by preventing exposure to contaminants in the groundwater.
* Provide information that will lead to the final remedy.

These three components are detailed below.

PROTECTION OF AQUATIC RECEPTORS

The first remedial action objective for the 100-HR-3 and 100-KR-4 Operable Units is to prevent the discharge of hexavalent chromium to the Columbia River substrate at concentrations exceeding those that are considered protective of aquatic life in the River and riverbed sediments. Prioritization of areas to be addressed by the remedial action will be based on suitable salmon habitat. The aquatic receptor exposure point of concern is within the river substrate at depths up to 18 inches (46 centimeters), where embryonic salmon and fry could be present during parts of the year. The relevant standard is the State of Washington's chronic Ambient Water Quality Standard for Protection of Freshwater Aquatic Life for hexavalent chromium of 11 parts per billion (WAC 173-201A-040). Monitoring will be performed to assess the effectiveness of the remedial action in meeting the Ambient Water Quality Standard. Remedial actions should improve water quality in the aquifer by removing contaminants, reducing mobility or toxicity.

Protection of Human Health From Exposure to Groundwater

A second remedial action objective for these operable units is to continue to protect the public such that there is no exposure to contaminants above health based levels. This objective can be achieved by preventing exposure to contaminated groundwater or reduction of contaminants to health based levels as a result of actions taken to protect ecological receptors.

Provide Information That Will Lead to the Final Remedy

Additional information will be obtained during the interim action prior to the development and implementation of a final action. Effectiveness of the interim action will be evaluated based on site-specific data. This evaluation should include: treatment cost, efficiency, evaluation of other technologies, hydraulic impacts, and effectiveness of contaminant removal from the aquifer.

VIII. DESCRIPTION OF ALTERNATIVES

The 100 Area Feasibility Study, Phases 1 and 2 provided a list of six generic groundwater alternatives that could be applied to the groundwater operable units in the 100 Areas. Of the six alternatives, only five were applicable to groundwater remediation at the 100-HR-3 and 100-KR-4 Operable Units:

- Alternative 1: No Action
- Alternative 2: Institutional Control/Continued Current Actions
- Alternative 3: Containment
- Alternative 4: Removal/Reverse Osmosis Treatment/Disposal
- Alternative 5: Removal/Ion Exchange Treatment/ Disposal.

The treatment of groundwater contaminants *in situ* was evaluated and dropped from the 100 Area Feasibility Study, Phases 1 and 2, as an appropriate alternative for the 100-HR-3 and 100-KR-4 Operable Units because insufficient information was available on in situ treatment methods. However, more recently DOE has conducted tests of reduction/oxidation in situ treatment technology and will consider this technology for implementation of future remedial actions at the 100-HR-3 and 100-KR-4 Operable Units.

8.1 Common Elements.

All five alternatives, except the no action alternative, evaluated for the 100-HR-3 and 100-KR-4 Operable Units include controls to prevent human access to groundwater and to require that groundwater concentrations will be tested. In addition to continued access restrictions, the present network of groundwater monitoring wells will be maintained, and samples will be collected to monitor chromium concentrations in groundwater. Monitoring will also aid in determining when these controls are no longer necessary. To provide a common basis for comparative purposes, costs, as shown below for each alternative were developed for the first 5-year period. A 5 percent annual discount rate was applied to calculate present worth. This 5-year cost-planning period is not a basis for cessation of the pump-and-treat action at the end of that period. As required by CERCLA, this remedy will be reviewed at least as often as every 5 years.

8.2 Remedial Alternatives Evaluated

Alternative 1: No Action - Evaluation of this alternative is required by CERCLA to compare the no action alternative with the different action alternatives, and to consider taking no action if appropriate. Under the no action alternative, no CERCLA groundwater monitoring would be required. Although the DOE would retain control of the site throughout the interim period,

no institutional controls would be implemented specifically for the no action alternative. Additional monitoring and restrictions would not be implemented, and contamination in the groundwater would flush into the Columbia River.

100-HR-3	Capitol Cost:	$0
	Operation and Maintenance Cost (5-year period):	$0
	Present Worth (5-year period):	$0
	Estimated Time to Implement:	0 Months
100-KR-4	Capitol Cost:	$0
	Operation and Maintenance Cost (5-year period):	$0
	Present Worth (5-year period):	$0
	Estimated Time to Implement:	0 Months

Alternative 2: Institutional Controls/Continued Current Actions - This alternative involves commitment to continued groundwater monitoring and institutional controls. Institutional controls would include, but may not be limited to, access and land-use restrictions, and site security. Groundwater monitoring would be used to continually evaluate the effectiveness of this interim action, and to support decisions to continue the action or implement other interim remedial actions (including the no action alternative). This alternative would also utilize the data from ongoing studies to evaluate this interim action, complete the groundwater conceptual model, and generate additional technology performance data.

100-HR-3	Capital Cost:	$0
	Operation and Maintenance Cost (5-year period):	$1,200,000
	Present Worth (5-year period):	$1,000,000
	Estimated Time to Implement:	0 Months
100-KR-4	Capital Cost:	$0
	Operation and Maintenance Cost (5-year period):	$600,000
	Present Worth (5-year period):	$500,000
	Estimated Time to Implement:	0 Months

Alternative 3: Containment - For this alternative, cutoff walls would be installed next to the Columbia River to isolate the existing groundwater chromium plume. A cutoff wall is a subsurface vertical barrier designed to prevent the migration of contaminants, divert uncontaminated groundwater around contaminant plumes, or completely surround contaminant plumes. A network of extraction and injection wells, termed hydraulic control, would be installed to intercept and control the contaminated groundwater plume and enhance the effectiveness of the cutoff wall. The objective of the containment alternative would be to eliminate receptor pathways by preventing migration of contaminated groundwater to environmental receptors, such as those in the Columbia River.

100-HR-3	Capital Cost:	$12,200,000
	Operation and Maintenance Cost (5-year period):	$15,300,000
	Present Worth (5-year period):	$25,400,000
	Estimated Time to Implement:	15 Months

100-KR-4	Capital Cost:	$32,200,000
	Operation and Maintenance Cost (5-year period):	$32,200,000
	Present Worth (5-year period):	$60,100,000
	Estimated Time to Implement:	15 Months

Alternative 4: Removal/Reverse Osmosis Treatment/ Disposal - Groundwater would be removed through a series of extraction wells placed within the groundwater plume. Reverse osmosis would be used to remove hexavalent chromium to the maximum extent practicable to speed the remedy, and in no event shall the effluent concentration exceed 50 μg/L. Reverse osmosis uses a membrane that allows water to pass, but will not pass chromium and most co-contaminants. Contaminants removed from the groundwater would be treated as needed to meet requirements for transportation to and disposal in an appropriate on-site facility such as the Environmental Restoration Disposal Facility. Treated groundwater would be reinjected to the aquifer. The objectives of this option would be to prevent migration of groundwater containing chromium above the AWQC into the Columbia River, to prevent migration outside the operable unit, and to minimize source-to-receptor pathways by removal, treatment, and disposal of groundwater contaminants. Costs below are based on treating 8.6 x 10^8 gallons at 100-HR-3 and 5.8 x 10^8 gallons at 100-KR-4.

100-HR-3	Capital Cost:	$7,400,000
	Operation and Maintenance Cost (5-year period):	$24,600,000
	Present Worth (5-year period):	$28,800,000
	Estimated Time to Implement:	15 Months
100-KR-4	Capital Cost:	$4,700,000
	Operation and Maintenance Cost (5-year period):	$13,800,000
	Present Worth (5-year period):	$16,700,000
	Estimated Time to Implement:	15 Months

Alternative 5: Removal/Ion Exchange Treatment/ Disposal - Groundwater will be removed through a series of extraction wells placed within the groundwater plume. Hexavalent chromium will be removed by ion exchange treatment to the maximum extent practicable to speed the remedy, and in no event shall the effluent concentration exceed 50 μ/L. The ion exchange media, when exhausted, would be replaced with new media. Exhausted media will be disposed at the Environmental Restoration Disposal Facility in the Hanford 200 Area. The objectives of this alternative are the same as for Alternative 4.

100-HR-3	Capital Cost:	$6,600,000
	Operation and Maintenance Cost (5-year period):	$13,700,000
	Present Worth (5-year period):	$18,600,000
	Estimated Time to Implement:	15 Months
100-KR-4	Capital Cost:	$4,200,000
	Operation and Maintenance Cost (5-year period):	$8,100,000
	Present Worth (5-year period):	$11,200,000
	Estimated Time to Implement:	15 Months

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IX. SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

9.1 CERCLA Nine Criteria

This section summarizes the relative performance of each of the alternatives with respect to the nine criteria identified in the NCP. These criteria fall into three categories: The first two (Overall Protection of Human Health and the Environment and Compliance with ARARs) are considered threshold criteria and must be met. The next five are considered balancing criteria and are used to compare technical and cost aspects of alternatives. The final two criteria (State and Community Acceptance) are considered modifying criteria. Modifications to remedial actions may be made based upon state and local comments and concerns. These were evaluated after all public comments were received.

A description of the nine evaluation criteria contained in the NCP, and a brief analysis of each alternative against the criteria is presented in the box below. The five alternatives are evaluated against these criteria to select the remedy. Only criteria pertinent to the selection of an interim action have been addressed in detail.

EXPLANATION OF CERCLA EVALUATION CRITERIA

Threshold Criteria:

1. *Overall Protection of Human Health and the Environment - How well does the alternative protect human health and the environment, both during and after construction?*

2. *Compliance with Applicable or Relevant and Appropriate Requirements - Does the alternative meet all federal and state applicable or relevant and appropriate requirements (ARARs)?*

Balancing Criteria:

3. *Long-Term Effectiveness and Permanence - How well does the alternative protect human health and the environment after completion of cleanup? What, if any, risks will remain at the site?*

4. *Reduction of Toxicity, Mobility, or Volume Through Treatment - Does the alternative effectively treat the contamination to significantly reduce the toxicity, mobility, and volume of the hazardous substances?*

5. *Short-Term Effectiveness - Are there potential adverse effects to either human health or the environment during construction or implementation of the alternative. How quickly does the alternative reach the cleanup goals?*

6. *Implementability - Is the alternative both technically and administratively feasible? Has the technology been used successfully on other similar sites?*

7. *Cost - What are the estimated costs of the alternative?*

Modifying Criteria:

8. *State Acceptance - What are the state's comments or concerns about the alternatives considered and about EPA's preferred alternative? Does the state support or oppose the preferred alternative?*

9. *Community Acceptance - What are the community's comments or concerns about the preferred alternative? Does the community generally support or oppose the preferred alternative?*

9.1.1 Overall Protection of Human Health and the Environment - All remedial alternatives except the No Action Alternative would protect human health because institutional controls limit direct exposure to groundwater. Alternative 3 (Containment), 4 (Reverse Osmosis), and 5 (Ion Exchange) would provide the best protection of the environment by reducing chromium concentrations and exposure of ecological receptors to chromium.

9.1.2 Compliance with Applicable or Relevant and Appropriate Requirements - The ARARs identified for the five alternatives include the State of Washington's Chronic Ambient Water Quality Standard for Protection of Freshwater Aquatic Life for hexavalent chromium (WAC 173-201A-040); state Underground Injection Standards (WAC 173-218) for chromium, for the injection of treated groundwater; and state dangerous waste management standards (WAC 173-303) for management and disposal of those treatment resins determined to be dangerous wastes.

Alternative 1 (No Action) would not invoke ARARs that would need to be satisfied. Alternative 1 (No Action) and Alternative 2 (Institutional Controls/Continued Current Actions) will not meet the water quality standards in the Columbia River, as these alternatives would allow hexavalent chromium to continue to exist in the river at levels above the ambient water quality standards.

Alternatives 3 (Containment), 4 (Reverse Osmosis), and 5 (Ion Exchange) would be designed with the intent of achieving ambient water quality standards for hexavalent chromium in the river substrate either by retarding (alternative 3) the flow of groundwater or by removing (alternatives 4 and 5) hexavalent chromium in groundwater before it discharges to the river.

The interim remedial action selected, is protective of human health and the environment, and complies with Federal and State applicable or relevant and appropriate requirements directly associated with this action (by preventing human exposure to contaminated groundwater, and preventing chromium exceedances of the AWQC in the Columbia River substrate). Ambient water quality standards, and state injection standards for contaminants other than chromium may not be met. Specifically, discharge of strontium-90, tritium, and nitrate are anticipated to be above standards. The interim remedial action addresses chromium and is part of a final remedial action that will satisfy ARAR requirements when completed.

9.1.3 Long-Term Effectiveness and Permanence - The ion exchange treatment alternative will be the most effective and permanent in reducing long-term risk, including risk of exposure to ecological receptors, and the system could be expanded. The reverse osmosis treatment alternative would be more difficult to expand should increased groundwater recovery rates be required. The containment alternative would provide protection of the river by limiting the migration of contaminants into the river, but there would be no reduction in the mass of contaminants in the aquifer, except by natural processes. Under the containment alternative, contaminants would eventually migrate past a barrier wall and into the river. Alternatives 1 (No Action) and 2 (Institutional Controls/ Continued Current Actions) do not provide significant long-term effectiveness.

9.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment - Through treatment, the ion exchange and reverse osmosis treatment alternatives would provide the most reduction in toxicity, mobility, and volume of chromium in the groundwater. The remaining alternatives contain no treatment.

9.1.5 Short-Term Effectiveness - Of the three alternatives judged most likely to meet the remedial action goal (Alternatives 3, 4, and 5), short-term effectiveness is met by reducing chromium exposure to ecological receptors. Alternative 3 (Containment) would causes the most short-term impacts to the riparian and terrestrial habitat and their inhabitants, as well as to cultural resources. Alternatives 4 and 5 (Reverse Osmosis and Ion Exchange) would cause lesser short-term impacts. These impacts would be mitigated, to the extent practicable, during construction. The Alternatives 1 (No Action) and 2 (Institutional Controls/Continued Current Actions) will not be effective in the short term. Alternative 4 (Reverse Osmosis) generates the greatest amount of sludge and thus the greatest sludge-disposal impact. Alternative 5 (Ion Exchange) generates less sludge volume whereas Alternatives 1, 2, and 3 generate no sludge and hence have no secondary disposal impacts.

9.1.6 Implementability - Alternative 2 (Institutional Controls/Continued Current Actions) would require administrative actions to implement restrictions and current monitoring. The technology for Alternative 5 (Ion Exchange) is well established and easily implemented. Alternative 4 (Reverse Osmosis) is somewhat more difficult to implement due to maintenance necessary to keep the membrane system functioning and the large capacity treatment system needed for the secondary waste slurry. Alternative 3 (Containment) using vertical barrier technology is difficult to implement because of geologic conditions such as large boulders. The hydraulic barrier technology is relatively easy to implement.

Implementation of any of the remedial alternatives would require close coordination with state and federal resource agencies, Native American Tribes, and Natural Resource Trustees to avoid or minimize further impacts to ecological receptors while conducting remedial activities.

9.1.7 Cost - Of the three alternatives judged most likely to meet the interim remedial action goal (Alternatives 3, 4, and 5), the lowest present worth costs are for Alternative 5 (Ion Exchange): $29,800,000, and Alternative 4 (Reverse Osmosis): $45,500,000. The highest present worth cost is for the Alternative 3 (Containment): $85,500,000. Alternatives 1 (No Action) and 2 (Institutional Controls/Continued Current Actions) would not require capital investment. The capital, operation and maintenance, and present worth costs of each alternative are presented in the alternative descriptions above. Costs presented are preliminary, and are presented for comparison purposes only. A definitive cost estimate for the selected remedy will be prepared as part of remedial design.

9.1.8 State Acceptance - The State of Washington concurs with the selected alternative.

9.1.9 Community Acceptance - Appendix A of this ROD is a responsiveness summary to comments received during the 45 day public comment. Written comments supported taking a cleanup action at these operable units. Generally the comments received during the public

meeting in Hood River (see Section III), although general in nature, were supportive of pump-and-treat actions to prevent the spread of groundwater contamination and to protect the Columbia River.

9.2 EVALUATION OF POTENTIAL ENVIRONMENTAL IMPACTS

The environmental consequences of implementing the remedial alternatives, including potential short-term direct and indirect impacts, have been evaluated in Section 6.0, Detailed Analysis of Alternatives, in 100-HR-3 Operable Unit Focused Feasibility Study and 100-KR-4 Operable Unit Focused Feasibility Study. Impacts are expected to be limited to potential exposure of remediation workers to hazardous or radioactive substances, short-term indirect impact to wildlife from construction noise, and disturbance of the land area designated for wells, equipment, and facilities. Removal of groundwater contamination is expected to improve rather than degrade ecological conditions in the river. The cumulative impact of implementing reasonable foreseeable remedial actions in 100 Area operable units is expected to generally improve ecological conditions in the 100 Areas in the long term.

Ecological review of the operable units indicates that the sites to be impacted by the interim remedial action are located within areas previously disturbed by pre-Hanford Site agricultural activities and by previous reactor operations at the Hanford Site. Because of the previous disturbance, ecological or cultural resources are not expected to be significantly impacted by the interim remedial action. However, Cultural and Natural Resource Reviews will be conducted before siting each well, pipeline, or treatment facility to determine the potential impacts associated with specific actions. Mitigation measures will include actions to minimize dust, use of protective equipment to minimize worker exposures, seasonal scheduling of site work to minimize disturbance to wildlife, archeological monitoring and/or data recovery, as appropriate, and revegetation of the site following interim action.

X. SELECTED REMEDY

The selected remedy shall satisfy ARARs and meet the remedial action objectives set forth in Section VII and includes the following:

- **Groundwater Extraction**
  Groundwater will be extracted from wells primarily located along the river in each of the three reactor areas. Extraction wells should be located at a sufficient distance inland from the river to minimize withdrawal of river water. Extraction wells shall be located such that the plume is captured to meet the remedial action objectives. Based on preliminary modeling accomplished for the operable unit focused feasibility studies, the following extraction well design was estimated as sufficient to capture the chromium plume to meet the chromium remedial action objectives:

  100-K Area: Eleven extraction wells spaced approximately 240 m (786 ft) apart with a composite withdrawal rate of 220 gpm.
  100-H Area: Nine extraction wells spaced approximately 160 m (515 ft) apart with a composite withdrawal rate of 225 gpm.
  100-D Area: Ten extraction wells spaced approximately 160 m (515 ft) apart with a composite withdrawal rate of 100 gpm.

  During remedial design, estimates will be improved based on the incorporation of the results of ongoing river pore water sampling and shoreline drive point sampling, recent groundwater sampling data, and other pertinent data collected since the completion of the focused feasibility study. The groundwater extraction system shall be designed in accordance with the Remedial Design Report/Remedial Action Work Plan (RDR/RAWP) as approved by EPA and Ecology.

- **Groundwater Treatment and Discharge Standards - Hexavalent Chromium**
  100-D, 100-H, and 100-K Areas: The groundwater treatment systems will reduce the effluent chromium concentrations to the maximum extent practicable. However, groundwater above 50 μg/L chromium will not be discharged. The average chromium concentrations in the effluent are expected to be below this standard. This will be performed using ion exchange resins such as a weak base anionic resin with a high selectivity toward chromate anions (hexavalent chromium).

- **Groundwater Treatment - Other Contaminants**
  Because this interim action is designed to reduce levels of hexavalent chromium in the groundwater and the river substrate, there is a potential for other groundwater co-contaminants to be present in the reinjected effluent at concentrations above the drinking water standards set for those contaminants. Potential co-contaminants include nitrate, strontium-90, tritium, uranium, and technicium-99. The ion exchange system required to remove chromium will also reduce concentrations of other anionic contaminants such as nitrate, technicium-99, and uranium-238. Strontium-90 exists in groundwater as a cation and is not expected to be removed in the ion exchange system.

Tritium is also not expected to be removed by the treatment system. In addition to chromium at both operable units, other potential co-contaminants include:

100-HR-3: nitrate, strontium-90, tritium, uranium, and technetium-99.
100-KR-4: tritium and strontium-90.

These other co-contaminants do not exceed the ecological risk criteria, and institutional controls (detailed elsewhere) limit human exposure.

- **Groundwater Reinjection**
After treatment, water will be reinjected into the upper aquifer, using injection wells located upgradient of the existing chromium plume in the 100-HR-3 and 100-KR-4 Operable Units respectively. Based on preliminary modeling accomplished for the operable unit Focused Feasibility Studies, the number of wells needed to accomplish this was estimated to be:

100-D Area: Five injection wells.
100-H Area: Three injection wells.
100-K Area: Two injection wells.

During the remedial design process, more precise estimates are expected to be developed based on the collection and incorporation of well and site-specific data. The groundwater treatment and reinjection system shall be designed in accordance with the RDR/RAWP as approved by EPA and Ecology.

- **Compliance Monitoring - River Protection**
The data analysis and evaluation procedures used to evaluate compliance with cleanup levels shall be defined in a compliance monitoring plan as part of the RDR/RAWP and prepared in accordance with WAC 173-340-720(8) and/or as approved by EPA and Ecology.

The aquatic receptor exposure point of concern is within the river substrate at depths up to 18 inches (46 centimeters), where embryonic salmon and fry could be present during parts of the year. Since it is impractical to routinely monitor the river substrate, groundwater will be monitored at near-river on-shore locations above the common high river mark. Monitoring shall be conducted at sufficient locations to evaluate the performance of the remedial action. The siting and design of the compliance monitoring system shall be in accordance with the RDR/RAWP as approved by EPA and Ecology. To account for dilution within the aquifer between the monitoring location on-shore and the aquatic receptor exposure point of concern within the river substrate, a preliminary dilution factor of 1:1 has been selected based on the available data (i.e., 22 μg/L hexavalent chromium in on-shore near-river well points is considered equivalent to 11 μg/L hexavalent chromium in the river substrate). It will take a period of time for the extraction system to have an effect on groundwater quality

adjacent to the Columbia River. Concentrations in excess of 22 μg/L may be observed in the compliance wells during the early stages of operation.

Groundwater sampling will be conducted when dilution by river water at the compliance monitoring points is minimal. The details of the groundwater quality monitoring program will be described in the RDR/RAWP. Chromium compliance monitoring will be conducted at multiple depth intervals. Baseline sampling will be conducted prior to the start of the interim action.

Sampling will be conducted monthly for at least three months following start-up of the extraction system. Subsequently, there may be substantial reductions in frequency, number of stations, and depths sampled, if demonstrated to be appropriate, and approved by EPA and Ecology. A network of piezometers (or comparable technique) will be installed and monitored such that the capture zone around the extraction wells can be estimated.

In the event of special conditions such as an unusual flood event or prolonged down-time of the pump-and-treat system, extra monitoring, at the direction of EPA or Ecology shall be conducted.

The analyte list will be defined during remedial design; it shall include:

- Hexavalent chromium (or total chromium assumed to be hexavalent). The method detection limit and quantitation limit of the selected test method shall be sufficiently low to allow comparison with the remedial action goals.
- Conductivity or comparable measurements adequate to indicate ratio of river-derived versus groundwater-derived water.
- On an infrequent basis, likely co-contaminants will be monitored as part of on-going Tri-Party Agreement activities to assess protectiveness of human health and the environment.

Compliance monitoring will include analysis of results in a timely manner to support modifications to the treatment system in order to meet the remedial action objectives. Significant system modifications as identified in the RDR/RAWP are subject to EPA and Ecology approval.

- **Compliance Monitoring - Effluent for Reinjection**
  The data analysis and evaluation procedures used to evaluate compliance with cleanup levels shall be defined in the RDR/RAWP and prepared using with WAC 173-340-720(8) and approved by EPA and Ecology.

- **Construction Requirements**
  Construction requirements shall be scoped as part of the RDR/RAWP with guidance provided by and as approved by EPA and Ecology. This Work Plan shall include at least the following elements:

- Construction is expected to comply with appropriate worker safety requirements.
- In coordination with wildlife and other resource management agencies, activities should avoid or minimize disruption to local wildlife and other natural resources to the extent practicable.
- Design should provide for flexibility following startup to accommodate changes in plume characteristics, or different understandings of actual or perceived responses of the aquifer/plume to the pump-and-treat system. When the actual response of the aquifer is known, the pump and treat systems may be altered as needed, and approved by EPA and Ecology to meet the remedial action objectives.
- For areas that are disturbed during construction and operation, it is expected that the land will be revegetated following construction in those areas that are not needed for operation and maintenance of the treatment system and where the land is also not expected to be re-disturbed within the next few years by other site activities. Following completion of the interim action, it is expected that rectification of the habitat affected by this activity will be conducted and coordinated with activities in the source operable units (100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, 100-KR-1, and 100-KR-2).
- To the extent practicable, facilities are expected to be designed and located in a manner that minimizes interference with and interference by remedial actions for the source waste sites.
- Sites with cultural resource significance should be avoided during remedial activities if avoidance is possible. Where avoidance is not possible, a data recovery/mitigation plan must be prepared in consultation with the affected resource trustee and carried out for each site impacted by remedial activities.

- **Schedule**

  Draft A of the RDR/RAWP is due to EPA and Ecology 120 calendar days after the ROD is signed.

  Phase 1: Two pump-and-treat systems designed in accordance with this ROD in two of the three reactor areas are to be operating as per the RDR/RAWP within 15 months of this ROD. Operating is defined as continuous removal and treatment of water at rates defined in the RDR/RAWP. Some limited testing needed to optimize the system is expected.

  Phase 2: The third pump-and-treat system in the third reactor area shall be operating as per the RDR/RAWP within 18 months of this ROD.

  The RDR/RAWP will establish a schedule including Tri-Party Agreement milestones for this interim remedial action. This Work Plan including the schedule is subject to EPA and Ecology approval.

- **Resin Disposal**

Waste generated during the remedial action, principally exhausted resins, will be disposed of at the Environmental Restoration Disposal Facility (ERDF) or at other on-site facilities as appropriate. Resins will be stabilized prior to disposal such that:

- The Chromium concentration in leachate generated using the Toxicity Characteristic Leachate Procedure (TCLP) is less than 5.0 mg/l
- ERDF waste acceptance criteria are met for disposal at ERDF.

In the event that some materials cannot be disposed to ERDF or other on-site facilities, and require disposal at an off-site facility, such a facility must be in compliance with EPA's Offsite Rule (40 CFR 300.440) concerning off-site disposal of wastes. If during the design or conduct of the remedial action it is determined that regeneration of resins is appropriate, that option may be implemented with any waste disposed as described for resins in this paragraph.

- **Human Access Institutional Controls**

Institutional controls are required to prevent human exposure to groundwater. The DOE is responsible for establishing and maintaining land use and access restrictions until MCLs and risk-based criteria are met or the final remedy is selected. Institutional controls include placing written notification of the remedial action in the facility land use master plan. The DOE will prohibit any activities that would interfere with the remedial activity without EPA and Ecology concurrence. In addition, measures necessary to ensure the continuation of these restrictions will be taken in the event of any transfer or lease of the property before a final remedy is selected. A copy of the notification will be given to any prospective purchaser/transferee before any transfer or lease. The DOE will provide EPA and Ecology with written verification that these restrictions have been put in place.

- **Up-time requirements**

Operating pump-and-treat systems as described in this ROD and the subsequent RDR/RAWP will achieve substantial treatment for this interim action. The extraction and treatment system shall be designed to run on an essentially continuous basis such that routine procedures such as resin changes and mechanical maintenance can be conducted with minimal impact to system operations.

The system should be winterized such that winter weather or preparation for winter weather does not cause extended shut-down of the system and compromise the remedial action objectives. The system shall be designed such that if one or several of the wells are down (such as due to a mechanical problem, or a well pump needs to be replaced), the rest of the system can continue operating. In the event of a partial or total system shutdown EPA or Ecology may impose additional near-river compliance sampling requirements. EPA and Ecology may also authorize short-term intentional shutdowns for the purposes of observing aquifer response or for other purposes as deemed appropriate. The provisions of this paragraph do not apply at the conclusion of the interim action.

- **Investigation-Derived Waste**
  Remedial investigation at 100-HR-3 and 100-KR-4 generated investigation-derived waste consisting of soil and slurries from monitoring well installation, and purge water generated during development and monitoring of the wells. This waste is stored in the respective reactor areas in drums. Soil will be disposed to ERDF, as will slurries following dewatering in accordance with ERDF waste acceptance criteria. Water may be processed via the ion exchange treatment system installed for groundwater under this ROD.

- **Impacts to RCRA Monitoring**
  Two RCRA treatment, storage, and disposal (TSD) units, 100-D Pond and the 183-H Solar Evaporation Basins, are located within the boundaries of the 100 HR-3 Operable Unit. The 183-H basins are anticipated to be remediated and closed under RCRA, and the 100-D Pond is currently an inactive unit. The implementation of the remedial actions under this Interim Action ROD are believed likely to impact the current RCRA groundwater sampling program around both of these facilities. For any RCRA unit whose monitoring compliance program is impacted, Ecology may approve modifications to the monitoring program as appropriate. Potential alternative compliance actions include monitoring other existing wells (including remediation wells) for appropriate RCRA constituents during the period when the groundwater is affected by the remedial action.

- **Operational Requirements**
  The pump and treat portion of the interim remedial action will continue until the selection of a final action or it is demonstrated to EPA's and Ecology's satisfaction that termination (or intermittent operation) is appropriate because: (A) sampling indicates that hexavalent chromium is below the compliance value, and site data indicate it will remain below the compliance value; or (B) based on an evaluation of the following criteria:

  - The effectiveness of the treatment technology does not justify further operation.
  - An alternate treatment technique, such as in situ chemical reduction or other improved treatment technique is evaluated and proves to be more effective, and/or less costly, and is consistent with the remedial action objectives.

- **Wetlands and Flood Plains**
  The interim action will be implemented such that to the extent practicable disturbance to wetlands will be avoided and system components except monitoring points will be located away from wetlands. System components will be located such that they will not increase deleterious effects of flooding.

- **Protectiveness**
  The interim action is expected to provide adequate protection of human health and ecological receptors in the Columbia River until implementation of the final remedy for the 100-HR-3 and 100-KR-4 groundwater operable units, or until such time that the

DOE demonstrates to Ecology and the EPA that no further interim action is required. Contaminated soil overlying these operable units are or will be addressed in separate remedial actions.

- **Disposal to ERDF and Lead Regulatory Agency**
  The 100-HR-3 Operable Unit was initially designated as a *Resource Conservation and Recovery Act* (RCRA) Past Practice unit. The Tri-Parties have decided to redesignate this operable unit as a CERCLA Past Practice unit in order to facilitate the disposal of contaminated materials at the CERCLA Environmental Restoration Disposal Facility (ERDF). Section 5.4 of the Hanford Federal Facility Agreement and Consent Order signed by the DOE, EPA, and Ecology (and hence termed the Tri-Party Agreement) describes the process that was followed to initially designate operable units as RCRA Past Practice or CERCLA Past Practice, and indicates that the remedial actions selected for operable units under either designation would be comprehensive to satisfy the technical requirements of both statutory authorities. Ecology will remain the lead regulatory agency for 100-HR-3 following redesignation.

XI. STATUTORY DETERMINATIONS

Under CERCLA Section 121, selected remedies must be protective of human health and the environment, comply with ARARs, be cost effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practical. In addition, CERCLA includes a preference for remedies that employ treatment that significantly and permanently reduces the volume, toxicity, or mobility of hazardous substances as their principal element. This section discusses how the selected remedy meets these statutory requirements.

The selected remedy provides the best balance of tradeoffs among the alternatives with respect to evaluation criteria that are used to evaluate remedies under CERCLA. The selected remedy will protect human health with institutional controls and protect the environment by reducing the discharge of contaminants to the river. It will comply with ARARs for hexavalent chromium directly associated with this action, is cost effective, and will utilize permanent solutions to the maximum extent practicable. The selected alternative satisfies the CERCLA preference for treatment as a principal element.

11.1 Protection of Human Health and the Environment

Site institutional controls will continue during the interim remedial action period. These controls limit human access to the groundwater and thereby limit human exposure to acceptable risk levels. The ecological risk resulting from the groundwater flow into the river is addressed by the pump-and-treat component of the action identified in this ROD. The pump-and-treat will reduce the concentration of chromium to Ambient Water Quality Standards within the river bottom substrate. Implementation of this remedial action will not pose unacceptable short-term risks toward site workers that cannot be mitigated through acceptable remediation practices.

11.2 Compliance with ARARs

The selected remedy will comply with the federal and state ARARs identified below. This interim remedial action addresses chromium in the groundwater (by preventing human exposure to contaminated groundwater, and preventing chromium exceedances of AWQC in the Columbia River substrate) and is only part of a final remedial action that will satisfy other ARAR requirements when completed. The ARARs identified for the action identified in this ROD are the following:

11.2.1 Chemical-Specific ARARs

- Underground Injection Standards (WAC 173-218) and Underground Injection Control Program (40 CFR 144, Subpart B) for chromium are applicable to reinjection of treated groundwater.

- *Clean Water Act*, Ambient Water Quality Criteria for Protection of Aquatic Life (50 FR 30788, 40 CFR 131) for chromium are relevant and appropriate for establishing cleanup goals that are protective of the Columbia River.

- *Water Quality Standards for Waters of the State of Washington*, (WAC 173-201A-040) for chromium are relevant and appropriate for establishing cleanup goals that are protective of the Columbia River.

11.2.2 Action-Specific ARARs

- *State of Washington Dangerous Waste Regulations*, (WAC 173-303) are applicable for the identification, treatment, storage, and land disposal of wastes determined to be dangerous wastes.

- Land Disposal Restrictions (40 CFR 268) are applicable to the land disposal of wastes determined to be hazardous wastes.

- *Minimum Standards for Construction and Maintenance of Wells* (WAC 173-160 and 162) are applicable regulations for the location, design, construction, and abandonment of groundwater extraction, reinjection, and monitoring wells.

- *Dangerous Waste Standards for Tank System Units* (WAC 173-303-640). The substantive requirements of this are relevant and appropriate to the construction, operation, maintenance and closure of any tanks and associated components (e.g. piping) that contain dangerous waste associated with both the water treatment system and the resin stabilization system.

11.2.3 Location-Specific ARARs

- *National Archeological and Historical Preservation Act* (16 USC Section 469); 36 CFR Part 65, is applicable to recover and preserve artifacts in areas where an action may cause irreparable harm, loss, or destruction of significant artifacts.

- *National Historic Preservation Act* (16 USC 470, *et. seq.)*; 36 CFR Part 800, is applicable to actions in order to preserve historic properties controlled by a federal agency.

- *Public Law 100-605, To Authorize a Study of the Hanford Reach of the Columbia River and for Other Purposes* is applicable to planning, designing, and locating activities in a manner that minimizes direct and adverse effects on the values for which the river is under study. The location of any facilities within 1/4 mile of the river will be coordinated with the National Park Service.

- *Endangered Species Act* of 1973 is applicable to protection of endangered or threatened species. Consultation with the U.S. Department of the Interior will occur as needed.

- *Migratory Bird Treaty Act* is relevant and appropriate to protection of migratory birds in the areas. Consultation with the U.S. Fish and Wildlife Service will occur as needed.

- *Bald and Golden Eagle Protection Act* of 1985 is applicable due to the known roosting of bald eagles in the general vicinity of potential extraction wells. Consultation with the U.S. Department of Interior will occur as needed.

11.2.4 Other Criteria, Advisories, or Guidance to be Considered for this Remedial Action (TBCs)

- *Floodplain Management Executive Order (E.O. 11988)* and *Protection of Wetlands Executive Order (E.O. 11990)* are relevant and appropriate to activities within the floodplains and wetlands. To the extent practicable, actions should avoid or minimize the impact to floodplains and wetlands, and minimize loss due to floods.

- *Environmental Restoration Disposal Facility (ERDF) Waste Acceptance Criteria* (BHI-00139, Rev. 0, October 1995) delineates primary requirements including regulatory requirements, specific isotopic constituents and contamination levels, the dangerous/hazardous constituents and concentrations, and the physical/chemical waste characteristics that are acceptable for disposal of wastes at ERDF.

11.3 Cost Effectiveness

The selected remedy was the most cost effective of the three remedies evaluated that achieved the remedial action objective.

11.4 Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Possible

The selected remedy utilizes permanent solutions. Pump-and-treat using ion-exchange is not an innovative technology.

11.5 Preference for Treatment as a Principal Element

The selected remedy utilizes treatment to concentrate the chromium into a small volume of resin relative to the large volume of treated groundwater. The resin is then solidified into cement. This process reduces the volume, mobility, and toxicity of the chromium.

11.6 CERCLA Section 104(d)(4) Determination

The CERCLA Section 104(d)(4) states where two or more non-contiguous facilities are reasonably related on the basis of geography, or on the basis of the threat or potential threat to the public health or welfare or the environment, the President may, at his discretion, treat these facilities as one for the purposes of this section.

The preamble to the NCP indicates that when non-contiguous facilities are reasonably close to one another and wastes at these sites are compatible for a selected treatment or disposal approach, CERCLA Section 104(d)(4) allows the lead agency to treat these related facilities as one site for response purposes and, therefore, allows waste transfer between such non-contiguous facilities without having to obtain a permit. The 100-HR-3 and 100-KR-4 Operable Units and the ERDF are all contained within the Hanford Site, and are subject to the Tri-Party Agreement. They are reasonably related based on geography, on the basis of the threat or potential threat to the public health, welfare or the environment, and therefore are being treated as a single site for response purposes under this ROD. This is consistent with the determination made in the January 20, 1995 ROD for the ERDF that stated... *"Therefore, the ERDF and the 100, 200, and 300 Area NPL sites are considered to be a single site for response purposes under this ROD."*

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XII. DOCUMENTATION OF SIGNIFICANT CHANGES

The DOE, EPA, and Ecology reviewed all written and verbal comments submitted during the public comment period. Upon review of these comments, it was determined that no significant changes to the selected remedy, as originally identified in the Proposed Plans, were necessary. The Proposed Plan for 100-KR-4 identified two contaminants (zinc and carbon-14) for remedial action, that upon more detailed analysis do not warrant inclusion in the interim action.

APPENDIX A - RESPONSIVENESS SUMMARY

Public comments reflected overwhelming support for taking an active pump-and-treat action to prevent plumes from entering the Columbia River. Most of the comments regarded the choice of treatment technique: ion-exchange resin verses other techniques. Regarding the other techniques, comments revolved around reverse osmosis relative to co-contaminants and also other new treatment techniques available by identified vendors.

Ion exchange verses reverse osmosis treatment techniques are discussed in the following comment response. Other treatment techniques are discussed in subsequent comment responses.

Why is the "ion exchange system" method of cleanup preferred to "reverse osmosis"? What are the benefits and advantages of the former over the latter?

First, a brief description of these two methods. Ion exchange requires pumping water through large tanks filled with a resin. Resins are a material to which chemicals tend to stick. Resins are designed to have a tremendous quantity of binding ("sticky") sites. As tanks of resins approach their capacity for contaminants, a progressively higher amount of contaminants pass through without being captured. Generally a number of these ion exchange tanks are plumbed together so that progressively cleaner water can be obtained at each stage. After several treatment steps, the contaminants may be essentially all removed, so large numbers of additional columns provide no added benefit. When contaminants "break-through" the first column, all the binding sites are not yet used. Continued use will eventually nearly saturate the binding sites, resulting in maximal use of the resin. By the time contaminant saturation of the resin in the first tank is nearly saturated, most of the contaminant input is breaking through to the second treatment tank. At that point, resin from the first tank is removed and regenerated for re-use, or disposed. The tank is then cleaned and refilled with fresh resin, and now becomes the final "polisher" tank. The choice of resin determines which contaminants are removed. It is anticipated that a weak base anionic resin bed will be used to capture chromium. Co-contaminants with similar chemical properties would also be retained by this resin (for example: uranium and nitrate). Co-contaminants such as strontium-90 and tritium would not be retained.

Reverse osmosis uses hydraulic pressure to push water through a membrane that is permeable to water but not to the contaminant. Clean water is drawn off from the clean side of the membrane. Water on the "dirty" side of the membrane becomes concentrated with particulate and dissolved contaminants and minerals, and its osmotic pressure rises. Water from the clean side of the membrane is inclined to pass back through the membrane to the dirty side in response to the osmotic pressure, but is held back by the hydraulic pressure applied to the clean side. Ever increasing hydraulic pressure is needed to overcome ever increasing osmotic pressure until the point of diminishing returns indicates that it is time to flush out the slurry on the dirty side of the membrane. The osmotic pressure is reduced and the system again operates

productively. In practice, a continuous flow system is usually used rather than the "batch mode" just described.

A major advantage of ion exchange over reverse osmosis is substantially less secondary wastes. With ion exchange, very small volumes of waste resins (relative to the volume of treated water) are generated. With reverse osmosis, relatively large volumes of contaminated liquid are generated. The expense associated with purchase, handling, and disposal of resins is small relative to the treatment and disposal of the solution generated with reverse osmosis. An additional advantage of the ion exchange is that it is a very reliable process. Having a treatment system with minimal down-time is an important element of being protective.

Are the various cleanup sites discrete, or are they interconnected by the same aquifers and affected by the same plumes?

When the three reactor areas covered by this ROD were in operation, they discharged large amounts of water that formed a mound on the former water table. This mound of water flowed in all directions, including upgradient (away from the river) against the natural groundwater flow direction. Thus groundwater in all directions from the reactor areas were initially contaminated with chromium. Following shutdown of the reactors, and an end to the discharge of the liquids, the mound dissipated and groundwater flows have returned to their natural directions. Wells upgradient of the reactors generally still have slightly elevated levels of chromium. In the 100-K and 100-H Areas, the residual chromium remaining in the upgradient portions of the aquifer should gradually be flushed back through the reactor area. However the 100-D Area is unique.

Chromium from the 100-D area that was pushed inland from the historic groundwater mound has in part been pushed into areas that naturally were upgradient of 100-H Area. With the return of groundwater flow to its natural direction, this chromium is in part flushing out towards the 100-H area. With this sketch of the process at work in the 100-D and 100-H Area, the net effect of all the processes at work result in the 100-D and 100-H discharges have mutually affected their mutual "upgradient" area resulting in the whole area having moderately elevated levels of chromium. Within the 100-D and 100-H area are discrete significantly elevated chromium plumes that result in the ecological risk that this ROD addresses. Because this is an interim action ROD, review of these operable units and the remedy will be ongoing as the Tri-Parties continue to develop and implement final remedial alternatives for the operable units and the 100 Area NPL site.

What is the target date of beginning this project?

Design can begin in earnest upon signature of this ROD. Well drilling will begin soon after the ROD. Groundwater extraction and treatment systems at two reactor areas will

be operational within 15 months of signature of this ROD. The system at the third reactor area will be operational within 18 months after signature of this ROD.

Once underway, what is the suspected length (time) of the project to completion.

More than a few years. The pump and treat portion of the interim remedial action will continue until the selection of a final action or it is demonstrated to EPA's and Ecology's satisfaction that termination (or intermittent operation) is appropriate because: (a) sampling indicates that hexavalent chromium is below the compliance value, and site data indicate it will remain below the compliance value, or (b) based on an evaluation of the following criteria:

- The effectiveness of the treatment technology does not justify further operation.
- An alternate treatment technique, such as in situ chemical reduction or other improved treatment technique is evaluated and proves to be more effective, and/or less costly, and is consistent with the remedial action objectives.

What is the total amount of water that needs to be pumped?

Water will be pumped at a rate sufficient to capture the chromium plume to an adequate degree to meet the remedial action objectives (see next comment). The total amount of water that will be pumped depends on how long the pump-and-treat system runs (see the previous and next comment).

How much will it cost.

Costs were estimated as part of the feasibility study for this interim action. If the systems were to run for 5 years, the total costs were estimated by DOE to be about 29.8 million dollars. Ecology and EPA believe the project could be designed, operated, and maintained for substantially less than that estimate. Actual costs for the project will be monitored.

What will be the residual levels of contamination at the conclusion of the project; and that would those levels mean in relation to human use or contact with the groundwater.

Residual levels of contamination will be such that the remedial action objectives are met. The remedial action objective for the pump-and-treat aspect of this is to protect ecological receptors in the Columbia River. Protection of human health under this interim action, however, is specifically addressed through institutional controls to limit human access to the ground water.

Is hexavalent chromium the only contaminant being targeted in this project?

As far as active remedial actions, yes. Site institutional controls will continue during the interim remedial action period. These controls limit human access to the

groundwater and thereby limit human exposure to groundwater that exceeds drinking water MCLs for a number of contaminants in addition to chromium.

Where will new wells be dug?

New wells will be located within the chromium plumes of the three reactor areas. It is anticipated that these primarily will be located along and inland from the river shore where the main portion of the chromium discharges. A combination of existing and new wells will be used to create a capture zone.

What is the goal of the project? What is clean, and what level of clean is the objective? Are there parameters that define what is safe for salmon eggs and fry, and if so is that the goal? What are EPA's standards for the protection of aquatic life, and are those the goal?

The goal of the pump-and-treat systems is to prevent discharge of hexavalent chromium at levels exceeding concentrations that are considered protective of aquatic life in the Columbia River and riverbed sediments. The aquatic receptor exposure point is within the river substrate at depths up to 18 inches (46 centimeters), where embryonic salmon and fry are present during parts of the year. The relevant standard is the State of Washington's Chronic Ambient Water Quality Standard for Protection of Freshwater Aquatic Life for hexavalent chromium of 11 parts per billion.

Development of site-specific toxicity information on the impacts of chromium to salmon eggs, larvae, and juveniles to support development of site-specific criteria to ensure protectiveness was suggested.

The EPA's AWQC for chromium of 11 μ/L was based largely on toxicity information for embryonic salmon and fry. The EPA's AWQC were used by the State of Washington to establish Water Quality Standards for Surface Waters of the State of Washington. Thus the legal threshold used in this ROD to define protectiveness, although not site-specific, has a species-specific basis. From the remedial action perspective, at this time, DOE, EPA, and Ecology do not consider site-specific toxicity information cost effective in light of other known cleanup needs that would go unfunded if additional bioassays were conducted. (See next comment for the natural resource damage perspective.)

Development of site-specific toxicity information is important for another reason. Impacts from chromium discharges into salmon redds are likely to be one of the more quantifiable injuries to natural resources, and are likely to be a major focus of a damage assessment. The commentor encourages prompt and accurate assessment and mitigation of these potential injuries as advocated by DOE guidance (DOE/EH-0192, page 12) and as required under CERCLA 107(f)(2)(A). The U.S. Fish and Wildlife Service expressed a desire to participate in impact assessment and mitigation planning.

For fiscal year 1996 (FY 96) DOE has initiated an initial scoping level risk assessment in support of the Columbia River Comprehensive Impact Assessment (CRCIA). The FY 96 effort also includes identifying remaining work believed to be needed by the CRCIA management team (comprised of DOE, EPA, Ecology, Tribal, Hanford Advisory Board, and State of Oregon representatives) to perform a "comprehensive" assessment of the Columbia River. The scoping level risk assessment involves determining exposure of a variety of species to a number of Hanford's contaminants in the Columbia River. The contaminants include chromium and the species include salmon. The assessment, the scope of which was agreed to by the CRCIA management team follows EPA guidelines for ecological risk assessment and is designated to support development of interim remedial actions. Based on the FY 96 work, any required mitigation and/or additional assessment needs will be determined. The U.S. Fish and Wildlife Service and other interested parties are encouraged to participate with the CRCIA management team in this assessment and any required mitigation activities.

Construction of extraction wells adjacent to the river has the potential to disturb roosting bald eagles, waterfowl, and terrestrial birds. To minimize impacts of the project, construction activities should be timed to avoid peak periods of bird activity. The U.S. Fish and Wildlife Service indicated a willingness to provide consultation of the most appropriate timing for construction activities.

The DOE will provide the Natural Resource Trustees an opportunity to comment on timing for in-field activities that are potentially disruptive to wildlife. The DOE will consult with the U.S. Department of the Interior and the U.S. Fish and Wildlife Service as appropriate.

The U.S. Fish and Wildlife offered to provide technical support to ensure that revegetation efforts, following the interim action, are technically feasible, appropriately restore disturbed natural resources, and would be compatible with designation of this area as a Wild and Scenic River corridor. It was requested that all the Natural Resource Trustees be consulted early in the revegetation planning. A description of pre-project conditions is necessary if appropriate revegetation is to occur.

Surface disturbance and ultimate restoration associated with these groundwater actions is largely co-located and similar in nature to what will be occurring with the surface waste sites. Revegetation/restoration of surface disturbance associated with actions from this ROD will be addressed as part of the revegetation/restoration of the source operable unit. Natural Resource Trustees will be included in those planning efforts. For areas that are disturbed during construction and operation, it is expected that the area will be revegetated following construction in those areas that are not needed for operation and maintenance of the treatment system and is also not expected to be re-disturbed within the next few years by other site activities. Following completion of the interim action, it is expected that rectification of the habitat affected by this activity will be conducted and coordinated with comparable activities for the source operable units (100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, 100-KR-1, and 100-KR-2).

Planning of pipeline locations should take into account and attempt to avoid higher quality habitat and other important natural resource features.

The ground surface on which these remedial activities will take place is primarily disturbed habitat, due to agriculture and defense related activities. To the extent practicable, areas of higher quality habitat will be avoided or impacts will be minimized.

A number of comments were received from business vendors or technical experts identifying themselves as competent to conduct the work as described in the proposed plan, or to identify innovative techniques that may be better or more cost effective, or to suggest alternate methods to achieve remedial action objectives.

Commitment to a pump-and-treat is a long-term expensive proposition. The Tri-Parties endorse the most cost effective remedial approach consistent with the CERCLA 9 criteria and the remedial action objectives. Evaluation of technologies is an ongoing process with incorporation as deemed appropriate. If in the future a substantially different remedial action approach is considered, public comment will be solicited before a decision to implement it is made. Treatability tests may be conducted without public comment.

There were comments regarding the fact that the proposed plans did not include any action directed at removal of the chromium that is already in the river sediments.

Hexavalent chromium is very soluble in water. Most of the hexavalent chromium is dissolved into and moving with the water. Thus the river bottom sediments to not accumulate hexavalent chromium. When hexavalent chromium is reduced to trivalent chromium, it becomes much less soluble and hence has the potential to accumulate in sediments. However it is also less toxic. Because it is less toxic and in particulate (not dissolved) form, it is generally less bioavailable, and therefore, less of an environmental threat.

A commentor noted his previous experience with ion exchange resins as not being cost effective, part of the problem being that the chromium destroyed the resins. Alternatives such as precipitation were suggested.

There has been considerable experience using resins to treat chromium that have been successful, including a treatability test at 100-HR-3. The resins have not been destroyed by chromium. Precipitation can be cost-effective with very high concentrations of chromium. Generally speaking, precipitation methods are not cost-effective for lower concentrations of chromium, and do not achieve the low concentrations required for this remedial action.

Currently, we plan to dispose of the resins after one use, however if resin regeneration is determined to be practicable, then regeneration may be utilized.

A commentor identified their company's electrocoagulation and electrochemical flocculation process as a remedial alternative.

This process was evaluated in the *100 Area Feasibility Study, Phases 1 and 2* against the following criteria and was eliminated:

- Effectiveness
- Implementability - Technical Feasibility
- Implementability - Administrative Feasibility
- Cost.

A commentor identified that the pump-and-treat system does not capture all the plume, and the treatment train does not remove all the chromium. It was stated that this "does not seem very effective".

It is correct that: (1) plume capture will be partial, and (2) treatment of the water will be partial. But the remedial action objective of this interim action is not to totally prevent chromium from entering the river. The remedial action is intended to capture and treat enough of the chromium that residuals that enter the river are at or below concentrations considered to be protective of the aquatic organisms that inhabit the Columbia River bottom.

A commentor identified that this interim action addresses part of the contaminated groundwater but does not address the remaining groundwater contamination.

Ecological risk is addressed by the pump-and-treat action for the single contaminant that exceeds the ecological-risk based threshold -- hexavalent chromium. Potential human health risks associated with exposure to remaining contaminants are addressed by institutional controls. Thus for the interim period addressed by this interim action, this action should be protective of human health and the environment. Because this is an interim action ROD, review of these operable units and the remedy will be ongoing as the Tri-Parties continue to develop and implement final remedial alternatives for the operable units and the 100 Area NPL site.

Commentors also reiterated another facet of the problem is the previously contaminated soil and the risk that these contaminants pose to surface exposure as well as a continuing to the groundwater.

In addition to the cleanup plan for the 100-HR-3 and 100-KR-4 groundwater operable units, action is being taken to address waste sites that are the historic sources of groundwater contamination. Surface waste sites that are within the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, 100-KR-1 and 100-KR-2 Operable Units received wastes during previous operation of the reactors and their support facilities. Cleanup of waste sites in the 100-DR-1 and 100-HR-1 Operable Units have been addressed in a September 1995 interim action Record of Decision. The 100-DR-2, 100-HR-2,

100-KR-1 and 100-KR-2 Operable Units will be the subject of future Proposed Plans. The 100-IU-4 Operable Unit upgradient of 100-HR-3 includes the former Sodium Dichromate Barrel Landfill, which contained empty crushed barrels that had been used to store sodium dichromate. The 100-IU-4 Operable Unit was remediated in April 1992 through an Expedited Response Action and has been addressed in a previous proposed plan.

While many comments identified that protection of salmon is an effort worthy of this action, it was noted that adverse effects to other wildlife must be considered in this plan.

Aquatic toxicity tests for chromium have been conducted for a wide variety of species, and embryonic salmon and fry are among the most sensitive to hexavalent chromium. The chronic exposure standard used for this remedial action of 11 μ/L hexavalent chromium was established to be protective of aquatic life in general, not just embryonic salmon and fry. Field activities will be conducted in a manner to minimize adverse impacts to wildlife.

The issue of bioaccumulation of hexavalent chromium was identified as a concern.

The criteria and standards for chromium have been established such that the bioconcentration or bioaccumulation of hexavalent chromium that occurs at those concentrations does not endanger aquatic life.

There were comments regarding the disposal of resins contaminated with chromium and other contaminants and the ultimate migration of these contaminants resulting in a future replay of the current problems.

The resins will be treated prior to disposal if necessary to meet the waste acceptance criteria for the Environmental Restoration Disposal Facility. This treatment is intended to reduce the mobility of the contaminants. Hexavalent chromium reacts with the resins resulting in conversion to the less toxic and less mobile trivalent form.

The Nez Perce Tribe comments expressed a request and interest in future involvement in many technical aspects of the conduct of this interim action.

The Tri-Parties intend to continue our policy to consult with affected Native American Indian Tribes on a government-to-government basis. The Tri-Parties will also continue to consult with the Tribes as well as the other Natural Resource Trustees regarding natural resource issues associated with this remedial action.

A number of comments addressed costs associated with the remedial action. Several addressed choosing the most cost effective remedy while others indicated that one cannot put a price tag on the importance of protecting the Columbia River.

This ROD addresses both concerns. The ion-exchange pump-and-treat was identified as the most cost effective remedial action that is protective of human health and the environment. As planned, it also reduces chromium to concentrations that should protect the health of the aquatic system, including embryonic salmon and fry in nests in the river bottom gravels.

A commentor noted that the initial modeling to support remedial design were identified as not to be construed as quantitatively accurate or reliable as indicators of effectiveness or efficiency. This suggests the interim remedial action should be accomplished with design contingency, in order to assure successful remediation.

During remedial design, initial modeling will be refined to better estimate appropriate well positioning for plume capture. Also, as the system comes on line, operational and compliance monitoring will be conducted. When the actual response of the aquifer is known, the design may be altered as needed and approved/directed by EPA and Ecology to meet the remedial action objectives. Contingency in the initial design capacity will be included based on uncertainty in design assumptions.

Interest was expressed in some of the alternate technology testing that was identified in the Proposed Plans for information purposes (are not specifically mandated by this ROD).

Cost effective remedial technologies for groundwater remediation is an active area of practical research. Chromium and other toxic metals are a common problem and are frequently the target of such research effort. Several techniques identified in the Proposed Plans and others not specifically mentioned have been and are under way at Hanford. Many other techniques are being developed and tested at other areas. Should a different technique show promise as a substitute for the ion-exchange pump-and-treat, the Tri-Parties may convert to this method. If this change is fundamentally different than described in this ROD, an opportunity for public comment will be provided.

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TREATABILITY TEST PLAN FOR IN SITU REDOX MANIPULATION IN THE 100-HR-3 OPERABLE UNIT D-AREA

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January 1997

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ACRONYMS AND ABBREVIATIONS

ARAR	applicable or relevant and appropriate requirement(s)
ASTM	American Society for Testing and Materials
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
DOE	U.S. Department of Energy
DQO	data quality objective
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERA	expedited response action
ERC	Environmental Restoration Contractor
ERDF	Environmental Restoration Disposal Facility
ETF	Effluent Treatment Facility
HEIS	Hanford Environmental Information System
ICP	inductively coupled plasma
ISRM	in situ redox manipulation
MS	mass spectrometer
NEPA	*National Environmental Policy Act of 1969*
PSDB	project-specific database
QA	quality assurance
QAPjP	Quality Assurance Project Plan
QMP	Quality Management Plan
RL	U.S. Department of Energy, Richland Operations Office
RWP	radiation work permit
SAP	Sampling and Analysis Plan
TBD	to be determined
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
WAC	*Washington Administrative Code* or waste acceptance criteria
WHC	Westinghouse Hanford Company

1.0 INTRODUCTION

The Hanford Site is located in southeastern Washington (Figure 1-1). It was established in 1943 to produce plutonium for nuclear weapons using reactors and chemical processing plants. The 100 Area of the Hanford Site is located along the Columbia River and includes nine deactivated U.S. Department of Energy (DOE) nuclear reactors used for plutonium production between 1943 and 1987. Operations at the Hanford Site are now focused on environmental restoration and waste management. In November 1989, the U.S. Environmental Protection Agency (EPA) designated the 100 Area of the Hanford Site a Superfund site and placed it on the National Priorities List because of soil and groundwater contamination that resulted from past operation of the nuclear facilities. To organize cleanup efforts under Superfund, contaminated areas at the nine deactivated reactors were subdivided into areas called "operable units."

The 100-HR-3 Operable Unit is located in the north-central part of the Hanford Site along a section of the Columbia River known as the "Hanford Reach." This operable unit includes the groundwater underlying the 100-D/DR and 100-H Reactor Areas and the 600 Area in between (Figure 1-2). The 100-D/DR Area is the site of two deactivated reactors: the 100-D Reactor, which operated from 1944 to 1967, and the 100-DR Reactor, which operated from 1950 to 1965. The 100-H Reactor operated from 1949 to 1965.

During reactor operations, hexavalent chromium or chromate, in the form of sodium dichromate ($Na_2Cr_2O_7$), was used as an anticorrosion agent in the reactor cooling water. Large volumes of reactor coolant water, containing sodium dichromate and short-lived radionuclides, were discharged to retention basins for ultimate disposal in the Columbia River through outfall pipelines. Liquid wastes from other reactor operations (decontamination, water treatment, etc.) also contained significant quantities of hexavalent chromium. These wastes were discharged to the soil column at cribs, trenches, and french drains, or leaked from storage facilities. Contaminant plumes in groundwater resulted from these former waste disposal practices. Groundwater contaminated with hexavalent chromium is present beneath the 100-D/DR and 100-H Reactor Area and is flowing toward and entering into the Columbia River because of the natural water-table gradient (see Figure 1-3). Another area where high concentrations (> 1 ppm) of hexavalent chromium have recently been detected in the groundwater in the 100-HR-3 Operable Unit is along the western edge of the 100-D Area at Well 199-D4-1. The 199-D4-1 well was drilled following a characterization program that measured chromate concentrations in the sediments of the Columbia River along the 100-H and 100-D Areas. High concentrations were detected in the interstitial waters of the river sediments but there were no wells in the vicinity to characterize the groundwater plume. These groundwater seeps, with elevated hexavalent chromium concentrations, pose a risk to aquatic organisms in the Columbia River adjacent to the 100-D/DR and 100-H Areas.

In Situ Redox Manipulation (ISRM) technology involves creating a permeable subsurface treatment zone to reduce chromate in groundwater. An unconfined aquifer is usually an oxidizing environment; therefore, most of the contaminants that are mobile in the aquifer are those that are mobile under oxidizing conditions. If the redox potential of the aquifer can be made reducing, then a variety of contaminants could be treated.

The goal of the ISRM treatability test is to create a subsurface permeable treatment zone for remediation of chromate contamination in aquifers. This permeable treatment zone is created by reducing the ferric iron (Fe^{3+}) to ferrous iron (Fe^{2+}) within the aquifer. This is accomplished by

injecting sodium dithionite into the aquifer and withdrawing unreacted reagent and reaction products. The sodium dithionite serves as a reducing agent for iron, changing ferric iron to ferrous iron within the unconfined aquifer sediments. Chromate ($Cr_2O_7^{2-}$), which is anionic in nature and soluble in groundwater, contains hexavalent chromium, Cr^{6+}. The altered subsurface environment containing the reduced iron will then act upon the Cr^{6+} species, reducing it to Cr^{3+}, which will then precipitate from the groundwater as $Cr(OH)_3$, thereby immobilizing the chromium.

1.1 PURPOSE AND SCOPE

The *Proposed Plan for Interim Remedial Measure at the 100-HR-3 Operable Unit* (DOE-RL1995b) identified the preferred alternative for an interim remedial measure at the 100-HR-3 Operable Unit. The preferred alternative is to pump contaminated groundwater from the 100-HR-3 Operable Unit, treat it by ion exchange, and dispose of treated groundwater by using upgradient injection wells to return it to the aquifer. The proposed plan also considered the possibility that alternative technologies could immobilize hexavalent chromium in the aquifer without pumping and treating. One of those technologies, ISRM, would immobilize hexavalent chromium by changing the soil and water chemistry in the aquifer and reducing the chromium to the less toxic and less mobile trivalent form. The ISRM technology offers promise of preventing the movement of hexavalent chromium to sensitive ecological receptors, without creating the secondary waste associated with surface treatment technologies while reducing the need for long-term operation and maintenance compared to pump and treat. ISRM technology could result in substantial cost savings as compared to pump-and-treat methods of groundwater plume remediation.

In general, the ISRM technology changes the redox potential of the groundwater through subsurface injection of chemical reducing agents. The chemical agents reduce the naturally occurring ferric iron found within the clay minerals of the aquifer sediments. Reagent and reaction products can be removed (withdrawn) from the subsurface after the aquifer sediments are reduced. Redox-sensitive contaminants migrating through this reduced zone (treatment zone) are in turn reduced and immobilized or degraded. This treatability test will demonstrate the ISRM technology on a pilot scale in the 100 Area. Reduction of ferric iron will be accomplished by injecting and withdrawing aqueous sodium dithionite into the aquifer. Hexavalent chromium in the groundwater moving through this zone will be reduced to the less soluble and less toxic trivalent form of chromium.

Pacific Northwest National Laboratory (PNNL), the developer of the ISRM technology, has conducted experiments to test the viability of the ISRM technology (see Fruchter et al., 1994, 1995, and 1996). These experiments have included a range of tests from bench-scale to field-scale testing. The ISRM Project began in fiscal year (FY) 1992 through DOE's Office of Health and Environmental Research - Subsurface Science Program. As part of this ISRM project, laboratory proof-of-principle abiotic and biotic studies, conceptual design reports, and preliminary planning documents were prepared (Fruchter et al. 1995). The potential for a remediation technology based on in situ manipulation of subsurface redox conditions has been established through theory and proof-of-principle laboratory experiments. However, attempts to control redox potential in an aquifer must overcome various scale-up complications arising from the interaction between contaminants, reducing agents, groundwater, and the natural variability of the subsurface. In FY 1994, a site at 100-H Area was selected for field-scale experiments of the ISRM technology. The laboratory and design studies as well as the FY 1994 and 1995 field tests were funded through

DOE's Office of Technology Development's In Situ Remediation Integrated Program. Results of these experiments will be used to design this full-scale field demonstration.

The specific objective of this demonstration project is to gather information pertinent to the full-scale implementation of the technology. In order to be accepted as a method of remediation under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), a technology must be evaluated on the basis of nine criteria of interest, as discussed below.

The nine criteria the EPA uses to identify its preferred alternative for a given site include two "threshold" criteria, five "balancing" criteria, and two "modifying" criteria. To be selected, an alternative must first meet the threshold criteria. The balancing criteria are used for comparing alternatives and selecting a preferred alternative. After public comment, the EPA may alter its preference on the basis of two modifying criteria (which will not be addressed by this treatability test).

Threshold Criteria:

1. **Overall Protection of Human Health and the Environment** - How well does the alternative protect human health and the environment, both during and after construction?

2. **Compliance with Applicable or Relevant and Appropriate Requirements** - Does the alternative meet all federal and state applicable or relevant and appropriate requirements (ARARs)?

Balancing Criteria:

3. **Long-Term Effectiveness and Permanence** - How well does the alternative protect human health and the environment after completion of cleanup? What, if any, risks will remain at the site?

4. **Reduction of Toxicity, Mobility, or Volume Through Treatment** - Does the alternative effectively treat the contamination to significantly reduce the toxicity, mobility, and volume of the hazardous substances?

5. **Short-Term Effectiveness** - Are there potential adverse effects to either human health or the environment during construction or implementation of the alternative? How quickly does the alternative reach the cleanup goals?

6. **Implementability** - Is the alternative both technically and administratively feasible? Has the technology been used successfully on other similar sites?

7. **Cost** - What are the estimated costs of the alternative?

Modifying Criteria:

8. **State Acceptance** - What are the state's comments or concerns about the alternatives considered and about EPA's preferred alternative? Does the state support or oppose the preferred alternative?

9. **Community Acceptance** - What are the community's comments or concerns about the preferred alternative? Does the community generally support or oppose the preferred alternative?

This treatability test will provide data that pertain to the first seven criteria.

1.2 TEST SITE SELECTION

Site selection for implementing the ISRM treatability study involved data evaluation of areas where chromate (Cr^{6+}) is present in the unconfined aquifer. Chromate concentration was the foremost consideration for locating the test site. Available groundwater data did not specifically identify chromate concentrations, but filtered, total chromium concentrations. Since hexavalent chromium is much more soluble in water than the trivalent form, hexavalent chromium is assumed to predominate.

Sodium dichromate was used during reactor operations as an anticorrosion agent and also for decontamination activities. As a result of these operations, chromium has been detected in groundwater at the 100-F, 100-D, and 100-H Areas, where these activities took place. Recent data indicates that chromium at 100-D exists in concentrations >1,000 ppb (see Figure 1-3), specifically in the 105-D Reactor area and on the western side of D Area in a well drilled in October 1996 (199-D4-1).

Based on the chromium concentration in the aquifer recently detected in Well 199-D4-1 and its proximity to the Columbia River (0.15 km [~ 500 ft]), this area was chosen as the principal location for implementing the ISRM treatability study. However, subsurface data from this area are needed to determine orientation and depth of barrier relative to the chromate plume. Additional subsurface data would include:

- Sufficient ferric iron present in aquifer sediments
- Chromate concentration in areas around Well 199-D4-1
- Lateral extension of confining unit
- Hydraulic Conductivity of aquifer
- Hydraulic gradient
- Physical properties of aquifer sediment (porosity, grain size distribution)

1.3 SITE DESCRIPTION

The 100-HR-3 Groundwater Operable Unit is located in the 100 Area of the Hanford Site and comprises the 100-H Area, the 100-D Area, and the 600 Area between the two (Figure 1-2). The 100-D Area is located in the 100-HR-3 Groundwater Operable Unit and consists of a site of past reactor operations, 105-D and 105-DR. Because of the nature and extent of these past practices, chromium contamination is present in groundwater in concentrations exceeding regulatory limits and has been determined to be a contaminant of potential concern (DOE-RL 1993). The 100-D Area is a focal point for groundwater remediation.

1.3.1 Geology

Geologic information for the site is based on the borehole log from well 199-D4-1. In this 32 m (105 ft) deep borehole, the Hanford formation is present from 0-17m (0-55 ft); a coarse-grained unit of the Ringold Formation is present from 17 m-30 m (55-98 ft); and a fine-grained unit of the Ringold Formation is present from 30 m - 32 m (98-105 ft) as shown in Figure 1-4. Hanford formation sediments encountered consist of 0.6 m - 3.4 m (2-11 ft thick) interbedded sand and sandy gravel layers. Coarse-grained Ringold Formation deposits underlie the Hanford formation; these deposits consist of sandy gravels to sandy silty gravels. Based on previous work in the 100-HR-3 Operable Unit by Lindsey and Jaeger (1993), these gravels probably represent Unit E of the Ringold formation as defined by Lindsey (1991, 1995). Underlying the Unit E gravels is a pale brown silty clay. This silty clay probably represents overbank-paleosol deposits; these overbank-paleosol deposits stratigraphically overlie the Ringold lower mud unit within the 100-D Area (Lindsey and Jaeger 1993).

1.3.2 Hydrogeology of the Unconfined Aquifer

The unconfined aquifer is approximately 4.9 m (16 ft) thick beneath the site and is contained within the sandy gravels and silty sandy gravels of the Ringold Formation, Unit E. A overbank-paleosol facies of the Ringold Formation, represented by a silty clay, forms the base of the upper unconfined aquifer. Limited hydrologic information is available for well 199-D4-1. This information is limited a specific capacity measurement of 50 L/Min/m obtained during well development activities (Johnson et al. 1996). A summary table of hydrogeologic information for well 199-D4-1 is shown in Table 1-1.

The hydraulic gradient (direction and magnitude) in the area of well 199-D4-1 has not been characterized due to the limited number of wells in the area. Given the proximity of the area to the Columbia River, the groundwater flow is assumed to be toward the river (toward the Northwest).

1.3.3 Groundwater Contamination

A table of groundwater data for well 199-D4-1 is shown in Table 1-2. Elevated constituents in this table consist of chromium (908 µg/L, filtered; 957 µg/L, unfiltered) and nitrate (58.4 mg/L). These values for chromium and nitrate are above the maximum contaminant levels (MCL) for these constituents (100 µg/L and 45 mg/L, respectively).

A plume map of chromium concentrations in the 100-D Area is shown in Figure 1-3. The plume is not well defined in the area of Well 199-D4-1. Potential sources for the chromate contamination in the western portion of the D-Area include leaks from the Sodium Dichromate Transfer Station and the associated french drain, the Process Sewer (100-DR process sewer) used to discharge wastes from the 183-DR and 190-DR water treatment facilities (sodium dichromate preparation for reactor coolant water), and/or the four 3.75 million gallon tanks (190-DR) used to store sodium dichromate solutions prior to use for reactor cooling. The 190-DR tanks have been removed and the area was subsequently used for a pit burial ground (126-DR-1). This use of this burial ground was discontinued due to potential chromate contamination of the soil and uncontrolled dumping (Carpenter, 1993, p. 5-18). A description of all these facilities can be found in Carpenter, 1993.

During reactor operations in the D-Area, very large quantities of cooling water from the reactors was discharged into leaking retention basins to provide for a "cooling off" period prior to discharge into the river. The groundwater flow direction was altered by the groundwater mounds created by

this discharge into retention basins (from the adjacent N-Area also). An analysis of the historical groundwater flow directions in the D-Area was conducted by Connelly (1997). This analysis showed that the extensive groundwater mounding in the northeast portion of the D-Area added a western component to the groundwater flow directions in the western side of the D-Area during reactor operations. Thus, potential sources of the chromate plume detected at 199-D4-1 could be located further to the east than that which would be inferred from the current (i.e., post-reactor operations) water table and could include any or all of the potential sources already discussed.

1.4 PREVIOUS TREATABILITY STUDIES

A previous treatability study conducted at the 100-HR-3 Operable Unit was the pilot-scale pump-and-treat system. Initially bench tested, this ion-exchange type system was implemented at the 100-D Reactor area in August 1994 for treating chromate-contaminated groundwater in response to a Tri-Party Agreement milestone (Ecology et al. 1990). The test was conducted in two phases: phase one, operation of the pump-and-treat system 8 hr/day and 5 days/week; and phase two, operation of the pump-and-treat system 24 hr/day and 7 days/week.

The objective of the pilot-scale demonstration was to determine the feasibility of the pump-and-treat system in treating chromium-contaminated groundwater. The test location was chosen at 100-D because high concentrations of chromium are present in the groundwater. The pump-and-treat extraction and injection network was set up using existing wells located in the 100-D/DR Reactor area. These existing wells were constructed as monitoring wells and were not specifically constructed for this pilot-scale study. Wells 199-D5-14, 199-D5-15, and 199-D5-16 were selected for extraction wells because of their location within the downgradient side of the chromium plume. Wells 199-D5-18 and 199-D5-19 were selected as injection wells within the upgradient side of the chromium plume.

The primary objective of the pump-and-treat pilot-scale treatability test was to determine the feasibility of treating chromium-contaminated groundwater to <50 ppb. The drinking water standard for chromate is 50 ppb as determined by the *Washington Administrative Code* (WAC), Chapter 173-200. The chromium-contaminated groundwater is extracted and treated ex situ using a strong base resin. Once the groundwater is treated ex situ, it is injected back into the aquifer via wells 199-D5-18 and 199-D5-19, upgradient of the chromium plume.

The pump-and-treat system was initially designed to operate manually on a 5-days/week, 8-hr/day basis. It was later reconfigured to operate automatically on a continuous basis. Phase I (manual) operations began on August 26, 1994, and lasted until November 14, 1994. Phase II (automated) operations were initiated March 21, 1995, and were ended in the summer of 1996.

The system was able to accomplish its primary objective, which was to achieve an effluent concentration of <50 ppb chromate. As of November 1, 1995, the total mass of hexavalent chromium removed was 29.9 kg (65.8 lb), which is approximately 9% to 14% of the total mass of chromate that was estimated to be in the plume. The objectives and results of the Phase I and II operations are summarized in *The Pilot-Scale Treatability Test Summary for the 100-HR-3 Operable Unit* (DOE-RL 1995c).

97/3541.1205

Figure 1-1. Hanford Area Site Map.

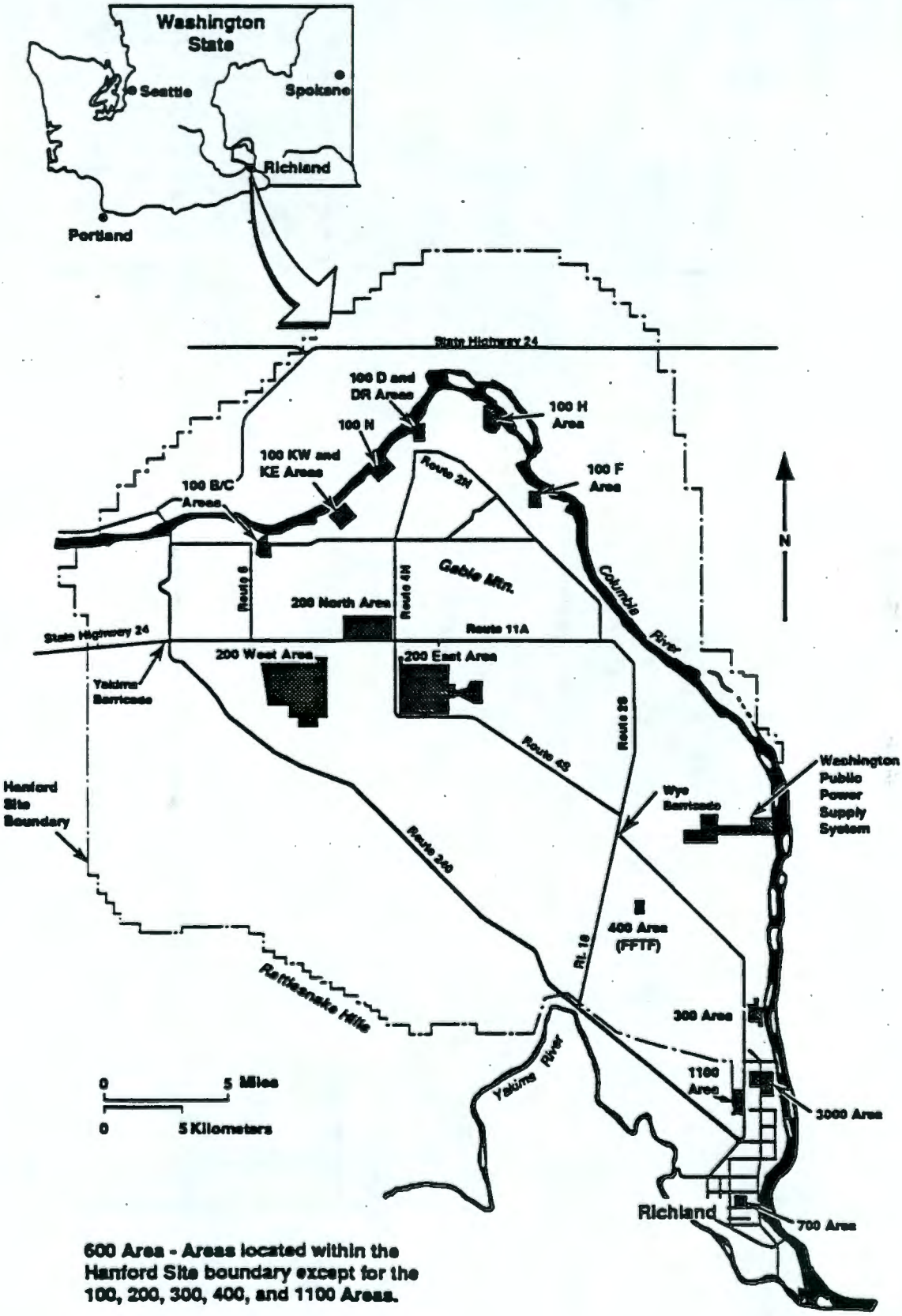
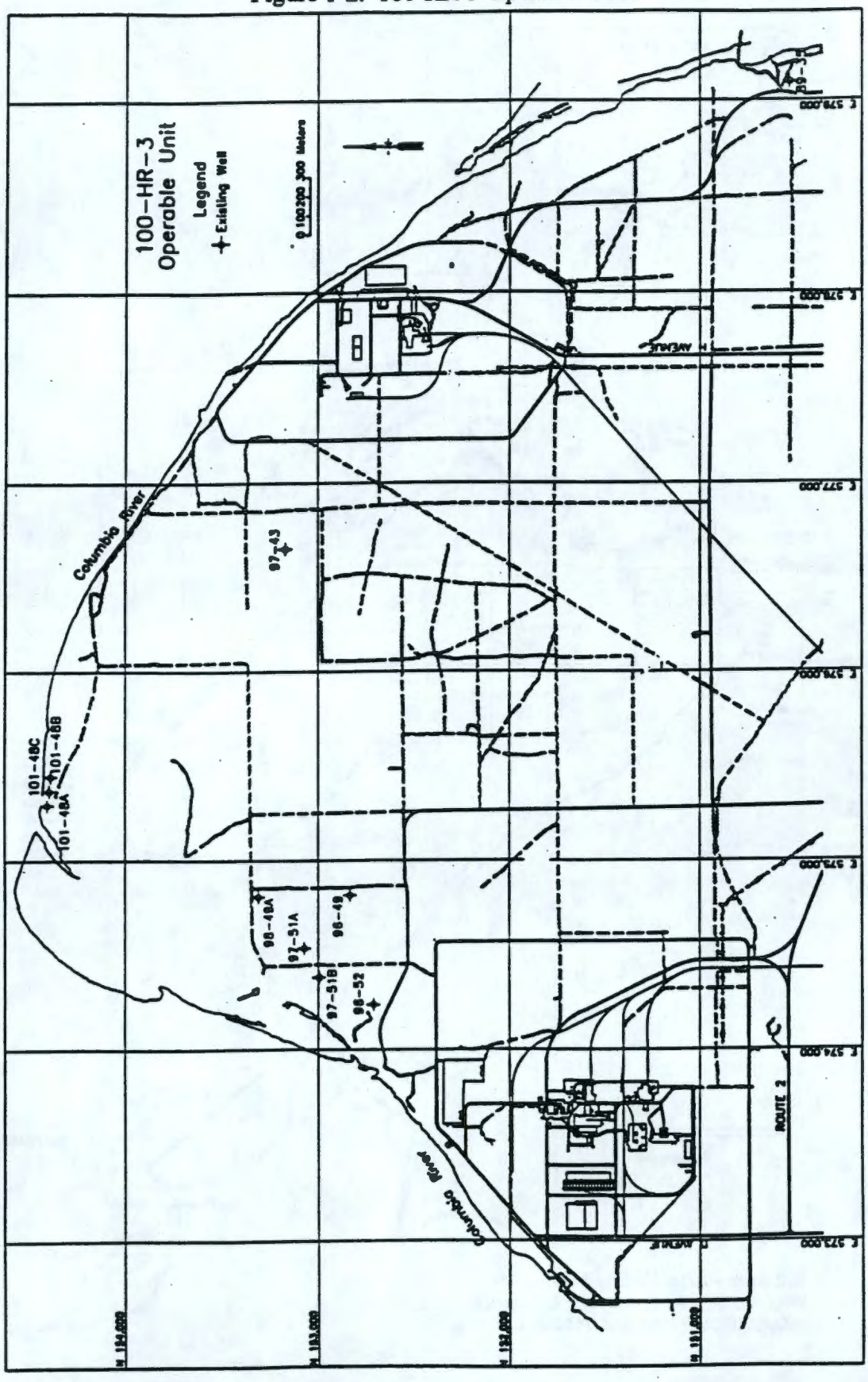


Figure 1-2. 100-HR-3 Operable Unit.



9713541.1206

Figure 1-3. 100-D Area Chromium (VI) Groundwater Contaminant Plume.

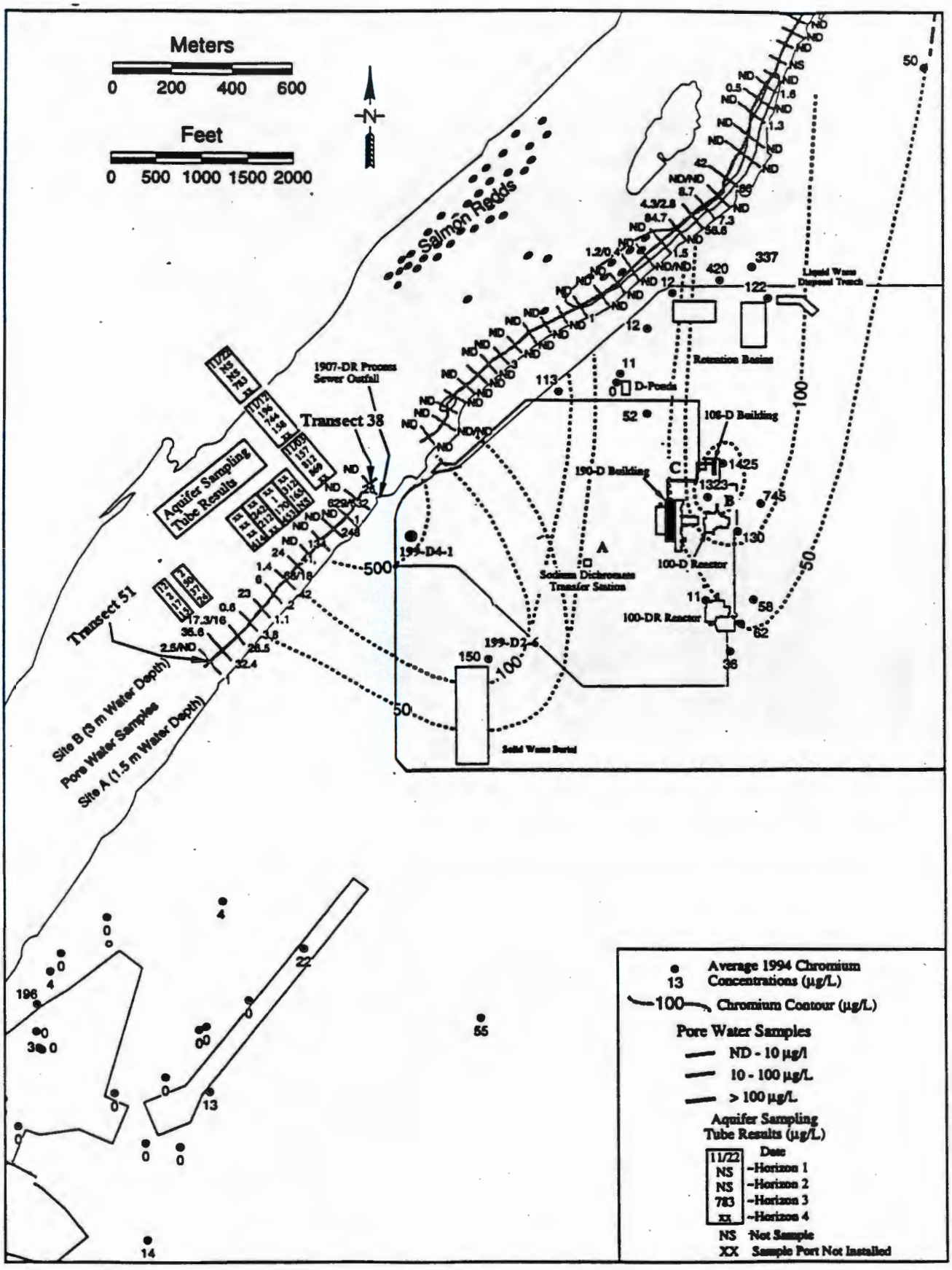


Figure 1-4. Geologic log of well 199-D4-1.

WELL SUMMARY SHEET

Boring or Well No. 199-D4-1

Sheet 1 of 1

Location ~2 mile west of D Reactor

Project 100-HR-3 IRM

Reviewed By Edward C. LaFrac / Edward C. LaFrac 10/31/96

Prepared by L.D. Walker / L.D. Walker

CONSTRUCTION DATA: Description	CONSTRUCTION DATA: Diagram	Depth in Feet	GEOLOGIC/HYDROLOGIC DATA: Graphic Log	GEOLOGIC/HYDROLOGIC DATA: Lithologic Description
				0-2': Sandy Gravel (sG)
				2'-5': Silty Sand (mS)
		10		5'-10': Sandy Gravel (sG)
Cement Grout: 0-64.8'				10'-13': Sand (S)
		20		13'-23': Sandy Gravel (sG)
				23'-27': Sand (S)
		30		27'-30': Sandy Gravel (sG)
6" stainless steel casing: +.60'→ 74.65'				30'-41': Sand (S)
		40		41'-55': Sandy Gravel (sG)
				Hanford-Ringold contact: 55'
		50		
10-20 silica sand: 64.8'-67.4'				
6-12 silica sand: 67.4'-70.2'		60		55'-70': Sandy Gravel (sG)
4-10 silica sand: 70.2'-104.9'				
		70		
				70'-80': Silty Sandy Gravel (msG)
6" stainless steel wire wrap		80		
0.060 slot screen: 74.65'-94.67'				80'-95': Sandy Gravel (sG)
		90		
				95'-98': Silty Sandy Gravel (msG)
Bottom of 6" stainless steel tailpipe: 97.72'		100		98'-105': Silty Clay (M)
		110		TD = 105'
				Water Level = 81.90' (10-30-96)
Depths are measured from ground surface				

A-6000-384 (01/93)

Table 1-1. Summary of available hydrogeologic information for well 199-D4-1.

PARAMETER	VALUE
Depth to Water Table	25.0 m (81.9 ft)
Depth to top of Ringold Formation, Unit E (from ground surface)	17 m (55 ft)
Depth to top of Ringold, overbank-paleosol facies (from ground surface)	30 m (98 ft)
Saturated thickness of aquifer	4.9 m (16 ft)
Dominant aquifer lithology	Sandy Gravel to Silty Sandy Gravel
Lithology of aquifer lower boundary (Ringold fine grained facies)	Silty Clay
Surface Elevation	143.13 m (469.59 ft)
Specific Capacity	50 L/Min/m

Table 1-2. Groundwater data for well 199-D4-1.

WELL NAME	SAMP DATE TIME	SCN LONG NAME	SAMP FILTERED	VALUE RPTD	QUALIFIER	ANAL UNITS RPTD	COUNTING ERROR
199-D4-1	10/31/96 11:52	Aluminum	N	238		ug/L	
199-D4-1	10/31/96 11:52	Aluminum	Y	58.5	U	ug/L	
199-D4-1	10/31/96 11:52	Antimony	N	32.5	B	ug/L	
199-D4-1	10/31/96 11:52	Antimony	Y	41.8	B	ug/L	
199-D4-1	10/31/96 11:52	Barium	N	75.8	B	ug/L	
199-D4-1	10/31/96 11:52	Barium	Y	73.4	B	ug/L	
199-D4-1	10/31/96 11:52	Beryllium	N	0.4	U	ug/L	
199-D4-1	10/31/96 11:52	Beryllium	Y	0.4	U	ug/L	
199-D4-1	10/31/96 11:52	Cadmium	N	3	U	ug/L	
199-D4-1	10/31/96 11:52	Cadmium	Y	3	U	ug/L	
199-D4-1	10/31/96 11:52	Calcium	N	81200		ug/L	
199-D4-1	10/31/96 11:52	Calcium	Y	77700		ug/L	
199-D4-1	10/31/96 11:52	Chloride	N	26.7		mg/L	
199-D4-1	10/31/96 11:52	Chromium	Y	908		ug/L	
199-D4-1	10/31/96 11:52	Chromium	N	957		ug/L	
199-D4-1	10/31/96 11:52	Cobalt	Y	3	U	ug/L	
199-D4-1	10/31/96 11:52	Cobalt	N	3	U	ug/L	
199-D4-1	10/31/96 11:52	Copper	Y	13.9	B	ug/L	
199-D4-1	10/31/96 11:52	Copper	N	14.4	B	ug/L	
199-D4-1	10/31/96 11:52	Fluoride	N	0.14		mg/L	
199-D4-1	10/31/96 11:52	Gross alpha	N	0.994	U	pCi/L	0.801
199-D4-1	10/31/96 11:52	Gross beta	N	7.6		pCi/L	1.89
199-D4-1	10/31/96 11:52	Iron	Y	13.7	BE	ug/L	
199-D4-1	10/31/96 11:52	Iron	N	329	E	ug/L	
199-D4-1	10/31/96 11:52	Magnesium	N	18200		ug/L	
199-D4-1	10/31/96 11:52	Magnesium	Y	17400		ug/L	
199-D4-1	10/31/96 11:52	Manganese	Y	6.8	B	ug/L	
199-D4-1	10/31/96 11:52	Manganese	N	21.5		ug/L	
199-D4-1	10/31/96 11:52	Nickel	Y	13.4	U	ug/L	
199-D4-1	10/31/96 11:52	Nickel	N	13.4	U	ug/L	
199-D4-1	10/31/96 11:52	Nitrate	N	58.4		mg/L	
199-D4-1	10/31/96 11:52	Potassium	Y	5160		ug/L	
199-D4-1	10/31/96 11:52	Potassium	N	3430	B	ug/L	
199-D4-1	10/31/96 11:52	Silver	Y	6.6	U	ug/L	
199-D4-1	10/31/96 11:52	Silver	N	6.6	U	ug/L	
199-D4-1	10/31/96 11:52	Sodium	Y	8820		ug/L	
199-D4-1	10/31/96 11:52	Sodium	N	9270		ug/L	
199-D4-1	10/31/96 11:52	Sulfate	N	109		mg/L	
199-D4-1	10/31/96 11:52	Tritium	N	438		pCi/L	158
199-D4-1	10/31/96 11:52	Vanadium	Y	14.2	B	ug/L	
199-D4-1	10/31/96 11:52	Vanadium	N	15.1	B	ug/L	
199-D4-1	10/31/96 11:52	Zinc	Y	50.4		ug/L	
199-D4-1	10/31/96 11:52	Zinc	N	49.1		ug/L	

Table 1-2. Groundwater Chemistry for Well 199-D4-1.

2.0 TREATMENT TECHNOLOGY DESCRIPTION

The ISRM approach is to be implemented as an innovative treatability test to inhibit the spread of redox-sensitive contaminants by reducing the potential for contaminant migration in the aquifer. A multi-scale approach, including bench-scale and field-scale experiments, was used during development of the ISRM technology. The intent of ISRM involves constructing a permeable subsurface treatment zone to determine feasibility and compare costs with existing remediation technologies.

2.1 TREATMENT CHEMISTRY

The redox altering reagent to be injected is sodium dithionite ($Na_2S_2O_4$). The dithionite (also commonly known as hydrosulfite) ion ($S_2O_4^{2-}$) in the injection solution is a strong reductant, particularly in strongly basic solutions (Amonette et al. 1994). This ion dissociates:

$$S_2O_4^{2-} \Leftrightarrow 2\ SO_2^{\bullet-}$$

into sulfoxyl radicals ($SO_2^{\bullet-}$), which are strong and highly reactive reductants. According to Amonette et al. (1994), reduction reactions with the dithionite ion typically involve two steps:

1. Dissociation of the ion to form the two $SO_2^{\bullet-}$ radicals
2. Reaction of these radicals with the oxidized species [e.g., Fe(III) contained in layered silicate and oxide minerals] yields a reduced species [e.g., Fe(II) contained in layered silicate minerals or as a soluble species (Fe^{2+})] and sulfite (SO_3^{2-}) or bisulfite (HSO_3^-).

Because sulfoxyl radicals ($SO_2^{\bullet-}$) are highly reactive, the dissociation of the dithionite ion ($S_2O_4^{2-}$) is the slow or rate-limiting step in most reactions.

2.1.1 Reduction Reactions

The desired reduction reaction with the dithionite ion takes place very quickly; half-life of the reaction based on laboratory data is on the order of 1 to 3 hr with sediments typically found at Hanford (both Ringold and Hanford formation sediments). The available ferric iron [Fe(III)] in the sediments of the aquifer is reduced to ferrous iron [Fe(II)] by the following reaction:

$$SO_2^{\bullet-} + Fe(III) + H_2O \Leftrightarrow SO_3^{2-} + Fe(II) + 2\ H^+.$$

The most available/accessible forms of iron in the subsurface sediments occur in those mineral phases (i.e., iron oxyhydroxides and iron-bearing layer silicates) with the highest specific surface areas (Amonette et al. 1994). It is desirable for the reduced iron species [i.e., Fe(II)] to remain in place, so the clay- and silt-sized iron-bearing layer silicates are being targeted because the iron in this mineral phase is retained in the mineral structure regardless of its oxidation state (Stucki 1988, Scott and Amonette 1988). In contrast, the iron oxyhydroxide mineral phase dissolves when its

iron is reduced unless there is sufficient carbonate for siderite ($FeCO_3$) to precipitate (Amonette et al. 1994).

Samples of Ringold Formation sediments taken from well 199-D5-19 at depths ranging from 22.4 m to 29 m (73.5 to 95 ft) indicate that ferric iron averages about 0.88% based on the maximum assumption of 19 wt% clay.

2.1.2 Disproportionation Reaction

The dithionite ion is not stable in acidic or neutral pH aqueous solutions for long periods. In addition to the reduction reactions discussed above, the dithionite ion undergoes a disproportionation reaction that yields thiosulfate, $S_2O_3^{2-}$, and bisulfite, HSO_3^-:

$$2\ S_2O_4^{2-} + H_2O \Leftrightarrow 2\ HSO_3^- + S_2O_3^{2-}.$$

This disproportionation reaction rate is slower than the reduction reaction rates discussed above and depends on the nature of the mineral surfaces encountered. Estimates of the reaction half-life based on laboratory experiments are on the order of 10 to 20 hr. The byproducts of both the reduction and disproportionation reactions (i.e., sulfites, bisulfites, and thiosulfates) all eventually oxidize (at much slower rates) to yield sulfate.

2.1.3 Composition of Reagent Solution to be Injected

The reagent solution to be injected is composed of sodium dithionite with a potassium carbonate/bicarbonate buffer. The buffer is used to maintain a relatively high pH because it enhances dithionite stability. The composition of the injected reagent for the experiment is typically 0.1 M sodium dithionite ($Na_2S_2O_4$), 0.4 M potassium carbonate (K_2CO_3), and 0.04 M potassium bicarbonate ($KHCO_3$). The pH of the injection solution is ~11 with a density of 1.06 g/cm^3.

2.1.4 Chromium Reduction, Groundwater Deoxygenation, and Metals Mobilization

Once a redox zone has been emplaced, the reduced iron in the sediments treated with dithionite will act to reduce the mobile Cr(VI) phase of chromium (CrO_4^{2-}) in migrating groundwater at a chromium-contaminated site. The reduction reaction converts the mobile phase to a precipitated Cr(III) phase [$Cr(OH)_3$] as follows:

$$3\ Fe(II) + CrO_4^{2-} + 5\ H^+ \Leftrightarrow Cr(OH)_{3\ (s)} + 3\ Fe(III) + H_2O\ .$$

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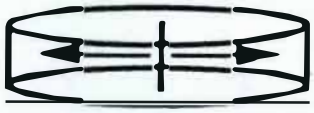
Figure 2-1. Scale of Experiments Performed in Support of the In Situ Redox Manipulation Experiment Showing the Progression from Bench-Scale Batch Studies Through the 100-H Area Field Experiment. Also shown is the pilot-scale treatability study for the 100-D Area planned for FY 1997.

	Objective	Experiment
Bench-Scale	• Identify geochemical reactions • Quantify reaction constants & rates • Reaction rates in flowing column	 Batch
Intermediate-Scale	• Clay/oxide movement • Reaction rates in radial flow field • Aquifer Clogging • Test field-scale operations • Trace metal mobilization	 1-D column Quasi-radial (15 m long small diameter(s) tubes) 7 m long wedge (radial, 11° arc)
Field-Scale	• Demonstrate application in small natural system • Reaction rates at field-scale (FY -95) • Demonstrate application in contaminated aquifer (FY-96 in progress)	 10 m radial injection (single injection well 14 monitoring wells) 60 m long multiple-well permeable treatment zone

The reduced sediments at the experimental site will remove any dissolved oxygen in the migrating groundwater by the following reaction:

$$4\ Fe(II) + O_2 + 4\ H^+ \Leftrightarrow 4\ Fe(III) + 2\ H_2O\ ,$$

which is very fast. As a result, there will be a deoxygenated plume of groundwater in and downstream of the redox zone. The magnitude of the deoxygenated plume will be diminished from the effects of dispersion and potential mixing of oxygen from the vadose zone. This reoxygenation of the plume is expected to be enhanced near the river as a result of water table fluctuations related to river stage variations.

In the same way that some reduced iron mineral phases are mobilized by reduction reactions (e.g., the iron oxyhydroxides discussed above), other metals in the mineral phases of the sediments may be mobilized by reduction reactions. Additionally, the change in pH and concentration conditions that exist during the injection, residence, and first few pore volumes of the withdrawal phase may result in a change in the adsorption properties of the sediment surfaces, and thus sorbed metals and radionuclides could be released and mobile metals could be sorbed. As the withdrawal stage continues, the injected reagent and buffers as well as any of the mobilized metals will be removed with the withdrawn fluid, and the pH and other concentration conditions in the aquifer sediments and fluids will return to normal. The redox conditions, however, will remain in the altered state because of the presence of the reduced iron [Fe(II)] in the structure of the clay- and silt-sized iron-bearing layer silicates of the aquifer sediments. Any mobilization of metals caused by reactions with the reagent or the altered conditions, other than the redox, should cease once the withdrawal stage is complete (i.e., when 4 to 5 pore volumes of natural groundwater have been flushed through the reacted sediments).

2.2 COMPLETED STUDIES

The ISRM technology was developed by PNNL with funding from the DOE's Office of Technology Development and the Office of Environmental Restoration. The basic strategy used to develop the ISRM technology was a phased approach wherein successively larger scale and more complex experiments were conducted, as shown in Figure 2-1. Each successively larger scale experiment was used to isolate effects related to each scale of experiment and to better design the next larger scale experiment to be undertaken. These experiments ranged from bench-scale batch and column experiments to an intermediate-scale, 7-m wedge (almost field-scale) experiment at Oregon State University to a field experiment at 100-H Area conducted during the summer of 1995. Results of these studies are described in Fruchter et al., 1996.

3.0 PERFORMANCE AND DATA QUALITY OBJECTIVES

The treatability test will provide the necessary data from which to evaluate the viability of the ISRM treatment technology.

3.1 TEST PERFORMANCE OBJECTIVES

Several data quality objective (DQO) workshops were held with the decision makers [DOE, Richland Operations Office (RL), Washington State Department of Ecology (Ecology), and EPA], and the following specific objectives for the treatability test were formulated.

•**Chromate concentration reduction.** The test should demonstrate a quantifiable reduction in the level of chromate contamination in the aquifer.

•**Cost comparisons.** Data need to be gathered to develop a cost model that can be used to compare the ISRM technology against conventional alternatives such as pump and treat. Cost comparisons should be performed on a unit cost basis (i.e., cost per unit mass of chromate reduction). Cost data need to be gathered to determine the economies of scale-up. It was considered that determination of the removal efficiency in percent may be necessary for comparability to other projects. This would be a relative performance standard, rather than a regulatory standard. Costs and efficiency will have to be compared with those of the 100-HR-3 pump-and-treat system. Cost data should be estimated on a total life-cycle cost basis and will include such factors as construction costs, operational and maintenance costs, and costs for re-injection for maintaining the reductive capacity of the treatment zone.

•**Mass reduction.** The test should be conducted on such a scale that a significant reduction in the mass of chromate in the aquifer can be achieved.

•**Implementability information.** The test should be conducted so that the technical feasibility of forming a treatment zone on a large scale can be assessed.

•**Determination of long-term effectiveness.** The test needs to gather data concerning the long-term viability of the technology. The stability of the treatment will be a major measure of success. There would be a determination of whether periodic treatments (i.e., re-injection of reducing agent) were needed. Monitoring intervals for this determination need to be established. Degradation curves, derived from monitoring of water and from soil cores, would provide input data. Bench-scale experiments with sediment collected from the treatment zone will be used to predict long-term performance.

•**Minimizing waste.** The test should be conducted to minimize waste. The treatment zone should be constructed such that it can be part of the large-scale treatment zone if the test proves successful.

•**Evaluation of long- and short-term time factors.** The test should provide information on both the immediate effectiveness of the treatment and the long-term longevity of the treatment.

•**Community acceptance.** The test should provide enough data so that if the test proves that the technology is both technically and economically feasible, the technology can be presented to the community as an alternative to the conventional treatment methods in the proposed plan.

3.2 DATA QUALITY OBJECTIVES

This section summarizes the decisions that will be made in implementing the ISRM treatability test. Table 3-1 is a "roadmap" of how the treatment barrier will be designed and how its performance will be evaluated. The letter in the fourth column is keyed to Table 3-2. Table A-2 in the Sampling and Analysis Plan (Appendix A) is a set of data sheets that are keyed to these letters. Table A-2 indicates how each parameter of interest will be measured in terms of the analytical method, detection limits, and frequency of measurement.

The detailed design of the ISRM treatability test will be based on data gathered during the pre-design characterization data phase of the test. A total of four wells will be drilled during this activity. These wells will be used to gather data regarding the extent of Cr (VI) contamination and to collect data (hydrologic and physical properties of the sediments) to be used for the detailed design of the barrier around the 199-D4-1 well. Chapter 5.0 describes the drilling strategy and outlines in more detail how the barrier will be designed.

3.3 ANALYSIS REQUIREMENTS AND COMPARISON LEVELS

3.3.1 Statistical Evaluation of Groundwater Data

Statistical methods published by EPA for evaluation groundwater data are designed to (1) compare groundwater data from upgradient and downgradient wells for the purpose of detecting contamination from a waste management unit or (2) compare downgradient wells with a regulatory standard (e.g., maximum contaminant level).

Neither of these methods can be directly employed at the ISRM test site, because it is anticipated that the downgradient concentrations will be profoundly lower than those in the upgradient wells. For this reason, statistics designed to detect small differences in concentrations between wells have little application in this study. If the differences are not large, statistical tests may be needed to compare up- and downgradient compositions, and the tests of type 1 mentioned above are designed to do this. These take the form of the Student's t-test and analysis of variance (ANOVA) tests and are discussed in *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities* (EPA 1989). Alternatives to these tests are several nonparametric hypothesis tests that compare two or more data sets. These tests include the Wilcoxon Rank Sum, Kruskal-Wallis (for comparison of more than two data sets), and Quantile tests.

3.3.2 Comparison Levels

The Columbia River is the point of compliance for evaluating any effects from the treatment. A chromate concentration of 11 ppb is the target goal in the river. To account for dilution within the aquifer between the monitoring location on-shore and the aquatic receptor exposure point of concern within the river substrate, a dilution factor of 1:1 is assumed so that 22 ppb would be the goal at the monitoring point within the aquifer (reference: Record of Decision for the USDOE

Hanford 100-HR-3 and 100-KR-4 Operable Units Interim Remedial Actions). Measurements for chromate, sulfate, and dissolved oxygen between the treatment zone and the river will be major inputs for evaluating the success of the project.

Table 3-1. In Situ Redox Manipulation Key Decisions				
Primary Objective	Decision	Detailed Subobjectives	Activity (See Table 3-2)	Data Analysis Method
Design Barrier	Barrier location	Locate in area of high Cr^{6+} concentration (1,000 ppb)	A	Plot Cr^{6+} concentration on area map
		Locate perpendicular to hydraulic gradient	A	Plot gradient on area map
		Locate in accessible area	Visual & GPR	Plot features on area map
	Dimensions of barrier	Determine radial extent of injection influence	A and B	Reactive Transport injection/withdrawal model
Evaluate Barrier Performance	Laboratory performance	Determine reductive capacity of sediment	J	Measure ability of sediments to reduce Cr^{6+} and Dissolved Oxygen
		Determine reductive efficiency of field method	J	Compare Fe reduction achieved in field with reduction achieved under more favorable laboratory conditions
	Field performance	Spacial distribution of reactive capacity in sediments	J	Spacial plot of microscale laboratory results and lithology. Integrate into an average performance
		Reduction of Cr^{6+}	G and H	Comparison of pre-/post-emplacement and upgradient/downgradient of Cr^{6+}
	Long-term effectiveness[a]	Dissolved O_2 and Cr^{6+} concentration changes	H	Comparison of pre-/post-emplacement and upgradient/downgradient of dissolved O_2 and Cr^{6+} over time
	Side Effects	Aquifer Plugging	G and I	Natural Gradient Tracer Test and Comparison of results of hydrologic tests from before and after emplacement
		Dowgradient Dissolved O_2 impact	G and H	Comparison of pre-/post-emplacement and upgradient/downgradient concentrations
		Trace metals, Residual reagents, Decomposition products, pH	G and H	Comparison of pre-/post-emplacement and upgradient/downgradient concentrations
Economic Feasibility	Economic Evaluation	Design/installation costs	Installation Tracking	Optimize design based on observation of test emplacement and reactive transport modeling
Operation /maintenance costs	Determined from long-term performance	Estimate long-term needs for re-injection of reagent, monitoring	Project Cost Tracking	Budget, schedule, and actual costs will be tracked using Microsoft Project
Cost comparison	Develop cost model for ISRM	Life-cycle cost comparison of ISRM versus pump and treat	Life Cycle Cost Determination	Compare ISRM life cycle costs for comparison with pump and treat systems at the Hanford Site.

[a]Long-term effectiveness will also be assessed by comparing groundwater concentrations of Cr^{6+} and dissolved O_2 up and downgradient from the barrier, reductive capacity of the sediments, and groundwater velocity.

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Table 3-2. In Situ Redox Manipulation Data-Gathering Activities.

Key (See Table 3-1)	Activity	Main Purpose	Data Provided
A	Pre-Design Characterization Wells (4)	Locate barrier, Sediment and chromate characterization of site	Plan view contour maps of chromate and hydraulic head. Aquifer bottom, sediment analysis (porosity, grain size distribution, bulk density), accessible ferric iron and reaction rates, variability in lithology, contaminants of concern (e.g. nitrate)
B	Initial Hydraulic Test	Determine hydraulic properties of aquifer for design analysis	Hydraulic conductivity, specific storage, specific yield, well production rates
C	Injection/Withdrawal and Monitoring Well Installation	Drill wells for barrier emplacement and monitoring (2 Stages of drilling)	Aquifer bottom, variability in lithology (may also need to collect sediment samples to verify parameters collected during Activity A)
D	Background	Determine geochemical conditions at site (pre-emplacement)	Chromate, dissolved oxygen, trace metals, other contaminants of concern
E	Tracer Injection/Withdrawal Test	Determine injection and withdrawal volumes. Pre-emplacement hydraulic properties	Field-scale porosity, injection and pumping volumes and rates. Hydraulic properties
F	Emplacement	Reduce ferric iron in sediment	Dithionite, conductivity, pH, dissolved oxygen in wells. Trace metals and sulfur species in withdrawal water. Criteria analysis for disposal.
G	Post-Emplacement Characterization	Determine hydraulic and geochemical conditions at site (post-emplacement)	Comparison to data from background characterization (Activity E). Chromate, trace metals, residuals (sulfate, sulfite, thiosulfate, carbonate, K, Na), other contaminants of concern, hydraulic properties.
H	Up/Downgradient Chromate Monitoring (ongoing)	Monitor chromate concentrations across barrier	Chromate, dissolved oxygen, pH, conductivity in monitoring wells. Plots of chromate concentrations with time for each well. Upgradient vs. downgradient chromate concentration.
I	Performance Assessment Tracer Experiment	Effectiveness of chromate reduction	Demonstrate travel path through barrier, measure effectiveness of chromate (up vs. downgradient wells), travel time across barrier.
J	Coreholes (4)	Determine effectiveness of reduction - estimate lifetime	Reduction (treatment) capacity of sediment from wells at different locations. Distribution of treatment capacity (pore volumes).

Note: All wells at ISRM site will be measured for hydraulic head, chromate, dissolved oxygen, pH, and conductivity on a Monthly/Quarterly basis after installation to establish baseline data.

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4.0 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

In accordance with the EPA's *Guide to Conducting Treatability Studies Under CERCLA* (EPA 1992), onsite treatability tests may be conducted without any federal, state, or local permits (40 CFR 300.400[e][1]); however, such studies must meet applicable or relevant and appropriate requirements (ARARs) under federal or state environmental laws or be exempted by a waiver under CERCLA Section 121(d)(4).

The ISRM treatability test will occur in proximity to the Columbia River [approximately 0.15 km (500 ft)] in an area that is not expected to be culturally and ecologically sensitive. The test requires the construction of groundwater wells. The test also has the potential to generate wastes and wastewater. The major ARARs pertinent to this treatability test are groundwater standards, Columbia River Protection standards, cultural and ecological resource protection requirements, and waste and wastewater management standards.

4.1 GROUNDWATER STANDARDS

The ISRM test will inject and withdraw sodium dithionite into the groundwater to reduce ferric iron in the sediments. Contaminated groundwater currently discharges to the Columbia River. Water quality standards for groundwater (WAC 173-200) will be used to evaluate the performance of the test.

This treatability test will inject a buffered (pH 10.5) sodium dithionite solution into the aquifer. The pH of the aquifer will be temporarily affected (increased to 10.5 for ~24 hr) during the injection and residence stages of the test. The pH will return to normal levels as the majority of the dithionite solution is withdrawn and any residual dithionite is mixed with and diluted by other water in the aquifer. Once the sodium dithionite is withdrawn from the aquifer, the quality of the aquifer will be improved because of the reduction of the chromate and return to normal pH and, therefore, will meet the substantive requirements of WAC 173-218.

4.2 COLUMBIA RIVER PROTECTION STANDARDS

Technology-based limitations and standards, control of toxic pollutants, and monitoring for discharges to waters of the United States, including stormwater, are addressed in 40 CFR 122. Public Law 100-605, *To Authorize a Study of the Hanford Reach of the Columbia River and for Other Purposes*, is applicable to planning, designing, and locating activities in a manner that minimizes direct and adverse effects on the values for which the river is under study.

Treatment facilities will be located greater than a quarter mile from the river and out of sight from the river. No wastewater discharges to the Columbia River are planned as part of this test. Erosion controls will be used during site preparation and installation of injection/withdrawal wells. The potential for stormwater runoff from the test area is unlikely.

4.3 CULTURAL AND ECOLOGICAL RESOURCE PROTECTION STANDARDS

Cultural resource protection requirements apply because of the potential presence of significant archeological sites or artifacts in the 100-D Area. An initial cultural resource survey has been performed (Appendix B). The *National Historic Preservation Act of 1966* (16 USC 470) is applicable and requires federal agencies to take into account the effect of an activity on any significant cultural resource. The *National Archeological and Historical Preservation Act of 1974* (16 USC 461) is applicable and requires action to recover and preserve artifacts in areas where activity may cause irreparable harm, loss, or destruction of significant artifacts.

The *Endangered Species Act of 1973* (7 USC 136) prohibits activities that threaten the continued existence of listed species or destroy critical habitat. *The Migratory Bird Treaty Act* (16 USC 701-718h) is applicable to protection of migratory birds in the areas. The State of Washington implements the *Bald Eagle Protection Act* (16 USC 668) under the *Bald Eagle Protection Rules* (WAC 232-12-292). These rules are applicable due to the known roosting of bald eagles along the Columbia River. Although threatened and endangered species are known to be present in the 100 Areas, a biological survey has been conducted (Appendix B) and has identified no potential impacts on protected species or critical habitat.

4.4 WASTE AND WASTEWATER MANAGEMENT STANDARDS

Prior to the test, groundwater wells will be installed. Purgewater generated during the installation and development of these wells that exceed maximum contaminant levels will be contained, transported, treated, and disposed of using the Purgewater Modutanks. Another potential alternative for treatment and disposal of groundwater from aquifer testing during well installations that exceed maximum containment levels would be to use the 100-HR-3 or 100-KR-4 pump-and-treat system as specified in the 100-HR-3 and 100-KR-4 Operable Unit Record of Decision.

During the test, sodium dithionite will be placed in the aquifer and allowed to react. Upon completion of the test, approximately **TBD** gallons of water containing sulfate, thiosulfate, sulfite, sodium, potassium, carbonate, and bicarbonate will be removed. This water will be placed in Frac Tanks or Modutanks (meeting the substantive requirements of WAC 173-303-630) located near the ISRM project wells. The container contents will be tested to characterize water for disposal. Trivalent chromium is expected to be the only species of chromium present in the withdrawn water (having been reduced by the injected dithionite). The discharge water will be transported, treated, and disposed at the ETF in the 200-Area.

All treatability test residuals will be evaluated and managed in compliance with appropriate waste regulations. WAC 173-303 requires the identification and appropriate management of dangerous wastes. WAC 173-304 requires the identification and appropriate management of solid wastes that are not dangerous wastes. Wastes generated during the test will be disposed of at the Environmental Restoration Disposal Facility (ERDF), which is designed to meet the substantive standards for disposal of solid and dangerous wastes. Decontamination of equipment will be performed to meet WAC 173-160-530.

5.0 CONCEPTUAL DESIGN

5.1 PILOT-SCALE BARRIER DESCRIPTION

The pilot-scale permeable treatment barrier in the conceptual design, as shown in Figures 5-1 and 5-2, is 46 m (150 ft) long, 15 m (50 ft) wide, and extends the thickness of the upper unconfined aquifer (~ 5 m or 16 ft). The width and reduction capacity of the barrier controls the volume of upgradient groundwater that will be treated. The length of the barrier is important in this treatability study because it provides some assurance that groundwater monitored downgradient from the barrier has moved through the barrier and has not been bypassed (due to the difficulty in measuring groundwater flow directions at a small scale). The barrier must also be sufficiently large to determine constructability and performance over a large area.

As shown in the initial barrier design in Figure 5-2, the barrier will be created by overlapping five injection/withdrawal operations. Each injection/withdrawal operation will consist of an injection stage, a residence stage to provide time for the reagent to react with the aquifer sediments, and a withdrawal stage to remove any unreacted reagents and degradation products. Groundwater samples will be collected and analyzed during these stages. Each operation will create an effective treatment radius of about 8 m (25 ft) from the injection wells as shown in Figure 5-2. This simple method for barrier emplacement was selected for the following reasons: (1) it provides good recovery of injected reagent and minimizes the volume of wastewater generated; (2) the changing gradients during the injection, residence, and withdrawal stages will enhance the ability of the reagent to invade low-permeability zones within the aquifer; and (3) this method is similar to the field experiment that was conducted at the end of FY 1995 at the 100-H Area. The groundwater flow and reactive transport chemistry of the injection, residence, and withdrawal stages of the barrier emplacement strategy will be modeled prior to emplacement in order to identify important characterization parameters, to refine the emplacement design, and to determine monitoring requirements. This design approach was used in the 100-H Area ISRM field experiment (see Section 9.5).

Additional emplacement approaches will also be investigated to identify/develop a more efficient emplacement design as part of this treatability study. Potential emplacement method alternatives involve the use of more than one well for injection/withdrawal (e.g., Dipole Method). These methods may provide for greater spacing between injection/withdrawal wells than shown in Figure 5-2 and provide for more uniform emplacement of reductive capacity. Issues to be investigated in these alternatives involve limitations of injection extent due to the dithionite reaction rates, volume of composition of reagent, volume and composition of withdrawal water, and requirements for the on-site water storage. Because the dithionite/Fe(III) reaction can limit the distance that dithionite can be injected, the amount of Fe(III) in the sediments at the site need to be adequately characterized across the site in order to pursue various emplacement alternatives. Starting the barrier emplacement for this treatability study with a single well injection/withdrawal ("push-pull") approach will provide more definitive data on the available Fe(III) and reaction rates at the site than can be obtained from laboratory studies of cores. This information is needed for the selection and design of the subsequent phases of injections at the site. The staged schedule for drilling will also allow modifications in well locations to accommodate refinements and modifications from these ongoing characterization and design analysis activities. Interested parties (i.e., Key Decision Makers) will be consulted prior to implementing any proposed changes in the barrier emplacement method.

The wells needed for this treatability study are shown in Figure 5-2. Two types of completed wells are required: 6-in. injection/withdrawal wells and 4-in. monitoring wells. After emplacement is complete, 4-in. coreholes will be drilled to collect sediment samples. The size of the wells indicates the completed well screen size. The total depth of each of these wells and coreholes is approximately 30 m (100 ft). The injection/withdrawal wells are used for the reagent injection and removal. The monitoring wells within the barrier are used to monitor the reagent during the injection/residence/withdrawal stages to determine the extent of the reagent plume created. The coreholes are used to extract sediment samples to determine the reductive capacity of the barrier after emplacement.

In addition to the monitoring wells within the barrier, upgradient and downgradient monitoring wells are required to assess the performance of chromium treatment by the permeable treatment barrier. Chromium concentrations measured in the upgradient monitoring well will be compared to chromium concentrations measured in the downgradient wells. Conservative nonreactive tracers will be added to the upgradient well to verify the travel path through the barrier and determine the arrival time of the water at the downgradient wells. Because of the potential slow groundwater flow velocity at the proposed site, the hydraulic gradients may need to be boosted by selective pumping or injection in order to evaluate the effectiveness within a reasonable period of time (i.e., within a year after the barrier is installed).

5.2 WELL INSTALLATION AND EMPLACEMENT STRATEGY

Figure 5-2 shows the initial design and layout for the wells at the 100-D Area site. Drilling will be conducted in four stages as indicated on the diagram. This staged approach to drilling permits the design/well locations in later stages of drilling to be adjusted based on data collected and the characterization and analysis activities conducted in the earlier stages. The flexibility of approach is particularly important due to the lack of characterization available in the area around the 199-D4-1 well.

In the first stage of drilling, four pre-design characterization wells will be installed at the site. These wells will be used for physical and chemical characterization of the sediment at the site, determination of hydraulic gradient and hydraulic properties, continuity of the confining layer, determination of concentrations of chromate at the site, and to adjust the final location and orientation of the barrier. In addition to pre-design characterization, these wells will be used during and after emplacement to monitor the performance of the barrier.

Due to the importance of chromate concentrations at the site, the first well to be drilled at the site (the upgradient well in Figure 5-2) will be developed and produced until chromate concentrations have stabilized before any more wells are drilled in order to assure adequate chromate concentrations for this treatability study (~ 1000 ppb). The crushing of ferro-magnesium minerals and fresh mineral surfaces during drilling creates a reduced zone around the borehole that reduces the initial chromate concentrations measured from a newly drilled well. This well may need to be pumped for a 1 to 2 day duration until the chromate concentrations stabilize. Additional drilling will be halted and alternative emplacement locations and strategies will be pursued if the chromate concentrations are not sufficient in the upgradient well.

The second stage of drilling (see the second group of wells on Figure 5-2) will begin once the pre-design characterization and design analysis is completed. The injection/withdrawal and monitoring wells installed will be used for additional characterization (e.g., tracer test) and the first

emplacement at the site to be conducted in FY-97. The first emplacement will be a "push-pull" type, similar to the method used in the 100-H Area ISRM experiment, as discussed in Sections 5.1 and 5.5.3.

The installation of piezometers into the river sediments for additional downgradient monitoring of the ISRM is being investigated given the proximity of the proposed ISRM Test site to the Columbia River (~0.15 km [500 ft]). Site characterization data will be analyzed to estimate the groundwater travel times to the river in order to help determine the need and potential downgradient locations for these piezometers. The piezometers would be installed to collect water samples for measuring water quality (e.g., chromate, dissolved oxygen, sulfate, and trace metals) in similar locations/depths as used for the water samples collected from the river sediments as shown in Figure 1-3. The piezometers for the river sediment monitoring will need to be installed at a fixed location for a long-duration (> 3 years) for the purpose of this treatability study.

The third stage of drilling will be conducted in FY-98 and will finish the installation of the injection/withdrawal and monitoring wells for the pilot-scale barrier. The design and layout for these wells that will complete the emplacement of the treatability test zone may be adjusted based on refinements to the design determined from an analysis of the results from the first emplacement.

The purpose of the fourth stage of drilling is to collect sediment samples from the reduced zone to measure the reductive capacity that was achieved by the treatability study. The analysis of these samples in laboratory column studies will be the basis of the estimate for barrier longevity.

5.3 CHEMICAL REQUIREMENTS

Based on the results of the 100-H Area ISRM study, the average concentration of the sodium dithionite in the injection solution used for the ISRM emplacement will be 0.065 molar. The injection solution also contains a pH buffer consisting of 0.26 molar potassium carbonate and 0.026 molar potassium bicarbonate. A conservative tracer (e.g., 100 ppm potassium bromide) may also be added to the injection solution.

To estimate the volume of sodium dithionite and buffer solution required to create the barrier, the following assumptions/parameters are used:

- 9-m (30-ft) radius of plume to create an 8-m (25-ft) radius reduced zone
- Five overlapping dithionite plumes [at 9-m (30-ft) radius] for a 15-m by 46-m (50-ft by 150-ft) barrier
- Porosity
- Thickness of aquifer
- Sodium dithionite and buffer solution volume for each plume:

  $= \text{porosity} \times \text{thickness} \times \pi \times (\text{radius})^2.$

The porosity and barrier thickness will be determined from the pre-design characterization data and analysis of the tracer test data. Volumes and concentrations of sodium dithionite and buffer solution required will then be estimated from this pre-design characterization data and tracer test analysis.

Experience from the 100-H Area ISRM experiment indicated that about four to five times the injection volume is needed to recover most of the unreacted reagent and reaction products during

the withdrawal phase. Better estimates of the required recovery volume will be estimated from the results of the field-scale bromide tracer test at the site. The major ions from the sodium dithionite degradation and reaction products in this withdrawal water include dithionite, sulfite, sulfate, thiosulfate, sodium, potassium, carbonate, and bicarbonate. Dithionite in the withdrawal water will be oxidized quickly after it has been in contact with any sediments containing accessible ferric iron. Under these conditions, dithionite has a first-order decay half-life of up to 10 hr with degradation products of sulfite, thiosulfate, and sulfate. This withdrawal water may also include trace metals mobilized by dithionite from the aquifer sediment (iron, lead, and arsenic) in addition to any local contamination in the 100-D Area groundwater (e.g. tritium, nitrate/nitrite).

5.4 TREATMENT CAPACITY OF BARRIER

The treatment capacity of the barrier will be estimated using analytical data from sediment samples collected at the site during the pre-design characterization stage. The actual treatment capacity will be determined from bench-scale batch or column experiments by circulating oxygen-saturated groundwater with 1,000 ppb chromate through sediment samples from the barrier following emplacement.

Dissolved oxygen, the targeted contaminant (i.e., chromate), and any other consumers of the structural Fe(II) in the reduced zone must be considered when estimating barrier longevity. It should also be noted that for many situations the levels the consumption of structural Fe(II) by the targeted contaminant(s) is small compared to the consumption by the oxygen in natural groundwater. For example in treating a 1-ppm chromium plume, nearly all of the treatment capacity (i.e., the structural Fe(II)) is consumed by the 8 ppm of oxygen typically found in groundwater.

While there are different ways to quantify treatment capacity, a convenient method is to express treatment capacity in terms of the number of pore volumes of oxygenated/contaminated groundwater that must pass through a unit volume of treated aquifer sediments before contaminant breakthrough at levels above those of regulatory concern occurs. Of course, the path through the treated aquifer sediments must be sufficiently long relative to the ambient flow rates and sediment/contaminant reaction rates. Treatment capacity quantified in this manner can be easily measured by studies on cores of treated sediments using natural oxygenated/contaminated groundwaters. Quantification in this manner also allows the lifetime of the redox barrier to be estimated directly from measure of the ambient groundwater flow rate at the site where the ISRM treatment zone is to be emplaced. Barrier longevity (B_l) in time units can be estimated from the treatment capacity (T_c) in pore volumes, the barrier width (b_w) in length units, and the expected groundwater velocity (v) at the emplacement location by the following equation.

$$B_l = T_c * b_w / v$$

For example, if a ISRM zone 15 m (50 ft) wide was emplaced with a treatment capacity of 50 pore volumes in an area where the groundwater flow rate was 15 m (50 ft)/yr then the estimated lifetime of the barrier would be ~50 years.

The thickness of the barrier multiplied by the number of pore volumes of treatment capacity within the barrier yields the upgradient distance from the barrier of groundwater that could be treated as depicted in Figure 5-1 (assuming a uniform aquifer thickness and that the contaminant does not

sorb onto the sediment, i.e., that it travels in the groundwater at the same rate as dissolved oxygen). Therefore, a 15-m- (50-ft) wide barrier with a 50 pore volume treatment capacity would be capable of treating groundwater up to 750 m (2,500 ft) upgradient from the barrier. Treatment distances greater than the current length of a groundwater plume may be desirable to treat continuous sources feeding the plume at the surface or in the vadose zone.

Most estimates of groundwater velocity around the 100-H Area are in the 0.3-m/day (1-ft/day) range. Using the 0.3-m/day (1-ft/day) value, one pore volume would move through a 15-m- (50-ft) wide barrier every 50 days. Multiplying this time by the treatment capacity of the barrier (assuming 85 pore volumes of treatment capacity) results in an expected lifetime of a barrier of about 11 yr. Detailed characterization of the iron content, hydraulic properties, and the efficiency of iron reduction by ISRM at the selected 100-D Area site is needed (and planned) to estimate the treatment capacity and expected lifetime of the emplaced permeable treatment barrier. The maximum treatment capacity and barrier lifetime at the 100-D Area is expected to be greater than at the 100-H Area ISRM site because the Ringold Formation sediments (forming the unconfined aquifer at the D-Area) generally have greater contents of available Fe(III) than Hanford Formation sediments (forming the unconfined aquifer at the H-Area) and groundwater flow rates at the 100-D Area (~ 8 to 15 m/yr [25 to 50 ft/yr]) are less than at the 100-H Area (~110 m/yr [365 ft/year]).

5.5 ISRM TREATABILITY TEST ACTIVITIES

This section describes the specific tasks that will be performed to complete the treatability test. The tasks correspond to the those presented with the DQOs in Section 3.0. These activities have been condensed to include design analysis, field characterization, permeable treatment barrier emplacement, and barrier performance assessment and monitoring.

5.5.1 Design Analysis

Data-gathering activities to support design analysis consist of the characterization wells, first and second groups (Activity A), and the initial hydraulic testing (Activity B) (Table 3-2 and Appendix A).

5.5.1.1 Pre-design Characterization Wells. Four wells will be drilled to determine the horizontal distribution of chromate, the amount of reducible iron in sediment, aquifer thickness, and direction of hydraulic gradient to establish the location and orientation for emplacement of the barrier. These characterization wells will also be used to monitor emplacement of the barrier. Bench-scale column experiments will be conducted with sediments collected from the aquifer at the site using the target concentration of sodium dithionite and buffer to estimate reaction rates and the available Fe(III) in the sediments.

5.5.1.2 Hydraulic Testing. Hydraulic testing will be performed to determine hydraulic properties of the aquifer. Data obtained from drilling the pre-design characterization wells will be evaluated to determine which well(s) will be tested. Numerical modeling integrating site data and experimental results to test and refine the barrier emplacement design will then be performed.

5.5.2 Field Characterization

The field characterization task involves drilling the injection/withdrawal and monitoring wells (Activity C) as shown in the conceptual design in Figure 5-2, collecting background samples (Activity D), and performing the injection/withdrawal tracer test (Activity E).

5.5.2.1 Injection/Withdrawal and Monitoring Well Installation. The layout of the injection/withdrawal and monitoring wells is shown in Figure 5-2. Exact locations and depths of these wells will be determined once the pre-design characterization wells have been drilled. Additional characterization data will be collected during the drilling of the injection/withdrawal wells. The extent of the characterization will depend on results of the pre-design characterization effort. Other aquifer testing will be conducted as part of the tracer test phase.

5.5.2.2 Background Sampling. Water quality testing will be performed to establish a baseline before barrier emplacement. Details of this testing are presented in the Sampling and Analysis Plan (Appendix A).

5.5.2.3 Injection/Withdrawal Tracer Test. An injection/residence/withdrawal tracer test will be conducted at the site with a nonreactive, conservative tracer (i.e., Bromide) prior to the injection/withdrawal of dithionite. The results of the tracer test will be used to determine the larger scale porosity of the aquifer, the amount of sodium dithionite required for injection, the amount of wastewater generated during the withdrawal, and the rates and durations needed for injection and withdrawal.

The tracer test will be conducted on the center injection/withdrawal well. Additional tracer tests may also be required on other injection/withdrawal wells based on observations of variations in lithology.

Aquifer testing is required to determine injection and withdrawal rates and to identify any large-scale heterogeneous zones within the barrier. These tests include short-duration pumping tests immediately following well completion to determine well performance characteristics (specific capacity) followed by slug interference and/or constant rate discharge tests to determine site-scale hydraulic properties.

The information obtained from the tracer test will be incorporated into a numerical model developed to simulate site-specific transport processes and aid in the evaluation and improvement of the design of the dithionite injection/withdrawal. The tracer experiment will help determine the volume of injection fluid required to create a 9-m (30-ft) radial plume and the withdrawal volume required to recover the injected conservative tracer and thus the injected reagent and reaction products from the barrier. The tracer experiment will also help fine-tune the sampling strategy (starting sampling time, sample volume, and sample frequency required at each location) and trouble-shoot systems (i.e., injection/withdrawal system equipment, sampling pumps, flowthrough cells, bromide probes, mixing tank). A general description of the tracer test is given in the following paragraphs.

For the injection/withdrawal tracer test, a potassium bromide solution (~100 ppm bromide) will be injected into the center injection/withdrawal well. Water for the solution will be pumped from the aquifer prior to the injection. The injection could last up to 24 hrs, depending on the onsite tracer solution storage capacity and the time required for the tracer to reach a 9-m- (30-ft) radius based on estimates made regarding tracer arrival at the monitoring wells. A set of baseline water samples will also be collected prior to injection.

During the tracer test, several groundwater parameters will be monitored using a flowthrough chamber and selected probes. Parameters to be monitored include pH, temperature, conductivity, dissolved oxygen, and bromide concentration; in addition, samples will be collected for laboratory analysis of bromide concentration.

Sample collection frequency and location will be determined based on final locations of monitoring wells and observations in lithology. Sampling frequency and duration will be dependant on radial distance from the point of injection. The monitoring well(s) nearest the injection well will initially be assigned a sampling interval. This sampling interval will continue until bromide has arrived at the closest monitoring wells, at which time sample collection will be initiated in monitoring wells located further (radially) from the injection/withdrawal well. Periodic sampling will be conducted at all wells to account for unpredicted behavior due to heterogeneities. Samples will be collected from these monitoring wells as required to describe the movement of the tracer front. The sampling interval for each monitoring well will be based on simulated response and adjusted in the field as necessary.

A residence phase of approximately 18 hr will follow the injection to determine the effects of drift at the site. After the residence phase, the bromide will be pumped out at a rate similar to the injection rate until the concentration in the withdrawal water is near background. Simulations show that about four times the injection volume is required for withdrawal, but heterogeneities and sorption of some of the injected reagent could increase the withdrawal volume. The tracer study should be able to isolate the withdrawal effects due to heterogeneities.

The withdrawn water containing bromide will be handled in accordance with the purgewater strategy (see Section 11.0). During the withdrawal phase, samples will be collected from monitoring wells and the withdrawal stream as required to describe transport of the injected tracer back to the injection/withdrawal well. The sampling strategy during the withdrawal phase will initially be based on simulated response and adjusted in the field as necessary.

5.5.3 Permeable Treatment Barrier Emplacement

This task consists of emplacing the permeable treatment barrier (Activity F) through five consecutive injection/residence/withdrawal stages in the injection wells shown in Figure 5-2.

5.5.3.1 Emplacement Process. As discussed previously, emplacement using the initial design consists of emplacing the barrier (injection stage), allowing time for the reagent to react with aquifer sediments (residence stage), and removing any unreacted reagent and/or degradation products (withdrawal stage).

Injection - During the injection stage (estimated to take ~24 hr per injection/withdrawal well), the reagent will be injected through each of the injection/withdrawal wells, one at a time, at a rate to be determined by field characterization data. Estimates of the injection volume will be made once the bromide tracer field experiment has been conducted.

Residence - The residence stage provides additional time for the reagent to react with the aquifer sediments. The duration of this stage will be ~18 hr.

Withdrawal - During the withdrawal stage, any unreacted reagent, mobile reaction products (sulfites, thiosulfate, and sulfate), and any mobilized species (e.g., iron and other metals) will be pumped from the aquifer. The 100-H experiment required about five times the injection volume of water to recover about 90% of the reagent, tracer, and buffers. The volume can be influenced by heterogeneities at the site. Better estimates of the required recovery volume (as has been discussed) can be calculated based on the results of the field-scale bromide tracer test once it is completed.

During each stage of the emplacement process sampling and monitoring will be performed on the solutions collected from the injection wells, the feed tank, the monitoring wells, and the overlapping injection wells. These samples will be analyzed for dithionite concentrations and other parameters as discussed in the Sampling and Analysis Plan (Appendix A).

The emplacement strategy has been developed to minimize the number of monitoring and injection/withdrawal wells (Figure 5-2). This strategy features the following:

- Successive reduction in the number of monitoring wells required for each injection/withdrawal process will help determine minimum number of wells for expandability of barrier
- Injection/withdrawal begins at center working outward on alternating sides for the first three injection/withdrawal processes.
- Central upgradient and downgradient monitoring wells are close to the barrier to provide short travel times for performance monitoring.
- Central upgradient and downgradient monitoring wells are 4-in. diameter to serve a dual purpose of providing for hydraulic testing (on the upgradient side) and gradient control (to increase travel times if needed).
- The injection/withdrawal process will be monitored from adjacent injection/withdrawal wells.

5.5.4 Barrier Performance Assessment and Monitoring

This task involves the evaluation of the permeable treatment barrier in its effectiveness in chromium remediation, impact on the water quality, and long-term capacity. The project stages included are post-emplacement characterization (Activity G), upgradient/downgradient monitoring (ongoing) (Activity H), performance assessment tracer experiment (Activity I), and coreholes (Activity J).

5.5.4.1 Post-Emplacement Characterization. After the barrier is emplaced, hydraulic testing (pumping test) is needed to determine if any detectable changes occurred to the hydraulic properties of the barrier/aquifer. The water quality downgradient from the barrier will also be monitored.

5.5.4.2 Upgradient/Downgradient Monitoring and Performance Assessment Tracer Experiment. As the main measure of the effectiveness of chromium remediation for the permeable treatment barrier, chromium concentrations will be monitored in the upgradient and downgradient monitoring wells. Tracers will be added to the upgradient well to determine the arrival of the upgradient water in the downgradient monitoring wells and to demonstrate the travel path through the barrier. Because of the slow estimated groundwater velocity in the region around the barrier, about 8 to 15 m/yr (25 to 50 ft/yr), some hydraulic control through the use of pumping

or injection may be required to shorten the travel time from the upgradient to downgradient wells. The downgradient wells will be a sufficient distance from the barrier to avoid any influences from the barrier emplacement.

5.5.4.3.3 Coreholes. After the injection/residence/withdrawal operation has been completed at all five injection wells, sediment samples will be collected by coreholes drilled within the barrier as shown in Figure 5-2. This sediment will be analyzed to determine the reductive capacity of the sediments within the barrier. This will be accomplished by batch and column studies of the sediment to determine the overall treatment capacity of the reduced sediment within the barrier.

Additional coreholes should be collected from the fringe and interior of the barrier at least 1 yr after the barrier emplacement in order to measure the loss of treatment capacity through bench-scale experiments. These additional coreholes are not shown in Figure 5-2.

Figure 5-1. Conceptual Plan View of ISRM Treatment.

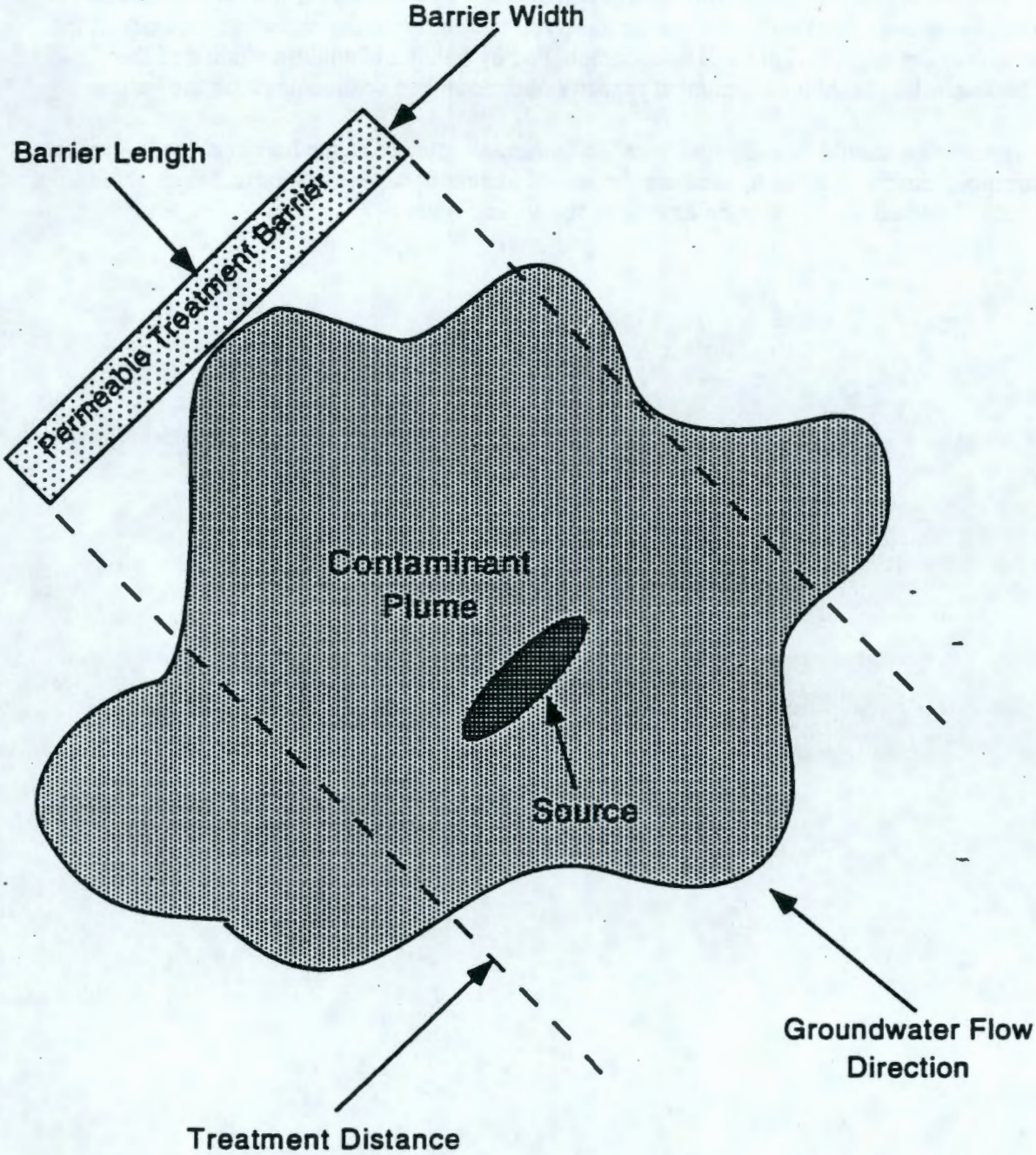

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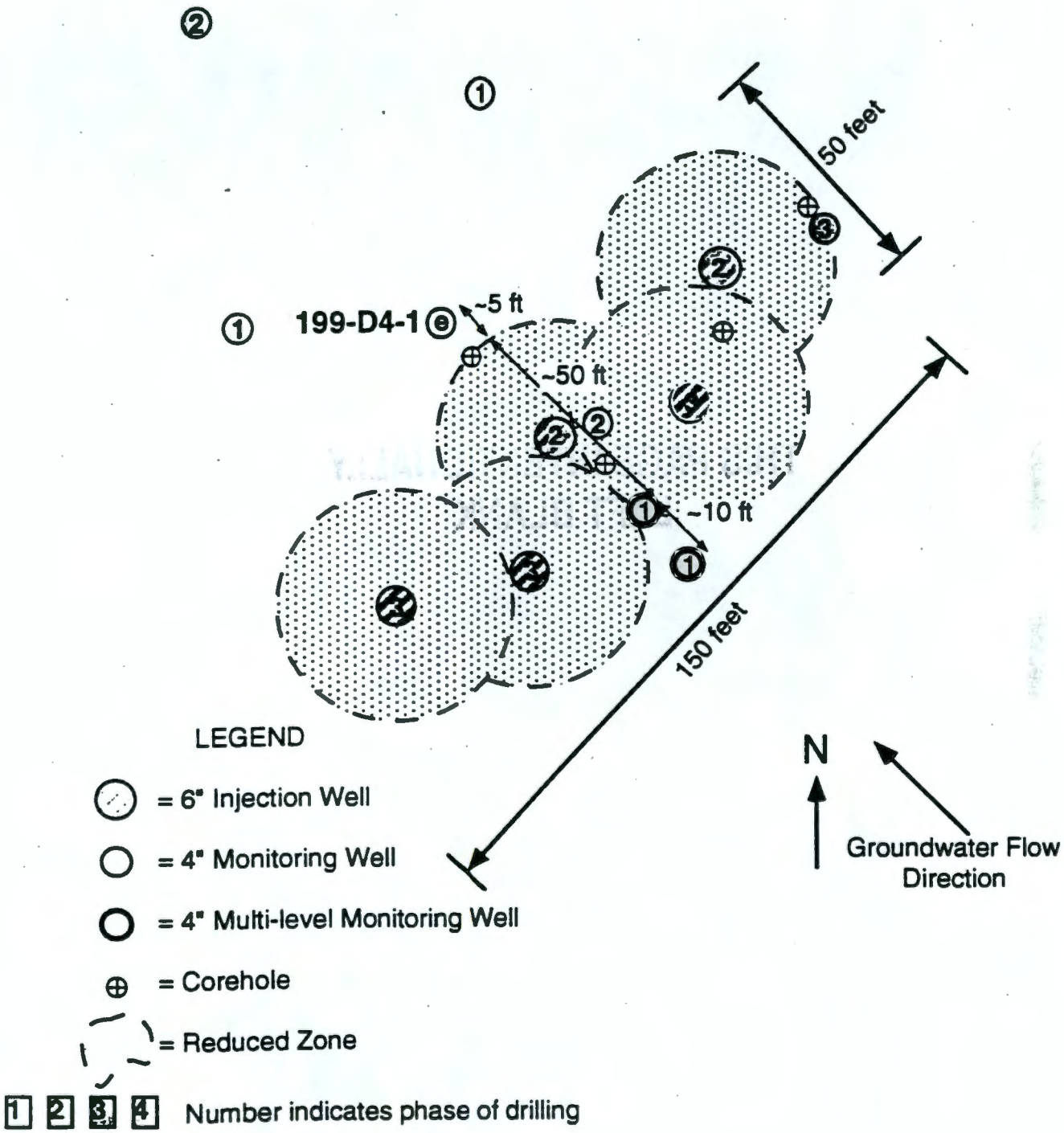
Figure 5-2. Conceptual Design of ISRM Permeable Treatment Barrier.



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6.0 EQUIPMENT AND MATERIALS

This section presents the field equipment and materials needed to emplace the ISRM barrier.

The conceptual layout of the ISRM field site is shown in Figure 6-1. Until the design analysis and field characterization phases of the treatability test are complete, equipment cannot be sized and volumes of material required cannot be determined.

The buffered reagent solution (sodium dithionite plus potassium carbonate and potassium bicarbonate) will be delivered premixed, in a concentrated liquid form. The injection solution will consist of an aqueous buffered reagent solution. The concentration of the injection solution will be determined after the design analysis and field characterization have been performed.

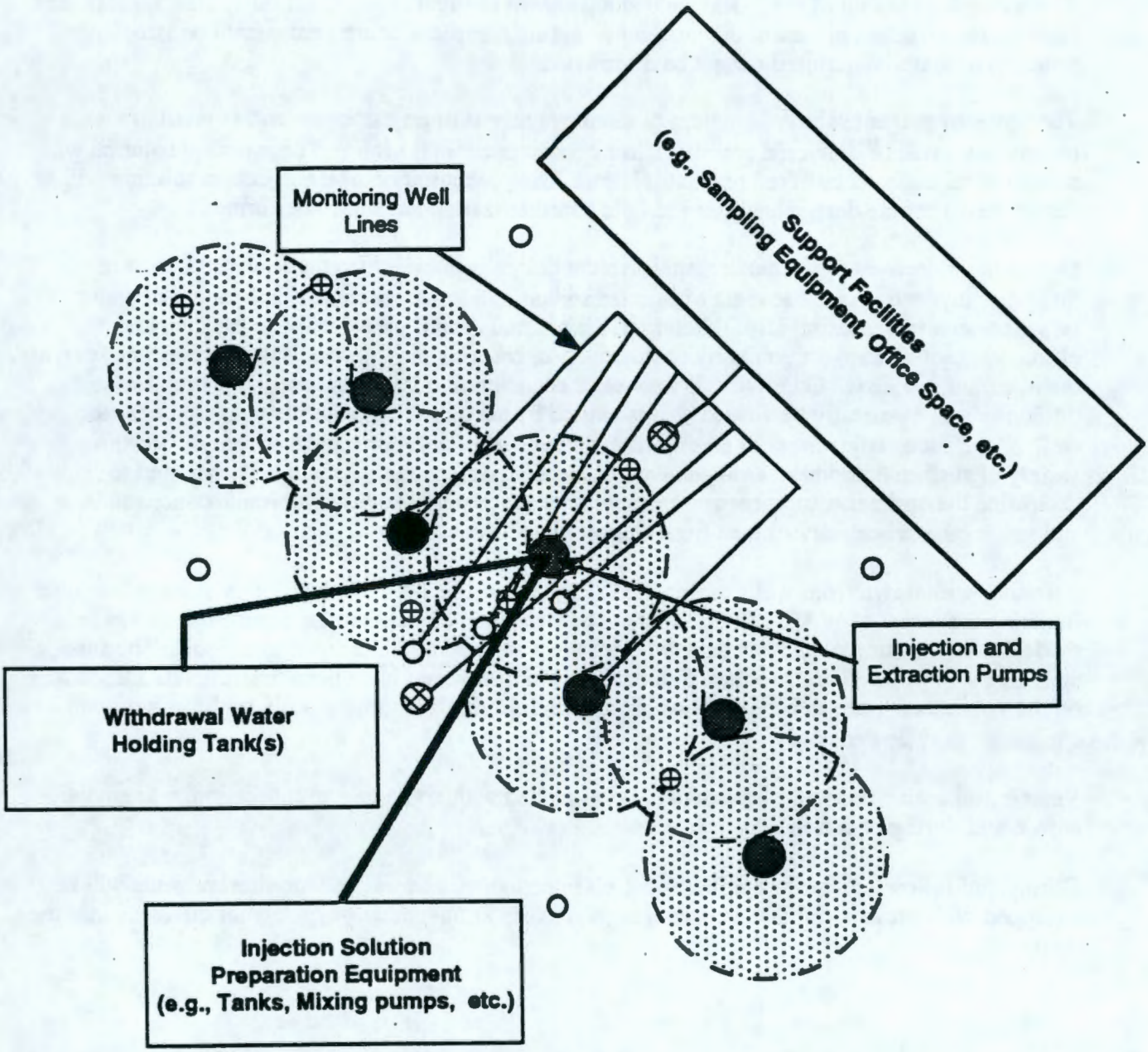
One of the objectives of the barrier emplacement design is to minimize the amount of sodium dithionite injected. As the amount of injected sodium dithionite increases, the volume of water to be withdrawn increases rapidly. Therefore, the optimal design would provide for the most efficient use of sodium dithionite by continuously *decreasing* the injection solution concentration as the injection proceeds. Otherwise, if a *constant* concentration is continuously injected, sodium dithionite will eventually be wasted as it is unused by the already-reduced ferrous iron near the well. Continuous adjustment of the injection solution concentration can be accomplished through a variety of surface equipment arrangements. A detailed design analysis will be performed to determine the optimal equipment arrangement once the required sodium dithionite concentrations and volume have been determined from characterization data.

All water withdrawn from wells during the ISRM test will be held in a temporary storage container (meeting the intent of WAC 173-303-630). The water will be held until a determination has been made, based on sample analysis data, whether the water can be discharged to the soil. The storage container will be sized after sodium dithionite injection volumes have been determined. Depending on the volume of water to be withdrawn from each injection/withdrawal well, multiple storage containers may be necessary.

Vessels containing dithionite reagent will be blanketed with argon to prevent dithionite degradation before and during injection.

During and following barrier emplacement, all injection/withdrawal and monitoring wells will be equipped with packers or blanketed with argon to keep atmospheric oxygen from diffusing into the wellbore.

Figure 6-1. In Situ Redox Manipulation Field Site Conceptual Layout.



Note: This diagram shows the setup for only one injection/withdrawal cycle. The process will be conducted sequentially on each injection/withdrawal well.

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7.0 SAMPLING AND ANALYSIS

As discussed in Section 5.0, sampling will be performed throughout the various stages of the ISRM treatability test. The Sampling and Analysis Plan (SAP), which includes the Field Sampling Plan (FSP), is presented in Appendix A.

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8.0 DATA MANAGEMENT

A project-specific database will be developed and maintained to collect, organize, store, verify/validate, and manage analytical laboratory data and/or field measurements for environmental samples. The data will be stored electronically in Microsoft Excel spreadsheets and paper copies will be maintained in the project files. A project data custodian will be designated to control and maintain the data. The following data will be contained, at a minimum, as part of the database:

- Sample identifier
- Sample location
- Sample medium type
- Sampling date
- Analysis date
- Laboratory name
- Analyte name
- Concentration value
- Measurement unit

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9.0 DATA ANALYSIS AND INTERPRETATION

Detailed discussions of the planned tests and sampling are found in Chapters 3.0 and 7.0. This chapter describes the plan that will be used for the analysis of the performance monitoring data. The planned ISRM performance monitoring and testing program includes:

- Establishing pre-emplacement Cr^{6+}, water quality, and aquifer characteristics at the test site to enable interpretation of ISRM performance
- Pre- and post-construction hydrologic testing at the site to determine the hydrologic properties of the ISRM treatment zone relative to the natural aquifer sediments
- Performing routine performance monitoring of Cr^{6+} and water quality at the test site for evaluation of ISRM performance
- Conducting tracer test to determine the path and travel time through the ISRM treatment zone, as well as to support Cr^{6+} performance evaluation
- Collecting aqueous samples on a periodic basis to assess any impacts on the aquifer or degradation of the ISRM treatment zone
- Collecting sediment from ISRM treatment zone for bench-scale tests to predict treatment capacity.

This chapter describes the analysis of data to interpret the performance of the ISRM treatment zone. The analysis can be viewed in terms of assessing barrier performance in four areas of functionality: (1) laboratory-scale performance (i.e., maximum theoretical performance ignoring effects of heterogeneities in the emplacement, wall effects, short circuiting, channeling); (2) field performance (i.e., performance as emplaced quantifying the effects of heterogeneities in the emplacement, wall effects, short circuiting, channeling); (3) long-term effectiveness of the treatment zone; and (4) side effects (i.e., quantify the effect the treatment zone has on the chemistry of the aquifer). Design of the barrier is the goal of a separate characterization effort and is described in Section 9.5.

A combination of hydrogeologic and chemical analyses will be performed to make these assessments. The hydrologic analyses will identify how groundwater is affected by the treatment zone, and the chemical analyses will identify how efficiently the treatment zone reduces the chromate. The overall performance of the technology will be judged by the combined effectiveness of these mechanisms.

9.1 BENCH-SCALE PERFORMANCE

The assessment of bench-scale performance will be based primarily on determining the ability of the reduced sediments to reduce chromate and the reductive capacity of the sediments after treatment as compared to the reductive capacity achieved under more favorable laboratory conditions. Bench-scale capacity to reduce chromate will be assessed by using core samples taken from within the treatment zone to reduce chromate in the laboratory.

Maximum reductive capacity of the sediments will be assessed by subjecting core samples to dithionite treatment and comparing the chromate treatment capacities of the sediments before and after laboratory dithionite treatment. This will allow for an assessment of the efficiency of the reduction by the field method.

9.2 FIELD PERFORMANCE

The assessment of field performance will be based on determining the spacial distribution of the reactive capacity of the sediments and by comparing the upgradient and downgradient chromate concentrations. A spacial plot of the reactive capacity will be prepared and used to define an average performance of the treatment zone. Where possible, the limited core and soil data (porosity, grain size distribution, and bulk density) will be used with drilling logs to characterize large-scale stratigraphic features at the site. This information may be used to identify features that could impact the performance and monitoring of the ISRM.

9.3 LONG-TERM PERFORMANCE

Long-term performance will be assessed by comparing the upgradient and downgradient concentrations of chromate and dissolved oxygen. Periodic groundwater samples will be collected over the course of a few years to possibly determine a trend in these concentrations and to predict the long-term viability of the treatment zone. Because of the estimated lifetime of the barrier (~10's years), the lifetime of the barrier cannot be determined by field observations over 1 or 2 years. Therefore, the barrier lifetime will be estimated from treatment capacity measured in the laboratory from sediment samples collected from the reduced zone.

9.4 SIDE EFFECTS

Side effects include potential plugging of the aquifer, changes in aquifer chemistry (such as dissolved oxygen and pH), mobilization of trace metals, and residual reagents and decomposition products. These issues were also addressed in the 100-H ISRM field experiment (see Fruchter et al., 1996).

Aquifer plugging will be assessed by comparing the results of aquifer hydraulic characteristic tests before and after emplacement of the treatment zone. Hydraulic head, hydraulic conductivity, and storativity estimates will be compared to quantify any changes in hydraulic properties caused by barrier emplacement.

Concentrations of key parameters will be measured in the aquifer to assess the effect of the treatment zone on the aquifer chemistry. Chromate, pH, dissolved oxygen, conductivity, sulfate/sulfite, inductively coupled plasma (ICP) metals, and concentrations of specific anions will be measured.

Due to the proximity of the test site location to the Columbia River, a contingency has been developed in the event that the dissolved oxygen concentrations are severely reduced in the groundwater entering the river. This will be determined by the concentrations observed in the farthest downgradient monitoring wells from the ISRM zone. The contingency involves the

initiation of pumping of groundwater from the injection/withdrawal wells and downgradient monitoring wells at the site in order to rapidly re-oxygenate the reduced zone to stop any additional groundwater with low dissolved oxygen concentrations from entering the river. The pumping will stop once the dissolved oxygen concentrations at the site are back to pre-emplacement levels.

9.5 DESIGN ANALYSIS

The design analysis will determine the parameters needed for the barrier emplacement (see Figure 9-1). These parameters include injection well spacing, dithionite and buffer concentrations for injection, injection and withdrawal rates, injection and withdrawal volumes, duration of reaction stage, and an estimate of the amount of reduction of ferric iron from the emplacement. The design analysis process integrates the site characterization data using numerical models. The site characterization data will be incorporated into these numerical models to simulate the dithionite injection, reaction, and withdrawal stages of the emplacement.

Two numerical models will be used as part on the design analysis. The first model to be used is a one-dimensional, radial, reactive transport computer code that was developed as part of the ISRM project last year. This code simulates the redox and degradation reactions of the injection of sodium dithionite and pH buffers into the aquifer. The rates of the reactions can be approximated by pseudo-first-order kinetics based on the results of batch and intermediate-scale experiments conducted over the past few years. The testing of the applicability of this code to the 100-H Area field experiment is currently under way. The reaction rates will also be determined for the Ringold sediment at the selected 100-D Area field site. The reaction rate of the reduction of ferric iron by sodium dithionite is short (~5 hr) in relation to the travel time to inject reagent to a target distance of 15 m (25 ft) (~18 hr). Therefore, a large excess of accessible ferric iron can inhibit the ability to reduce sediment at a large distance from the injection well. Using the pre-design characterization data, a number of different combinations of injection rate, injection duration, and injection concentration (varying during the course of the injection) will be investigated using this reactive-transport code. A strategy of multiple injection/withdrawal of reagent at one location may also need to be pursued. These simulations will determine the parameters needed to reduce sediment out to the target radial distance from the injection/withdrawal well. The spacing of injection wells will be based on the radial extent of the reduced zone in the design and will provide for overlap between the reduced zones.

A second numerical model will be used in the design analysis to simulate more complex hydrologic processes. Specifically, this model will be used to simulate the transient transport effects of the mounding of the water table during injection and the pumping cone-of-depression formed during the withdrawal. This model will help predict the amount of reagent that is transported to the injection mound (above the ambient water table) during the injection and the impact on recovery of reagent and reaction products during the withdrawal stage by the slow drainage of reagent trapped in the vadose zone by the injection mound. Although strongly influenced by heterogeneities, the rate and duration of withdrawal will also be estimated from this modeling activity. This model will also help in determining the sampling timing and frequency at the observation wells.

Heterogeneities will be addressed by sensitivity modeling using the ranges in parameters measured from the boreholes at the site (e.g., reactable iron, porosity). The distribution of these parameters will be inferred from the lithologic description matched to the limited number of sediment samples that will be analyzed in the laboratory for physical and chemical properties. The final design will be based on a reasonable distribution of properties at the field site. The design will be tested at the

field site by the tracer test and the emplacement strategy (i.e., additional monitoring wells in the first dithionite injection/withdrawal), as discussed in Section 5.3.3.1.

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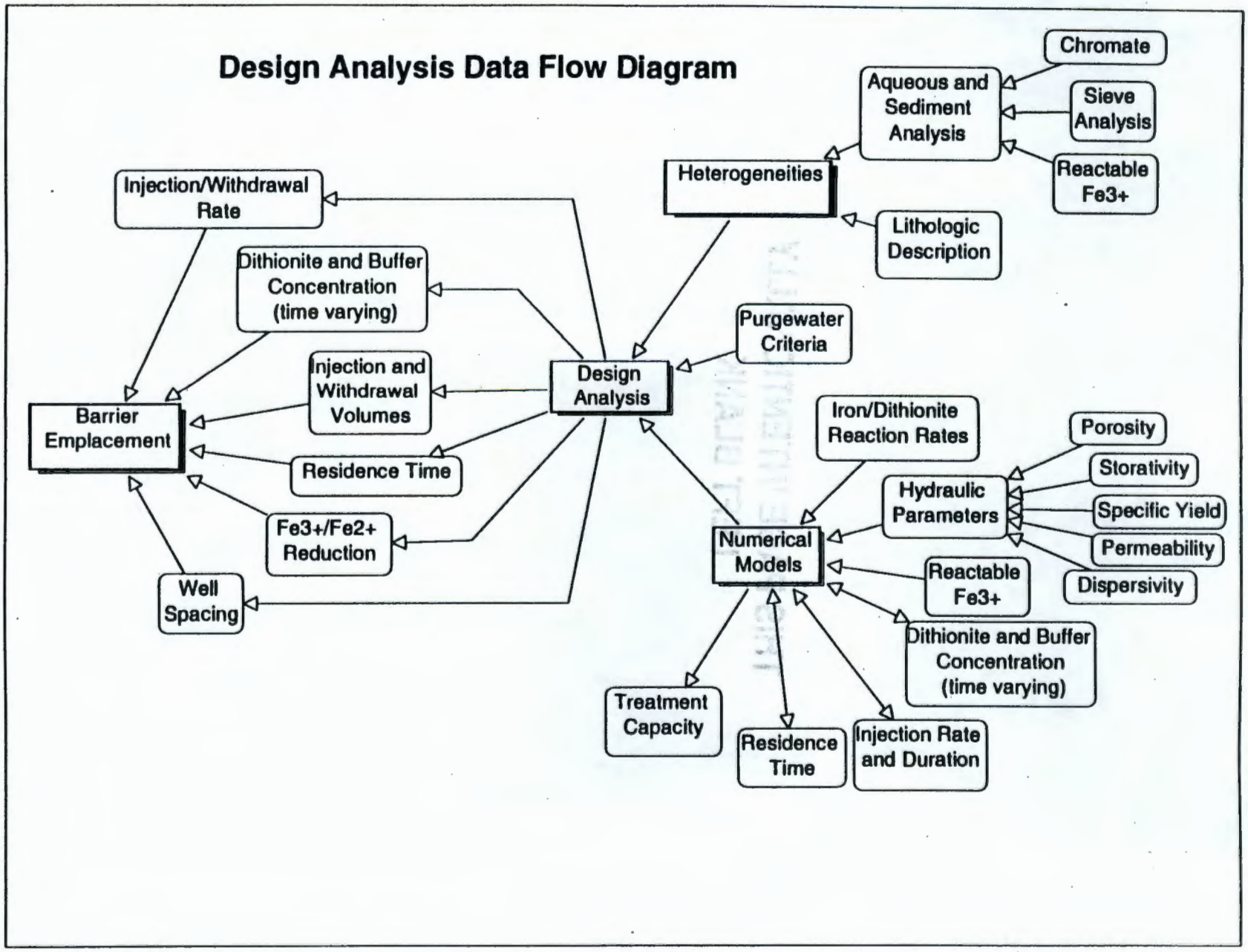

Figure 9-1. ISRM Design Analysis Flow Diagram.

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10.0 HEALTH AND SAFETY

Safety and health issues relating to the treatability test are addressed in site-specific safety documents that identify both radiological and industrial safety and health hazards as well as control measures for those hazards. Safety documents include specific training requirements for all site workers as well as visitors. Job-specific Health and Safety plans have been prepared for the drilling activities. A Health and Safety Plan covering the emplacement procedures was developed for the 100-H Area Experiment and will be modified for applicability to the 100-D Area Treatability Study. This Health and Safety Plan will be included in the appendix of the final version of this test plan.

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11.0 RESIDUALS MANAGEMENT

Management of residuals (soil and water samples and drill cuttings) relating to the well and corehole drilling for this treatability test are addressed in the waste control plan submitted with the Description of Work as part of the drilling. Management of residuals as part of the emplacement (only water samples will be generated during this process) will be conducted as described in the Waste and Wastewater Management Section above (Section 4.4).

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12.0 QUALITY ASSURANCE

All work conducted by the Pacific Northwest National Laboratory (PNNL) shall be performed according to appropriate standards of quality, reliability, environmental compliance, and safety based on client requirements, cost and program objectives, and potential consequences or malfunction or error. To provide clients with quality products and services, PNNL has established and implemented a formal Quality Assurance (QA) Program. These management controls are documented in the PNNL Standards-Based Management System (SBMS) and the Quality Assurance Manual (PNL-MA-70) and its accompanying standards and procedures. The QA Program is based upon the basic requirements and supplements of ASME NQA-1 (1989), Quality Assurance Program Requirements for Nuclear Facilities, as interpreted for PNNL activities. Additionally, the quality requirements are augmented to include the Total Quality approach defined in the Department of Energy Order 5700.6C/10 CFR 830.120, Quality Assurance. The QA Plan for sampling and analysis is contained in Appendix A.

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13.0 COMMUNITY RELATIONS

The DOE, Ecology, and EPA developed a Community Relations Plan in April 1990 as part of the overall Hanford Site restoration. The Plan was designed to promote public awareness of the investigations and public involvement in the decision-making process. The Plan summarizes known concerns based on community interviews. Since that time several public meetings have been held and numerous fact sheets have been distributed in an effort to keep the public informed about Hanford cleanup issues. The Plan was updated in 1993 to enhance public involvement and is currently undergoing an additional update.

The 100 Area Focused Feasibility Study Document (DOE-RL 1995a) and Proposed Plan for 100-HR-3 (DOE-RL 1995b) were made available to the public in both the Administrative Record and the Information Repositories. These documents underwent a 45-day public comment from September 11, 1995 to October 25, 1995. "Tests to Immobilize Chromium in the Aquifer" were described in general terms in the Proposed Plan for 100-HR-3.

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14.0 NEPA VALUES

In accordance with DOE Order 451.1 and DOE Secretarial NEPA Policy, DOE CERCLA documents are to incorporate *National Environmental Policy Act of 1969* (NEPA) values to the extent practicable. NEPA values, such as analysis of cumulative offsite ecological and socioeconomic impacts, description of the affected environment (including meteorology, hydrology, geology, cultural and ecological resources, and land use), short-term and long-term impacts on human health and the environment, emissions to air and water, and cost, are typically included in CERCLA feasibility study.

Several NEPA values common to all of the 100 Area operable units, including laws and guidelines, are addressed in the *100 Area Feasibility Study Phases 1 and 2* (DOE-RL 1993). NEPA values associated with ISRM treatability test were evaluated in the *100-HR-3 Operable Unit Focused Feasibility Study* (DOE-RL 1995a).

NEPA values specific to the ISRM project are as follows.

- Cultural and ecological resources' reviews were performed in support of the ISRM project (Appendix B). The survey reports indicate that the area where the in situ test is to occur has been previously disturbed. No cultural resources are reported or anticipated with the project area.

- Particulate releases to the atmosphere would be limited to fugitive dust emissions that might occur as a result of the proposed activities (e.g., movement of vehicles and equipment). The Columbia River is located at least 0.15 km (500 ft) from the proposed the ISRM project area; care would be taken to minimize the chance of the river becoming a consequential pathway for particulates.

- Droplet releases might result from the use of uncontaminated water, which would be applied as necessary to mitigate dust during the well installations and construction of the ISRM project.

- Removal, storage, and disposal of waste would be in accordance with applicable federal and state regulations and guidelines and would not impact employees or the environment.

- The proposed activity is 0.15 km (500 ft) from the Columbia River. Public Law 100-605, *Study of the Hanford Reach of the Columbia River,* requires notification of the National Park Service (NPS) of the U.S. Department of the Interior if the project is to be conducted within 1/4 mile of the Columbia River. Since the project is at a location within the 1/4-mile limit, the NPS will be notified of the project so that a review can be completed. Any NEPA mitigation measures identified by NPS will be incorporated into the project plan. Standard construction practices would prevent adverse impact to the 100-yr floodplain or wetlands. Precautions will be taken to ensure that stormwater runoff from the construction area does not enter the river.

- The ISRM project represents a small fraction of the total Hanford budget. Therefore, the project is not expected to impact socioeconomics of the Tri-Cities or other parts of Benton and Franklin Counties.

- The project staff and materials associated with the ISRM project would not significantly impact transportation in the area.

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15.0 REPORTS

A test report summarizing the results of the treatability test will be prepared. The format of the report will be based on the suggested outline for treatability test reports provided in the *Guide for Conducting Treatability Studies Under CERCLA* (EPA 1992). Project briefings will be given at unit manager meetings between DOE and the regulators.

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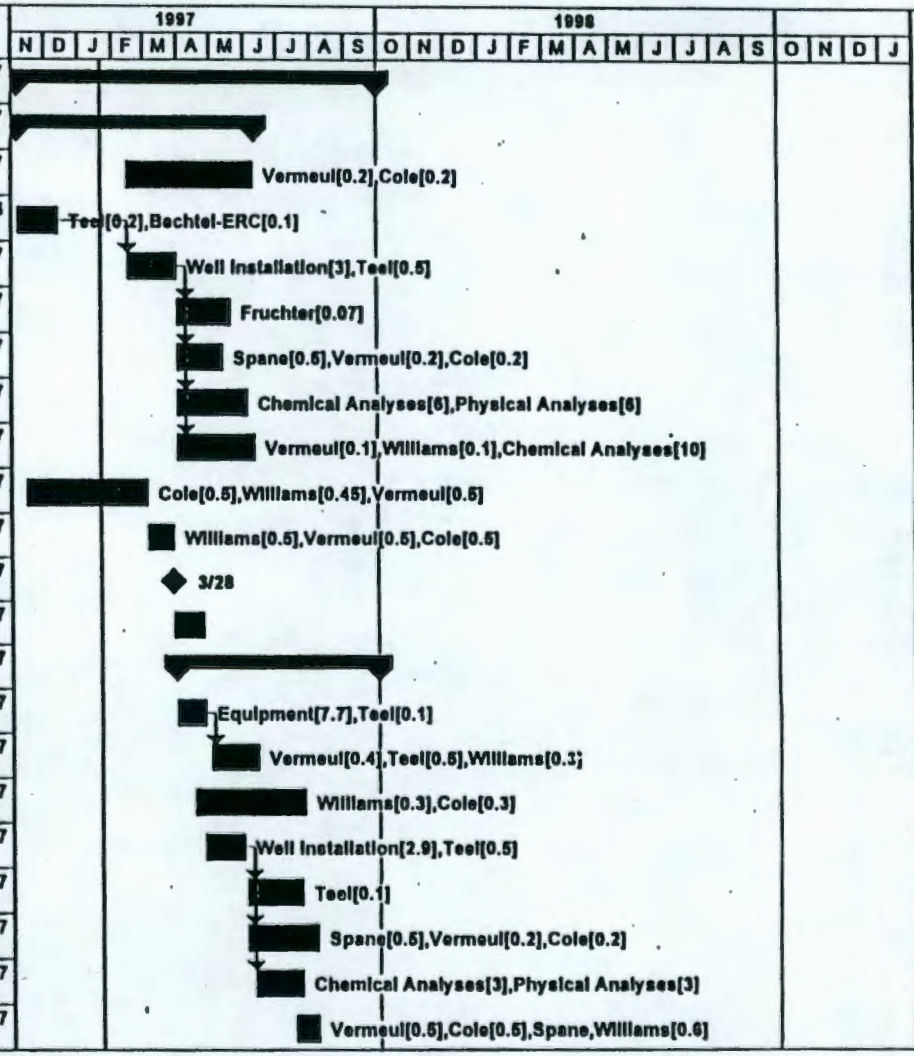
16.0 SCHEDULE

The current project schedule shown in Figure 16-1 lists key activities for the ISRM project. The schedule shows durations of each major activity.

Table 16-1. ISRM Treatability Test Project Schedule.

ID	Task Name	Start	Finish
1	Support 100D Treatability Test	Thu 11/7/96	Wed 10/1/97
2	Pre-Injection Characterization and Tre	Thu 11/7/96	Tue 6/10/97
3	Field Support -Characterization	Fri 2/14/97	Mon 6/9/97
4	Prepare Drilling Documentation	Thu 11/7/96	Fri 12/13/96
5	Drill Wells - Phase 1	Sat 2/15/97	Mon 3/31/97
6	Chromate Analysis	Tue 4/1/97	Mon 5/19/97
7	Hydraulic Tests	Tue 4/1/97	Mon 5/12/97
8	Physical And Chemical Analysis	Tue 4/1/97	Tue 6/3/97
9	Well Monitoring	Tue 4/1/97	Tue 6/10/97
10	Design Analysis	Fri 11/15/96	Tue 3/4/97
11	Finalize Test Plan	Wed 3/5/97	Fri 3/28/97
12	Submit Test Plan	Fri 3/28/97	Fri 3/28/97
13	Test Plan Approval	Fri 3/28/97	Thu 4/24/97
14	Construction and Dithionite Injection	Mon 3/31/97	Wed 10/1/97
15	Procure Equipment	Mon 3/31/97	Fri 4/25/97
16	Set Up Equipment	Thu 5/1/97	Thu 6/12/97
17	Field Support - Construction	Wed 4/16/97	Fri 7/25/97
18	Drill Wells - Phase 2	Fri 4/25/97	Fri 5/30/97
19	Chromate Analysis	Mon 6/2/97	Tue 7/22/97
20	Hydraulic tests	Mon 6/2/97	Tue 8/5/97
21	Physical and Chemical Analyses	Mon 6/9/97	Tue 7/22/97
22	Tracer test	Wed 7/16/97	Tue 8/5/97



Project: Redox97
Date: Tue 1/21/97

Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress

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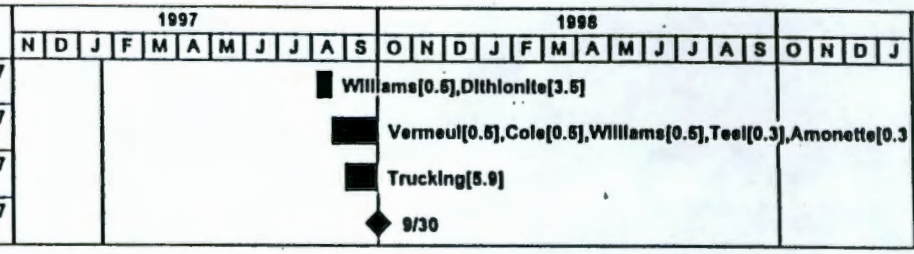
Table 16-1. ISRM Treatability Test Project Schedule (continued).

ID	Task Name	Start	Finish
23	Purchase Dithionite	Wed 8/6/97	Tue 8/19/97
24	Inject Dithionite	Wed 8/20/97	Wed 10/1/97
25	Purge Water Shipment	Mon 9/1/97	Mon 9/29/97
26	Complete Dithionite Injection	Tue 9/30/97	Tue 9/30/97



Project: Redox97
Date: Tue 1/21/97

Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress

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APPENDIX A

SAMPLING AND ANALYSIS PLAN

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APPENDIX A

SAMPLING AND ANALYSIS PLAN

A1.0 SCOPE OF WORK

The scope of work encompassed in this Sampling and Analysis Plan (SAP) includes the collection and analysis of groundwater and sediment samples from the saturated zone. Samples will be collected during the various stages of the ISRM treatability test at the 100-D/DR Area of the Hanford Site. The treatability test includes the following elements.

- Injection/Withdrawal and Monitoring Well Installation
- Background Sampling
- Tracer Injection/Withdrawal Test
- Barrier Emplacement
- Post-Emplacement Characterization
- Up/Downgradient Chromate Monitoring (ongoing)
- Performance Assessment Tracer Experiment
- Corehole Installation.

The logic and explanation of the various stages is discussed in the test plan.

The of the aquifer is the subject of the Description *of Work Pre-Design Characterization in Support of the 100-D In Situ Redox Manipulation Treatability Test* (PNNL 1997). The scope of work to be performed under that document includes pre-design characterization wells drilling and sampling of the groundwater and sediments and initial hydraulic testing.

This SAP covers sampling and analysis activities following the completion of the pre-design characterization. This SAP consists of two main sections. Section 2.0 is the Field Sampling Plan (FSP) that details the requirements for collecting samples. Section 3.0 is the Quality Assurance Project Plan (QAPjP) that either provides or references procedures for making accurate measurements and obtaining representative, accurate, and precise analytical data from the sampling.

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A2.0 FIELD SAMPLING PLAN

This FSP defines the sampling methodologies and strategies that will be used during each stage of the treatability test.

A2.1 SAMPLING OBJECTIVES

The objective of the sampling activities described in this FSP is to satisfy the data needs presented in Section A3.4 of the QAPjP. The data obtained will be used to evaluate the effectiveness of the ISRM technology at treating chromium-contaminated groundwater.

A2.2 GENERAL PROCEDURES

Field sampling will be conducted in accordance with the applicable Procedures for Ground-Water Investigations (PNL-MA-567). These procedures include the following:

Procedures for Ground-Water Investigations (PNL-MA-567)

AD-2	Ground-Water Sample Chain-of-Custody Procedure
AD-4	Sediment Sample Chain-of-Custody Procedure
AD-5	Ground-Water Sample Check-In Procedure
AD-6	Control Measures for Identification of Wells Requiring Purgewater Containment
AD-7	Control Measures for Identification of Samples Requiring Offsite Radioactive Shipping Documentation
GC-1	Ground-Water Sample Collection Procedure
SA-1	Sediment Sample Analysis/Sample Control Procedure
GC-11	Preparation of Documents and Sample Containers for Ground-Water Sample Collection
WL-1	Water-Level Measurement Procedure
DO-1	Collection and Documentation of Borehole Samples and Well Construction Data
AT-6	Aquifer Slug Injection and Withdrawal Test

Specific Procedures

NHFP-AT-07	Slug Interference Test
NHFP-AT-09	Tracer-Dilution and Tracer Drift/Pumpback Tests
NHFP-AT-10	Procedure for Conducting a Forced Gradient Tracer Test

A2.2.1 Sample Processing

Samples will be transported by staff to either the designated offsite laboratory or to the specified onsite laboratory personnel responsible for analysis. Unused sample material will be disposed of at the collection site or by the laboratory personnel according to laboratory procedures. All sample handling will be documented on chain-of-custody forms, per AD-2 (Ground-Water Sample Chain-of-Custody Procedure) or AD-4 (Sediment Sample Chain-of-Custody Procedure).

A2.3 SAMPLING STRATEGY/FREQUENCY

The sampling and analysis stages correspond to the data quality objective (DQO) activities presented in Section A3.4 of the QAPjP (Table A-3). For convenience of discussion, related activities have been grouped together.

A2.3.1 Pre-design Characterization

As previously mentioned, sampling and analysis for the pre-design characterization wells (Activities A and B) is described in the corresponding description of work (DOW) (PNNL 1997). Once these three activities are completed, the test barrier will be designed and the scope of work covered by this sampling and analysis plan will commence.

A2.3.2 Field Characterization and Site Preparation

The field characterization and site preparation task involves collecting background samples (Activity D); drilling the injection/withdrawal and monitoring wells (Activity C) as shown in the conceptual design in Figure 5-2 of the Treatability Test Plan (TTP); and performing the injection/withdrawal tracer test (Activity E).

Water quality testing is needed to establish a baseline before the barrier is installed. In addition, water and sediment samples may need to be collected during the drilling in Activity C to verify parameters collected during the pre-design characterization and analysis phase. The frequency of this sampling will be determined after the pre-design characterization (Activities A and B) and barrier design have been completed and will be documented in the drilling DOW for the barrier emplacement.

An injection/residence/withdrawal test will be conducted at the site with a nonreactive conservative tracer prior to the barrier emplacement. This test will determine the larger scale porosity of the aquifer, the amount of sodium dithionite required for injection, the amount of wastewater generated during the withdrawal, and the rates and durations needed for injection and withdrawal. The test will be conducted on the center injection/withdrawal well. Additional tracer tests may also be required on other injection/withdrawal wells based on observations in lithology.

A2.3.3 Permeable Treatment Barrier Emplacement

This task consists of emplacing the permeable treatment barrier (Activity F) through seven consecutive injection/residence/withdrawal stages in the injection wells shown in Figure 5-2 of the TTP.

For each of the seven injection wells, the injection and residence stages together last about 24 hr. The withdrawal stage will last a few days. During the operation at each injection well, the fluid in the feed tank, the monitoring wells, and overlapping injection wells will be collected and analyzed for dithionite concentrations. The frequency of this sampling is summarized in Table A-1. As with many of the other stages already discussed, sampling frequency cannot be determined until pre-design characterization data have been collected and analyzed.

Table A-1. Emplacement Sampling Frequency.

Analyte	Frequency
pH	To be determined based on well spacing and injection/withdrawal rates.
Dissolved Oxygen	
Eh	
Specific Conductivity	
Tracer	
Dithionite	
Chromate	Selected samples of injection stream, withdrawal stream, purgewater.
Nitrate	
Thiosulfate	
Sulfite	
Sulfate	
Trace Metals	

Finally, this task also includes analysis of withdrawn water from the ISRM test to determine how to treat or dispose of it.

A2.3.4 Barrier Performance Assessment and Monitoring

This task involves the evaluation of the permeable treatment barrier in its effectiveness in chromium remediation, impact on the water quality, and long-term capacity. The project stages included are post-emplacement characterization (Activity G), up/downgradient monitoring (ongoing) (Activity H), performance assessment tracer experiment (Activity I), and coreholes (Activity J).

After the barrier is emplaced, hydraulic testing (slug interference) is needed to determine if any detectable changes occurred to the hydraulic properties of the barrier/aquifer. The hydraulic testing will be per AT-6 or NHFP-AT-07 and will be performed on the first injection/withdrawal well. The water quality downgradient from the barrier will also be sampled, one sample per downgradient monitoring well.

As the main measure of the effectiveness of chromium remediation for the permeable treatment barrier, chromium concentrations will be monitored in the up and downgradient monitoring wells. Samples will be collected biweekly, one sample per well.

Tracers will be added to the upgradient wells to determine the arrival of the upgradient water in the downgradient monitoring wells. The up/downgradient wells will be sampled to monitor the tracer; the frequency will be determined based on flow rate estimates (~weekly to monthly) until the tracer is below a minimum determined value.

Because of the slow estimated groundwater velocity in the region around the barrier, about 8 to 15 m/yr (25 to 50 ft/yr), some hydraulic control through the use of pumping or injection may be required to shorten the travel time from the upgradient to downgradient wells.

After the injection/residence/withdrawal operation has been completed at the injection wells, sediment samples will be collected by coreholes drilled within the barrier as shown in Figure 5-2 of the TTP. This sediment will be analyzed to determine the amount of iron reduction that occurred within the barrier. This will be accomplished by both iron analysis and column studies of the

reoxygenation of the sediment to determine the treatment capacity of the reduced sediment within the barrier. The number of coreholes to be drilled will be determined from pre-design characterization data. Groundwater may need to be sampled from the coreholes to compare to pre-design characterization data. The frequency of groundwater sample collection will be determined from pre-design characterization data.

Additional coreholes should be collected from the fringe and interior of the barrier at least 1 yr after barrier emplacement in order to measure the loss of treatment capacity. This will involve iron analysis and reoxygenation column studies. These additional coreholes are not shown in Figure 5-2.

A2.4 SAMPLE COLLECTION PROCEDURES

Sediment and groundwater sample collection procedures will be consistent throughout all of the stages of the project unless otherwise specified.

A2.4.1 Sediment Sampling

Sediment samples shall be collected for analyses presented for Activity J, Coreholes, in Table 3-2. The samples shall be collected in Lexan liners; the priority for liner capping of reactable iron, treatment capacity, porosity and bulk density, and physical property samples is as follows:

1. Reactable iron and treatment capacity sample Lexan liner capping
2. Physical property sample liner capping.

The individual steps for each of these activities are described in the following sections.

Reactable Iron and Treatment Capacity Sample Liner Capping

Capping the sample liner for reactable iron analysis is conducted after the liner has been retrieved, as follows:

- Cap both ends of the liner with vinyl end caps
- Write the date and time of sampling, the well number and depth, and the sampler's initials on the Lexan liner and mark on or attach a label to the liner: (1) "CHEM"; and (2) an arrow pointing in the up direction.

Porosity and Bulk Density Sampling

The liner designated for porosity and bulk density analyses must be completely full of sediment. This will ensure that the sediment structure is not destroyed during transport and that sediment samples are representative of the particle size fraction present in the sampled interval. Cap and label as above, except that the liner is labeled "PHYS" instead of "CHEM".

A2.4.1.1 Sample Preservation Procedures. Preservation procedures for reactable iron samples, particle size samples, and porosity and bulk density samples are described below.

Reactable Iron and Treatment Capacity Sediment Samples

The liner designated for reactable iron or treatment capacity characterization will be sealed with end caps and will be refrigerated and kept in an oxygen-free environment (plastic bag filled with argon gas) until delivery to the laboratory to maintain iron valence.

Porosity/Bulk Density and Particle Size Samples

Porosity/bulk density samples must retain the sediment structure intact to the highest degree possible during sample collection and transport. To ensure that the sediment structure of the samples taken for these analyses remains intact, the Lexan liners in which these samples are collected must be completely full of sediment. The sampled sediment will be sealed inside the liners with liner caps and the caps taped in place. Samples do not require refrigeration during transport. The holding time limit for the porosity and bulk density samples is 90 days.

A2.4.2 Groundwater Sampling

Groundwater samples will be collected according to GC-1.

A2.4.2.1 Sample Collection and Preservation Procedures. Tests will be conducted during the tracer studies to determine the purge volume required to obtain a representative sample. If this volume cannot be adequately determined, three casing volumes shall be purged from the well prior to sampling. Purgewater will be stored in the modular tank that will be used for temporary storage of the groundwater extracted as part of the emplacement phase of the treatability test. Purgewater management will be in accordance with the Waste Control Plan. During emplacement, the fluid in the feed tank will be monitored for dithionite concentrations.

A2.4.2.2 Quality Control Samples. Quality control requirements are listed in the Quality Assurance Project Plan (Section A3.0).

A2.4.2.3 Sample Disposal. Samples sent off of the Hanford Site will be disposed of as specified by the contract with the laboratory. Sampled material that remains on the Hanford Site will be disposed of according to the waste control plan.

A3.0 QUALITY ASSURANCE PROJECT PLAN

A3.1 PROJECT DESCRIPTION/OBJECTIVE

This Quality Assurance Project Plan applies to sampling and data-gathering activities in support of the In Situ Redox Treatability Test in the 100-HR-3 Operable Unit, 100-D Area. Data resulting from this test will be utilized to evaluate the suitability of the ISRM technology for remediation of the chromium-contaminated groundwater in the 100-D/DR Area of the Hanford Site.

The purpose of this QAPjP is to specify the overall procedures and controls for performing sampling and data gathering activities with the level of quality control commensurate with the cost, schedule and risks associated with this project. All staff working within the scope of PNNL responsibilities will be trained to this QA Plan and will meet its requirements during performance of the work.

A3.1.1 Client

U.S. Department of Energy

A3.1.2 Authorizing Document

DOE, EM-50 (Metals and Radionuclides Remediation), TTP number RL-3-7-SS-52.

A3.1.3 QA Requirements Specification(s)

Impact Level III activities shall comply with the applicable requirements of PNL-MA-70 for the work being performed. This QAPjP also identifies client QA requirements and any imposed exclusions or limitations to PNNL procedure requirements. If other quality-related activities are later performed, the appropriate PNL-MA-70 requirements and procedures shall be applied, unless specifically excluded.

A3.1.4 QA Program/Organization

The QA program described here was developed to address the U. S. Environmental Protection Agency's (EPA) QAMS-005/80, Interim Guidelines for Preparing Quality Assurance Project Plans. PNNL's current Quality Assurance Program is documented in the Quality Assurance manual, PNL-MA-70. It is based on ASME NQA-1-1989, Quality Assurance Program Requirements for Nuclear Facilities and meets the majority of the requirements of DOE 5700.6C.

A3.1.5 Impact Level

The Impact Level for this project has been designated Impact Level III.

A3.1.6 Change Control (Scope, Schedule, Budget)

Requests for changes in project scope, schedule or budget from that in the Test Plan (other than changes in the sampling site, frequency, or parameters) must be documented and receive approval from the client.

A3.2 PROJECT DESCRIPTION

Pacific Northwest National Laboratory (PNNL), the developer of the ISRM technology, has conducted experiments to test the viability of the ISRM technology from bench-scale to field-scale testing. The ISRM Project began in fiscal year (FY) 1992 through DOE's Office of Health and Environmental Research - Subsurface Science Program. As part of this ISRM project, laboratory

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proof-of-principle abiotic and biotic studies, conceptual design reports, and preliminary planning documents were prepared (Fruchter et al. 1995). The potential for a remediation technology based on in situ manipulation of subsurface redox conditions has been established through theory and proof-of-principle laboratory experiments. However, attempts to control redox potential in an aquifer must overcome various scale-up complications arising from the interaction between contaminants, reducing agents, groundwater, and the natural variability of the subsurface. In FY 1994, a site at 100-H Area was selected for field-scale experiments of the ISRM technology. The laboratory and design studies as well as the FY 1994 and 1995 field tests were funded through DOE's Office of Technology Development's In Situ Remediation Integrated Program.

Results of these experiments will be used to design this full-scale field demonstration. This treatability test will demonstrate the ISRM technology on a pilot scale in the 100-D Area. Reduction of ferric iron will be accomplished by injecting and withdrawing aqueous sodium dithionite into the aquifer. Hexavalent chromium in the groundwater moving through this zone will be reduced to the less soluble and less toxic trivalent form of chromium.

A3.3 PROJECT ORGANIZATION AND RESPONSIBILITIES

The responsibilities of key PNNL personnel are summarized in Table A-2.

TABLE A-2. KEY PROJECT PERSONNEL

PERSONNEL	RESPONSIBILITIES
Project Manager (JS Fruchter)	Ensures that all project objectives are accomplished in a timely manner and within the program budget. Assigns qualified staff to the project. Ensures the quality of the work done on the project and maintains direct communication with the client.
Technical Lead (CR Cole, MD Williams)	Works directly with the Project Manager and Staff. Provides technical oversight for the project.
Task Leaders (VR Vermeul, SS Teel)	Provide planning and management assistance to the Project Manager by developing planning documents, directing day-to-day activities to accomplish the project objectives, and coordinate tasks, personnel and schedules. Manage the budget, investigate suspect results, and review records. Contribute relevant task information to the final technical memoranda.
Project Staff	Perform sampling activities in accordance with methods identified in the planning documents. Works under supervision of the Task Leaders.

A3.4 QA OBJECTIVES FOR MEASUREMENTS

The data collected for this project will be used to evaluate the suitability of the ISRM technology for remediation of the chromium-contaminated groundwater in the 100-D/DR Area of the Hanford Site. It is critical that sampling activities are well planned and conducted according to procedures to ensure representativeness and comparability as well as a level of precision and accuracy to be expected from field activities. To assure the quality of the data, quality control specifications for measuring precision and accuracy will be given to the laboratory in the Statement of Work .

A3.4.1 Data Quality

The characteristics used to define data quality are accuracy, precision, completeness, comparability, and representativeness. These terms are defined in the following sections. The definitions for accuracy and precision terms are those contained in Appendix A of QAMS-005/80, Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans.

Analytical requirements (detection limit/range/accuracy) are shown in Table A-3. Representativeness and comparability of data are ensured through procedures and well planned sampling practices and activities and, as defined in Appendix A of QAMS-005/80, will be addressed, as appropriate, in deliverable reports.

A3.4.1.1 Accuracy

Accuracy is a measure of the error between reported test results and the true sample concentration. Insomuch as true sample concentrations are not known, accuracy is usually inferred from recovery data as determined by sample spiking.

For the laboratory metals analyses, the laboratories will analyze samples spiked with a known concentration of a reference standard to assess laboratory accuracy. Perfect accuracy is 100 percent recovery; acceptable accuracies are ±25% recovery. Matrix spikes will be analyzed at a frequency recommended by the analytical method or Laboratory QA manual.

A.3.4.1.2 Precision

Precision is a measure of the variability of the data when more than one measurement is made on the same sample. Variability is commonly attributable to sampling activities and/or chemical analysis. For duplicate measurements, precision can be expressed as the relative percent difference (RPD). Analysis of field duplicate samples measures the precision of sampling procedures. Analysis of laboratory duplicate samples will serve to measure the precision of laboratory procedures. Laboratory duplicates will be analyzed at a frequency recommended by the analytical method and/or laboratory QA Plan. The objectives for precision are 20% RPD. The frequency at which field duplicate samples should be collected is 10 percent.

A.3.4.1.3 Completeness

Completeness is defined as the total number of samples taken for which acceptable analytical data are generated divided by the total number of samples analyzed and multiplied by 100. An overall completeness goal for this project has been set at 95 percent.

A.3.4.1.4 Comparability

Comparability expresses the confidence that one data set can be compared to another. Comparability of the data will be maintained by using established procedures in both the sampling activities and the analytical methods used.

A.3.4.1.5 Representativeness

Representativeness is a measure of how closely the measured results reflect the actual concentration or distribution of the chemical constituent in the matrix sampled.

Representativeness is accomplished by choosing sampling procedures that will produce results that depict as accurately and precisely as possible the matrix and conditions being measured; by developing protocols for storage, preservation, and transportation that preserve the representativeness of the collected samples; and by using documentation methods that assure that protocols have been followed and that samples are properly identified so that their integrity is maintained.

A.3.4.1.6 Detection Limit

The detection limit refers to the reporting detection limit that the lab will report as per the Laboratory Statement of Work (SOW). Detection limits are shown in Table A-3.

A3.5 SAMPLING AND LABORATORY PROCEDURES

A list of procedures that will be used for this work is shown in Table A-3 and A-4. These procedures include field procedures, sampling procedures, and laboratory procedures.

A3.5.1 Sampling Procedures

All samples shall be collected in accordance with the requirements contained in the Sampling and Analysis Plan (Section A.1.0 and A.2.0).

A.3.5.2 Analytical Chemistry Procedures

The analytical laboratories performing analyses will use procedures noted in Table A-3.
The analytical chemistry lab manager will be responsible for all chemistry analyses. Requirements for the analysis will be documented in a Statement of Work (SOW) to the lab. The analyses will be distributed as listed below. Changes to this list shall be approved by the Project Manager prior to submittal to the laboratory for analysis.

A3.6 SAMPLE CUSTODY AND FIELD/LAB DOCUMENTATION

All of the samples shall be handled in such a manner to ensure sample integrity. The sample containers shall be sealed to minimize moisture loss and prevent possible contamination, and shall be kept cold, but not frozen, until delivered to the place of testing.

A3.6.1 Sample Chain-of-Custody

The chain-of-custody of samples from the field to the analytical labs shall be controlled in accordance with **PNL-MA-567, AD-2: Ground-Water Sample Chain of Custody and Field Record Form Procedure.**

A3.6.2 Field Record Forms

Field Record Forms, Field Notebooks, or the Geologists Log will be used to document field sampling activities performed by PNNL staff. Field Record Forms are used for groundwater sampling, conductivity, pH and water level measurements in accordance with the **PNL-MA-567, AD-2: Ground-Water Sample Chain of Custody and Field Record Form Procedure.** Field Log Books or Geologists Logs shall be used to document collection of the sediment samples.

If Laboratory Record Books (LRB) are used to document other activities they shall be used in accordance with the requirements contained in **PNL-MA-68, Section 6.2, Laboratory Record Books.**

Only black ink shall be used to record information on data forms and the LRBs. Pencil drafts may be used provided that record originals are prepared by photocopying or through transcription onto another form. If the penciled documents are transcribed onto another form, the original pencil document shall also be kept as a record.

A3.6.3 Corrections to Documentation

If an error is made on any field or laboratory documentation, an individual may correct the error by drawing a single line through the error and entering the correct information. The error shall not be obliterated. All non-editorial corrections shall be initialed and dated.

A.3.7 CALIBRATION PROCEDURES AND FREQUENCY

All measuring and test equipment (M&TE) must be controlled in accordance with PNL-MA-70 Administrative Procedure **PAP-70-1201, Calibration Control System.** All M&TE used on this project shall be traceable to the data collected and shall be calibrated before use.

A3.7.1 Field Instrument Calibration

Field instruments used in obtaining water quality data (i.e. pH, temperature, and conductivity) must be calibrated daily before use in accordance with manufacurer's specifications; such calibration shall be documented on standardized data forms.

A3.7.2 Analytical Chemistry Calibration

Calibration methods for all chemical analytical processes shall be addressed in each specific procedure. As a minimum, calibrations should include:

- standards that are traceable to nationally recognized standard organization(s)
- standards that are within their expiration date
- using standard concentrations that bracket the expected concentration of the sample(s)

All laboratory equipment shall either be calibrated or performance checked with traceable standards (bulletted above) as applicable, prior to work being performed for this project.

A3.8 DATA MANAGEMENT AND REPORTING

Analytical results shall be entered into the project database and verified against the hard copy spreadsheet or data report.

In addition to original deliverables from the laboratories, a computer database shall be maintained to store results of field measurements, laboratory analyses, and groundwater level measurements. Field measurements will be recorded on standardized data forms.

A3.8.1 Sample Tracking

Sample tracking procedures shall used to indicate whether analytical samples collected are contained, transported, and analyzed according to methods and holding times specified. The sample tracking shall verify that analyses requested for each sample listed on the chain-of-custody were performed by the analytical laboratories. Printouts shall be generated for any outstanding results or discrepancies.

A3.8.2 Data Entry

Data shall be entered into the database manually or by direct download of laboratory supplied electronic data. Regardless of the method of data entry, data entry quality control shall be

maintained through several types of data checking. Data checking is carried out prior to merging the temporary input file with the master database file. This checking system shall involve direct comparison of hardcopy listings of the temporary input database to the hardcopy laboratory or field reports. If corrections are required, they will be written directly on the printout. Once the correction is made, a revised printout will be placed with the original to document the change. Notations will be made of the date and the initials of the reviewer. After the corrections are completed, the log will be dated and initialed. Following correction of any inconsistencies in either the data file or the laboratory reports, the temporary input file is merged to a proxy master file. This proxy file is used as a daily working file, and backups of it as well as the master file are maintained.

A3.8.3 Process for Handling Suspect or Unacceptable Data

When the initial data review identifies suspect data, that data must be investigated to establish whether it reflects true conditions or an error. The investigation shall be documented. If the data value is determined to be in error, the source of the error must be investigated, the correct value established if possible, and the erroneous value replaced with the correct value. If the investigation concludes that the data are suspect (possibly in error) but a correct value cannot be determined, the data must be flagged to indicate its suspect status.

A3.9 INTERNAL QUALITY CONTROL CHECKS

CHEMISTRY ANALYSIS

Matrix Spikes - All matrix spike recoveries which are outside the established DQOs shall be noted in the narrative and flagged on the final data report. In addition, the number of results which exceed the range per batch shall be noted to determine if the problem affects the sample data for that batch and to determine any other appropriate corrective action

Surrogates - For parameters where one surrogate is used, all samples with recoveries outside the established limits (see Table 6.2) need to be re-extracted and re-analyzed. When multiple surrogates are used, and more than one is outside of these limits, re-extraction and re-analysis of that sample is required. If after re-analysis, the same recoveries are outside the limits, the problem will be considered a matrix effect and a third re-extraction and re-analysis is not required.

Replicates - All samples associated with replicates (matrix spike duplicates and triplicates) that are outside the established control limits will be noted in the narrative and flagged in the final data report. In addition, the number of results which exceed the range per batch shall be noted to determine if the problem affects the sample data for that batch and to determine any other appropriate corrective action.

SRMs - SRM values exceeding the PD range from the certified value should be noted in the narrative and flagged in the final data report. In addition, the number of results which exceed the range per batch shall be noted to determine if the problem affects the sample data for that batch and to determine any other appropriate corrective action.

Method Blanks - Any blank values detected above the established criteria should be noted in the narrative and the corresponding data should be flagged as blank contaminated. In addition, the number of results which exceed the range per batch shall be noted to determine if the problem affects the sample data for that batch and to determine any other appropriate corrective action.

Equipment Blanks - Frequency for equipment blank collection will be based on the number of samples collected each day. Equipment blanks will be collected at a frequency of

5 percent or once per day when 10 or more samples are collected per day. When less than 10 samples are collected per day, this batch of samples will be submitted with the samples and equipment blank collected on the following day. Field duplicate samples will be collected at least once per day for each sample parameter (and for each media type, if more than one sampled per day. Laboratory method blanks, used to assess the level of laboratory background contamination, will be analyzed at a frequency specified by the analytical method.

A3.10 ASSESSMENTS

Project management will determine if areas of the project should be assessed to ensure that key requirements are being met. These assessments, if performed, will be in accordance with **QP-07, Management Self-Assessments**, with the exception that a memo may be utilized as a reporting format. The results of assessments shall be made available to project and line management as well as to key individuals contacted.

A3.11 SPECIFIC ROUTINE PROCEDURES USED TO ASSESS DATA PRECISION, ACCURACY, COMPARABILITY AND COMPLETENESS

Because of the nature of environmental measurements, it is frequently difficult or impossible to know the "true" value of the measured parameter. The accuracy of the measured value must instead be inferred through the use of QC samples of known composition. This project uses this method to verify that the data quality objectives (DQOs) have been met.

The task leader will verify that data precision, accuracy, comparability, and completeness are reviewed and within the DQOs. Results of this review will be included in the final report.

A3.12 CORRECTIVE ACTION

Results outside the established criteria in Table A-2 shall be brought to the attention of the Task Leader and the Project Manager who shall determine and document the appropriate corrective action. These actions may include, but are not limited to, review of data and calculations, flagging of suspect data or re-analyses of individual or entire batches of samples.

The need for corrective action may be identified by the technical staff during the course of their work. Each individual performing field, laboratory, or data processing activities will be responsible for notifying the appropriate supervisory personnel of any circumstance that could affect the quality or integrity of the data.

Unplanned deviations from procedural, contractual, or regulatory requirements must be documented by completing a Deficiency Report (DR) in accordance with PNL-MA-70 Administrative Procedure **PAP-70-1502, Deficiency Reports (DRs)**. The DR must identify the requirement deviated from, the cause of the deviation, whether any results were effected, and corrective action needed to remedy the immediate problem and to prevent recurrence.

Planned deviations, documented (including justification) and approved by the Project Manager or Task Leader in advance, do not constitute a deficiency as defined in PAP-70-1502 and do not require development of a DR. Deviations typically result from unforeseen circumstances and must be documented. Deviations are different from deficiencies and will be documented in a field notebook or geologists log.

A3.13 QUALITY ASSURANCE REPORTS TO MANAGEMENT

Significant problems (e.g., problems affecting the quality of the work) uncovered by project

personnel must be reported to line management immediately for resolution. Significant problems involving data quality or sample integrity must be thoroughly documented. Line management must be included on the distribution of all audit and surveillance reports. Significant problems encountered in day-to-day operations must be reported to line management immediately by the Project Manager.

QA assessment results will be documented and reported to the Project Manager and Task Leaders when assessments are performed.

A3.14 RECORDS

Records shall be indexed and subsequently maintained in accordance with **PAP-70-1701, Records System**. All project records shall be made available for storage after project completion and/or after client approval of the final report. The retention period for storage shall be specified on the Records Inventory/Disposition Schedule (RIDS). Records will not be turned over to the client unless specifically requested.

A3.15 PROCUREMENT CONTROL

Procurement of items and subcontracted services are governed by PNL-MA-70 Administrative Procedure **PAP-70-401, Purchase Requisitions.**

Samples submitted to analytical labs shall be accompanied with, as a minimum, directions for the following: 1) chain-of-custody; 2) analysis turnaround time; 3) QC requirements; 4) methods; and 5) notification of PNNL staff when Data Quality Objective (DQO) requirements are not met. Corrective action for DQO exceedences shall be coordinated with PNNL and analytical staff and shall follow the guidance of section 13.0 of this QAPjP.

A3.16 STAFF TRAINING

Staff performing activities affecting quality shall have documented training for the applicable administrative procedures and standard operating procedures, the Sampling and Analysis Plan and this QAPjP.

Training shall be documented in accordance with **PNL-MA-4, PNNL Training and Qualification Manual**, either through the issuance of training assignments for read/study training or through briefings given by the Quality Engineer, Program Manager or Task Leaders, or others, as appropriate.

Table A-3. Analytical Requirements for the ISRM Treatability Test. (10 Sheets)

A - Pre-Design Characterization

Aqueous Sampling and Analysis

Parameter	Analysis Method		Detection Limit / Range / Accuracy
Chromate	diphenylcarbazide method Hach 8023[1], SM-3500-Cr-D[2], EPA 7196[4]		0.005 - 0.6 ppm
pH	pH Electrode Hach 8156[1], SM-4500-H[2]		± 0.1
Dissolved Oxygen	Membrane Electrode SM-4500-O G[2]		±1 % (air sat)
Conductivity	Electrode Hach 8160[1], SM-2510[2]		± 1 µS/cm
Nitrate	Colorimetric indicator test strip FSP-1-12[1], DOE MS-310[3]		0.7 - 50 ppm
	Cd reduction, diazotization	Hach 8192[1]	0.01 - 0.40 ppm
		Hach 8171[1]	0.1 - 4.5 ppm
		Hach 8039[1]	1.0 - 30.0 ppm
Sulfate	$BaSO_4$ method Hach 8051[1]		5 - 70 ppm

Sediment Sampling and Analysis[a]

Parameter	Analysis Method	Detection Limit / Range / Accuracy
Specific Gravity Bulk Density/Porosity	ASTM[5] or other Standard Method	n/a
Grain Size Distribution	Sieve, ASTM[5] or other Standard Method	n/a
Lithologic Description	Field Geologist, DO-1 [7]	n/a
Accessible Iron and Reaction Rate Analysis	Dithionite Treatment (PNNL Laboratory-Specific Procedure)[6]	n/a

Hydraulic Sampling and Analysis

Parameter	Analysis Method	Detection Limit / Range / Accuracy
Hydraulic Head	Standardized Steel Tape or Water-Level Indicator, WL-1[7]	0.003 m (0.01 ft)

Notes: a) Sediment samples from one well must be sealed in an argon-gas filled bags and temporarily stored in coolers for preservation of iron valence within the samples. These samples will be transferred to anaerobic chambers for analysis.

Table A-3. Analytical Requirements for the ISRM Treatability Test. (10 Sheets)

B - Initial Hydraulic Test		
Aqueous Sampling and Analysis		
Parameter	Analysis Method	Detection Limit / Range / Accuracy
n/a		
Sediment Sampling and Analysis		
Parameter	Analysis Method	Detection Limit / Range / Accuracy
n/a		
Hydraulic Sampling and Analysis		
Parameter	Analysis Method	Detection Limit / Range / Accuracy
Hydraulic Conductivity	Slug Interference and/or Constant Rate Discharge Test, AT-6 and/or NHFP-AT-07 [7]	n/a
Specific Yield	Constant Rate Discharge Test, AT-6 and/or NHFP-AT-07 [7]	n/a
Specific Storage	Slug Interference and/or Constant Rate Discharge Test, AT-6 and/or NHFP-AT-07 [7]	n/a
Maximum Production Rate	Step Drawdown Test, AT-6 [7]	n/a
Hydraulic Head	Water-Level Indicator or Pressure Transducer, manufacturer's instructions	n/a

Table A-3. Analytical Requirements for the ISRM Treatability Test. (10 Sheets)

C - Injection/Withdrawal and Monitoring Well Installation			
Aqueous Sampling and Analysis			
Parameter	Analysis Method		Detection Limit / Range / Accuracy
Chromate	diphenylcarbazide method Hach 8023[1], SM-3500-Cr-D[2], EPA 7196[4]		0.005 - 0.6 ppm
pH	pH Electrode Hach 8156[1], SM-4500-H[2]		± 0.1
Dissolved Oxygen	Membrane Electrode SM-4500-O G[2]		±1 % (air sat)
Conductivity	Electrode Hach 8160[1], SM-2510[2]		± 1 µS/cm
Nitrate	Colorimetric indicator test strip FSP-1-12[1], DOE MS-310[3]		0.7 - 50 ppm
	Cd reduction, diazotization	Hach 8192[1]	0.01 - 0.40 ppm
		Hach 8171[1]	0.1 - 4.5 ppm
		Hach 8039[1]	1.0 - 30.0 ppm
Sulfate	$BaSO_4$ method Hach 8051[1]		5 - 70 ppm
Sediment Sampling and Analysis			
Parameter	Analysis Method		Detection Limit / Range / Accuracy
Specific Gravity Bulk Density/Porosity	ASTM[5] or other Standard Method		n/a
Grain Size Distribution	Sieve, ASTM[5] or other Standard Method		n/a
Lithologic Description	Field Geologist, DO-1[7]		n/a
Accessible Iron and Reaction Rate Analysis	Dithionite Treatment Method (PNNL Laboratory-Specific Procedure)[6]		n/a
Hydraulic Sampling and Analysis			
Parameter	Analysis Method		Detection Limit / Range / Accuracy
Hydraulic Head	Standardized Steel Tape or Water-Level Indicator, WL-1[7]		0.003 m (0.01 ft)

Table A-3. Analytical Requirements for the ISRM Treatability Test. (10 Sheets)

D - Background		
Aqueous Sampling and Analysis		
Parameter	Analysis Method	Detection Limit / Range / Accuracy
Chromate	diphenylcarbazide method Hach 8023[1], SM-3500-Cr-D[2], EPA 7196[4]	0.005 - 0.6 ppm
pH	pH Electrode Hach 8156[1], SM-4500-H[2]	± 0.1
Dissolved Oxygen	Membrane Electrode SM-4500-O G[2]	±1 % (air sat)
Conductivity	Electrode Hach 8160[1], SM-2510[2]	± 1 µS/cm
ICP Metals (filtered)	SW-846, 6010	75% - 125%
Anions (Cl, SO4, PO4, NO2, NO3)	EPA 300.0	75% - 125%
NO2-NO3	EPA 353.1	75% - 125%
SO3	EPA 377.1	75% - 125%
Sulfide	SW-846 9030	75% - 125%
Ammonia	EPA 350.1	75% - 125%
Sediment Sampling and Analysis		
Parameter	Analysis Method	Detection Limit / Range / Accuracy
none		
Hydraulic Sampling and Analysis		
Parameter	Analysis Method	Detection Limit / Range / Accuracy
Hydraulic Head	Standardized Steel Tape or Water-Level Indicator, WL-1[7]	0.003 m (0.01 ft)

Table A-3. Analytical Requirements for the ISRM Treatability Test. (10 Sheets)

E- Tracer Injection/Withdrawal Test		
Aqueous Sampling and Analysis		
Parameter	Analysis Method	Detection Limit / Range / Accuracy
Tracer (bromide)	Ion Specific Electrode	75% - 125%
Sediment Sampling and Analysis		
Parameter	Analysis Method	Detection Limit / Range / Accuracy
n/a		
Hydraulic Sampling and Analysis		
Parameter	Analysis Method	Detection Limit / Range / Accuracy
Hydraulic Head	Pressure Transducer, manufacturer's instructions	n/a
Injection/Withdrawal Rate	Flow Meter, manufacturer's instructions	n/a
Hydraulic Conductivity, Specific Yield, and Specific Storage	Constant Rate Discharge Test, AT-6 and/or NHFP-AT-07 [7]	n/a
Maximum Production Rate	Step Drawdown Test, AT-6 [7]	n/a

Table A-3. Analytical Requirements for the ISRM Treatability Test. (10 Sheets)

F - Emplacement			
Aqueous Sampling and Analysis[a]			
Parameter	Analysis Method		Detection Limit / Range / Accuracy
pH	pH Electrode Hach 8156[1], SM-4500-H[2]		± 0.1
Dissolved Oxygen	Membrane Electrode SM-4500-O G[2]		±1 % (air sat)
Conductivity	Electrode Hach 8160[1], SM-2510[2]		± 1 µS/cm
Tracer	Ion Specific Electrode		75% - 125%
Dithionite	UV/Vis or HPLC		0.0001 M
Chromate	diphenylcarbazide method Hach 8023[1], SM-3500-Cr-D[2], EPA 7196[4]		0.005 - 0.6 ppm
Nitrate	Colorimetric indicator test strip FSP-1-12[1], DOE MS-310[3]		0.7 - 50 ppm
	Cd reduction, diazotization	Hach 8192[1]	0.01 - 0.40 ppm
		Hach 8171[1]	0.1 - 4.5 ppm
		Hach 8039[1]	1.0 - 30.0 ppm
Thiosulfate	Ion Chromatography		75% - 125%
Sulfite	iodate-iodide method Hach 8071[1]		1 ppm
Sulfate	$BaSO_4$ method Hach 8051[1]		5 - 70 ppm
Trace Metals	SW-846 6010		75% - 125%
Sediment Sampling and Analysis			
Parameter	Analysis Method		Detection Limit / Range / Accuracy
none			
Hydraulic Sampling and Analysis			
Parameter	Analysis Method		Detection Limit / Range / Accuracy
Inj/Wdrwl Rate	Flow Meter		n/a
Hydraulic Head	Pressure transducer		n/a

Notes: a) Aqueous sampling/analysis will be conducted on the injection solution, monitoring wells, withdrawal water, and purgewater storage.

Table A-3. Analytical Requirements for the ISRM Treatability Test. (10 Sheets)

G - Post-Emplacement Characterization		
Aqueous Sampling and Analysis		
Parameter	Analysis Method	Detection Limit / Range / Accuracy
Chromate	diphenylcarbazide method Hach 8023[1], SM-3500-Cr-D[2], EPA 7196[4]	0.005 - 0.6 ppm
pH	pH Electrode Hach 8156[1], SM-4500-H[2]	± 0.1
Dissolved Oxygen	Membrane Electrode SM-4500-O G[2]	±1 % (air sat)
Conductivity	Electrode Hach 8160[1], SM-2510[2]	± 1 µS/cm
Thiosulfate	Ion Chromatography	75% - 125%
ICP Metals (filtered)	SW-846 6010	75% - 125%
Anions (Cl, SO4, NO2, NO3)	EPA 300.0	75% - 125%
NO2-NO3	353.1	75% - 125%
SO3	EPA 377.1	75% - 125%
Sulfide	9030	75% - 125%
Ammonia	EPA 350.1	75% - 125%
Sediment Sampling and Analysis		
Parameter	Analysis Method	Detection Limit / Range / Accuracy
none		
Hydraulic Sampling and Analysis[a]		
Parameter	Analysis Method	Detection Limit / Range / Accuracy
Hydraulic Head	Pressure Transducer	n/a
Withdrawal Rate	Flow Meter	n/a
Hydraulic Conductivity, and Specific Storage	Slug Interference Test and/or Constant Rate Discharge Test, AT-6 and/or NHFP-AT-07 [7]	n/a

Notes: a)The Hydraulic tests will be conducted in the central injection/withdrawal well.

Table A-3. Analytical Requirements for the ISRM Treatability Test. (10 Sheets)

H- Up/Downgradient Chromate Monitoring			
Aqueous Sampling and Analysis			
Parameter	Analysis Method		Detection Limit / Range / Accuracy
Chromate	diphenylcarbazide method Hach 8023[1], SM-3500-Cr-D[2], EPA 7196[4]		0.005 - 0.6 ppm
pH	pH Electrode Hach 8156[1], SM-4500-H[2]		± 0.1
Dissolved Oxygen	Membrane Electrode SM-4500-O G[2]		±1 % (air sat)
Conductivity	Electrode Hach 8160[1], SM-2510[2]		± 1 µS/cm
Nitrate	Colorimetric indicator test strip FSP-1-12[1], DOE MS-310[3]		0.7 - 50 ppm
	Cd reduction, diazotization	Hach 8192[1]	0.01 - 0.40 ppm
		Hach 8171[1]	0.1 - 4.5 ppm
		Hach 8039[1]	1.0 - 30.0 ppm
Sulfate	$BaSO_4$ method Hach 8051[1]		5 - 70 ppm
Sediment Sampling and Analysis			
Parameter	Analysis Method		Detection Limit / Range / Accuracy
none			
Hydraulic Sampling and Analysis			
Parameter	Analysis Method		Detection Limit / Range / Accuracy
Hydraulic Head	Standardized Steel Tape or Water-Level Indicator, WL-1[7]		0.003 m (0.01 ft)

Table A-3. Analytical Requirements for the ISRM Treatability Test. (10 Sheets)

I - Performance Assessment Tracer Experiment

Aqueous Sampling and Analysis

Parameter	Analysis Method		Detection Limit / Range / Accuracy
Tracer (species TBD)	Field method (ion specific probe)		
Chromate	diphenylcarbazide method Hach 8023[1], SM-3500-Cr-D[2], EPA 7196[4]		0.005 - 0.6 ppm
pH	pH Electrode Hach 8156[1], SM-4500-H[2]		± 0.1
Dissolved Oxygen	Membrane Electrode SM-4500-O G[2]		±1 % (air sat)
Conductivity	Electrode Hach 8160[1], SM-2510[2]		± 1 µS/cm
Nitrate	Colorimetric indicator test strip FSP-1-12[1], DOE MS-310[3]		0.7 - 50 ppm
	Cd reduction, diazotization	Hach 8192[1]	0.01 - 0.40 ppm
		Hach 8171[1]	0.1 - 4.5 ppm
		Hach 8039[1]	1.0 - 30.0 ppm
Sulfate	$BaSO_4$ method Hach 8051[1]		5 - 70 ppm

Sediment Sampling and Analysis

Parameter	Analysis Method	Detection Limit / Range / Accuracy
none		

Hydraulic Sampling and Analysis

Parameter	Analysis Method	Detection Limit / Range / Accuracy
Tracer Test	NHFP-AT-09 and/or NHFP-AT-10[7]	n/a
Hydraulic Head	Standardized Steel Tape or Water-Level Indicator, EIP 7.1[8]0.003 m (0.01 ft)	0.003 m (0.01 ft)

Table A-3. Analytical Requirements for the ISRM Treatability Test. (10 Sheets)

J - Coreholes			
Aqueous Sampling and Analysis			
Parameter	Analysis Method		Detection Limit / Range / Accuracy
Chromate	diphenylcarbazide method Hach 8023[1], SM-3500-Cr-D[2], EPA 7196[4]		0.005 - 0.6 ppm
pH	pH Electrode Hach 8156[1], SM-4500-H[2]		± 0.1
Dissolved Oxygen	Membrane Electrode SM-4500-O G[2]		±1 % (air sat)
Conductivity	Electrode Hach 8160[1], SM-2510[2]		± 1 µS/cm
Nitrate	Colorimetric indicator test strip FSP-1-12[1], DOE MS-310[3]		0.7 - 50 ppm
	Cd reduction, diazotization	Hach 8192[1]	0.01 - 0.40 ppm
		Hach 8171[1]	0.1 - 4.5 ppm
		Hach 8039[1]	1.0 - 30.0 ppm
Sulfate	$BaSO_4$ method Hach 8051[1]		5 - 70 ppm
Sediment Sampling and Analysis[a]			
Parameter	Analysis Method		Detection Limit / Range / Accuracy
Specific Gravity Bulk Density/Porosity	ASTM[5] or other Standard Method		n/a
Grain Size Distribution	Sieve, ASTM[5] or other Standard Method		n/a
Lithologic Description	Field Geologist, DO-1[7]		n/a
Accessible ferric Iron Analysis	Dithionite Treatment Method		n/a
Treatment Capacity (pore volumes of oxygenated water and chromate)	Bench-Scale Chromate Treatment Experiments (batch or column)		n/a
Hydraulic Sampling and Analysis			
Parameter	Analysis Method		Detection Limit / Range / Accuracy
none			

Notes: a) All sediment samples must be sealed in an argon-gas filled bags and temporarily stored in coolers for preservation of iron valence within the samples. They will be transferred to anaerobic chambers for analysis.

[1]Hach (1992); **Water Analysis Handbook, 2nd Edition**, Hach Company, Loveland, CO, 1992.

[2]APHA/AWWA/WPCF (1989); **Standard Methods for the Examination of Water and Wastewater, 17th Edn**; American Public Health Association, Washington, DC, 1989.

[3]Goheen, S.C. et al (editors) (1994); **DOE Methods for Evaluating Environmental and Waste Management Samples**; U.S. Department of Energy, DOE/EM-0089T, Rev 2.

[4]EPA (1989); **Test Methods for Evaluating Solid Waste**; SW-846, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

[5]ASTM; **Annual Book of ASTM Standards**, American Society for Testing and Materials, Philadelphia, Pennsylvania.

[6]Material will be treated by PNNL with dithionite in an anaerobic glovebox. Dithionite concentrations in the sediment/dithionite mixture will be measured periodically (~ hourly). The reaction rate of the reduction of ferric iron by dithionite is significantly faster than the disproportionation and degradation rates; therefore, the rate of decrease in dithionite concentration is much less after all the accessible ferric iron is reduced. A plot of the dithionite concentration vs elapsed time is constructed for use in determining when all the accessible ferric iron is reduced.

[7] EIP 7.0, **Procedures for Ground-Water Investigations (PNL-MA-567)**

WL-1 Water-Level Measurement Procedure
DO-1 Collection and Documentation of Borehole Samples and Well Construction Data
AT-6 Aquifer Slug Injection and Withdrawal Test

[8] **Specific Procedures**

NHFP-AT-07 Slug Interference Test
NHFP-AT-09 Tracer-Dilution and Tracer Drift/Punpback Tests
NHFP-AT-10 Procedure for Conducting a Forced Gradient Tracer Test

Table A-4 Field Procedures

Procedures for Ground-Water Investigations (PNL-MA-567)

AD-2	Ground-Water Sample Chain-of-Custody Procedure
AD-4	Sediment Sample Chain-of-Custody Procedure
AD-5	Ground-Water Sample Check-In Procedure
AD-6	Control Measures for Identification of Wells Requiring Purgewater Containment
AD-7	Control Measures for Identification of Samples Requiring Offsite Radioactive Shipping Documentation
GC-1	Ground-Water Sample Collection Procedure
SA-1	Sediment Sample Analysis/Sample Control Procedure
GC-11	Preparation of Documents and Sample Containers for Ground-Water Sample Collection
FA-1	Temperature Measurement Procedure
FA-2	Calibration of Conductivity Meter and Measurement of Field Conductivity
FA-3	Calibration of pH meter and Measurement of Field pH
FA-4	Calibration of Turbidimeter and Measurement of Field Turbidity
WL-1	Water-Level Measurement Procedure
DO-1	Collection and Documentation of Borehole Samples and Well Construction Data
AT-6	Aquifer Slug Injection and Withdrawal Test

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APPENDIX B
CULTURAL AND ECOLOGICAL DOCUMENTATION

Cultural and ecological reviews were conducted in the vicinity of the proposed ISRM treatability test (Attachments B-1 and B-2) (Note: Hot Spot Well #1 is Well 199-D4-1). These reviews were conducted for the initial installation of the monitoring well 199-D4-1. No cultural or ecological resources would be threatened by the activities. Expanded cultural, ecological, and ground penetrating radar surveys are currently underway to cover the entire area for the ISRM Test and will be included in the final version of this Test Plan.

ATTACHMENT 1
CULTURAL RESOURCES REVIEW - 100-HR-3 GROUNDWATER MONITORING WELLS AT 100-D AREA (HCRC# 96-100-012B)

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9713541.1252

Environmental Restoration Contractor **ERC Team**

Interoffice Memorandum

Job No. 22192
Written Response Required? NO
Class CCN: N/A
OU: N/A
TSD: N/A
ERA: N/A
Subject Code: 6500

TO: R. C. Havenor, X1-85

DATE: October 3, 1996

COPIES: See Below

FROM: Darci D. Teel, Manager
Natural Resources & Risk Assessment
H0-02/372-9633

SUBJECT: CULTURAL RESOURCES REVIEW - MONITORING WELLS AT 100-D (HCRC #96-100-012B

In response to your request of October 2, 1996, a Cultural Resource Review was conducted for the 100-HR-3 Interim Remedial Action project. The scope of this project involves the installation of two monitoring wells at 100-D (Attachment 1). The Hanford Cultural Resources Management Plan identifies this project as a Class IV undertaking: New Construction in a Disturbed High Sensitivity Area.

A records and literature review was conducted for this project by Darby C. Stapp on October 3, 1996. A site visit was made on October 3, 1996. No cultural resources are recorded within or immediately adjacent to the project area. Hot Spot Well #1 is located in an area that has been covered extensively with gravel. No original ground surface could be observed at this location. Hot Spot Well #2 is located in an area that has also been graveled, but to a lesser extent. Some original ground surface was observed in this area. Given the disturbed nature of the two well locations and the absence of known cultural resources, and the minimal disturbance that will be created by the construction, this project can proceed as planned; no additional cultural resource work is needed.

Although highly unlikely, cultural materials could exist in the project area, therefore all workers must be directed to watch for cultural material (e.g., bone, stone tools) during all work activities. If any cultural materials are encountered as work proceeds, work in the vicinity of the discovery must stop until a Cultural Resources Specialist has been notified, the significance of the find is assessed, the appropriate Tribes are notified, and, if necessary, arrangements have been made for mitigation of the find. In the event of any discoveries, please contact Thomas E. Marceau at 372-9289.

If any changes occur relative to work scope or areas to be impacted, it is important that you contact the Cultural Resources staff for additional review/action that might be required. Please use the HCRC# 96-100-048 for any further correspondence concerning this project.

A copy of this memo will be formally transmitted by the ERC Manager of Projects to Dee W. Lloyd, Manager, Cultural Resources Program, A5-15, DOE-RL, as official documentaion at a later date.

Author Signature: Darby C. Stapp
Cultural Resources Coordinator

Approval Signature: Thomas E. Marceau
Cultural Resources Supervisor

Copies
N.A. Cadoret K6-75
K.A. Gano H0-02
A.J. Knepp H4-80
T.E. Marceau H0-02
W.L. Pamplin H0-18
D.C. Stapp H9-03
BHI Document Control H0-09

9713541.1253

Environmental Restoration Contractor **ERC Team**

Interoffice Memorandum

Job No. 22192
Written Response Required? NO
Class CCN: N/A
OU: N/A
TSD: N/A
ERA: N/A
Subject Code: 6500

TO: R. C. Havenor, X1-85

DATE: October 3, 1996

COPIES: See Below

FROM: Darci D. Teel, Manager
Natural Resources & Risk Assessment
H0-02/372-9633

SUBJECT: CULTURAL RESOURCES REVIEW - MONITORING WELLS AT 100-D (HCRC #96-100-012B

In response to your request of October 2, 1996, a Cultural Resource Review was conducted for the 100-HR-3 Interim Remedial Action project. The scope of this project involves the installation of two monitoring wells at 100-D (Attachment 1). The Hanford Cultural Resources Management Plan identifies this project as a Class IV undertaking: New Construction in a Disturbed High Sensitivity Area.

A records and literature review was conducted for this project by Darby C. Stapp on October 3, 1996. A site visit was made on October 3, 1996. No cultural resources are recorded within or immediately adjacent to the project area. Hot Spot Well #1 is located in an area that has been covered extensively with gravel. No original ground surface could be observed at this location. Hot Spot Well #2 is located in an area that has also been graveled, but to a lesser extent. Some original ground surface was observed in this area. Given the disturbed nature of the two well locations and the absence of known cultural resources, and the minimal disturbance that will be created by the construction, this project can proceed as planned; no additional cultural resource work is needed.

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If any changes occur relative to work scope or areas to be impacted, it is important that you contact the Cultural Resources staff for additional review/action that might be required. Please use the HCRC# 96-100-048 for any further correspondence concerning this project.

A copy of this memo will be formally transmitted by the ERC Manager of Projects to Dee W. Lloyd, Manager, Cultural Resources Program, A5-15, DOE-RL, as official documentaion at a later date.

Author Signature: Darby C. Stapp
Cultural Resources Coordinator

Approval Signature: Thomas E. Marceau
Cultural Resources Supervisor

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D.C. Stapp H9-03
BHI Document Control H0-09

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ATTACHMENT 2
ECOLOGICAL REVIEW FOR 100-HR-3 PIEZOMETER WELLS NEAR 100-D (96-ER-036)

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Environmental Restoration Contractor **ERC Team**

Interoffice Memorandum

Job No. 22192
Written Response Required? No
Closes CCN: N/A
OU: N/A
TSD: N/A
ERA: N/A
Subject Code: E240

TO: R. C. Havenor X1-85

DATE: October 7, 1996

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C. J. Kemp H0-02
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D. C. Stapp H9-03
S. G. Weiss H9-03
DDT: Letterbook H0-02
BHI Document Control H0-09

FROM: K A Gano for
D. D. Teel, Manager
Natural Resources & Risk Assessment
H0-02/372-9633

MAR 1997 RECEIVED EDMC

SUBJECT: **ECOLOGICAL REVIEW OF TWO WELL SITES AT 100-D AREA (96-ER-036)**

This memo is in response to your request for an Ecological Review of two proposed well sites in the 100-HR-3 Operable Unit. One site is in the northeast corner of 100-D Area on the bluff near the 181-D Pumphouse. The other site is directly south approximately 400 meters, just off the paved road and directly east of the existing meteorology tower.

These two sites were surveyed by Natural Resources on October 4, 1996. The first site near the pumphouse is located on highly disturbed ground consisting of coarse gravels and sand. The small amount of vegetation present at this site consists of weedy species such as Russian thistle. The site near the tower is on a coarse sandy soil and contains cheatgrass, sand dropseed, yarrow, gray rabbitbrush, hoary aster, and a small amount of diffuse knapweed. Neither of these two sites support any plant or animal species of concern and no impacts to ecological resources will occur from construction of well pads at these locations.

If there are any major changes in the scope of activities that could result in any disturbance to soils or habitats outside the description of this project, please contact Ken Gano on 372-9316 and refer to the Ecological Review number given in the subject line.

KAG:dds