Office of Inspector General

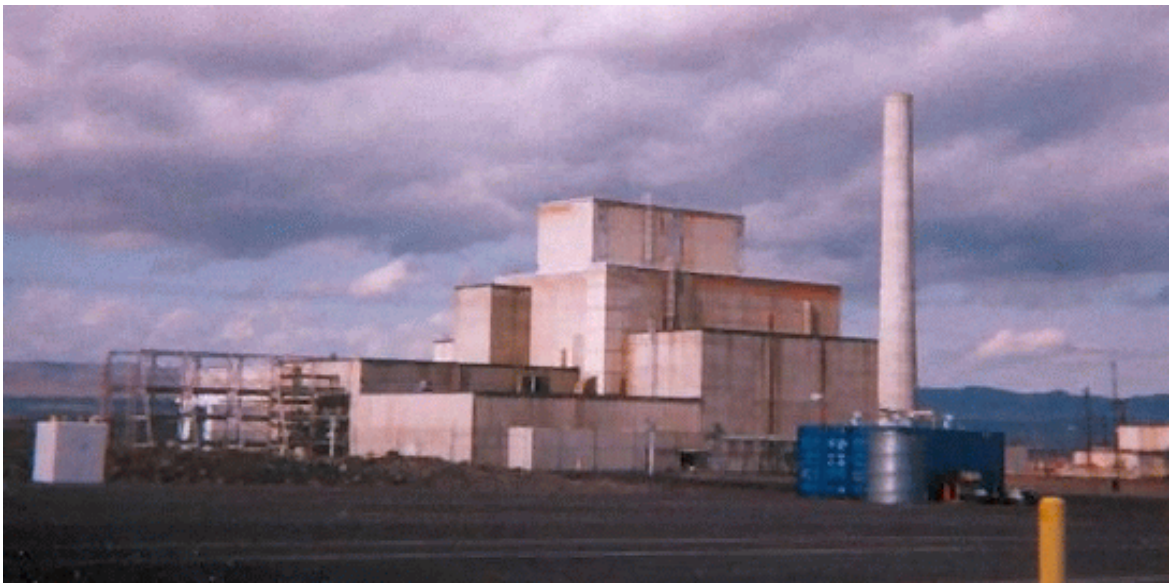
Evaluation Report

Federal Facility Cleanups

EPA Region 10 Needs to Improve Oversight of Remediation Activities at the Hanford Superfund 100-K Area

Report No. 2003-P-00002

November 4, 2002



Report Contributors: **Carolyn Copper, Director**
Michael Owen, Assignment Manager
Phil Weihrouch, Project Manager
Kimberly Murphy, Auditor
Madeline Mullen, Program Analyst

Abbreviations

CERCLA:	Comprehensive Environmental Response, Compensation, and Liability Act
DOE:	U.S. Department of Energy
EPA:	U.S. Environmental Protection Agency
FFACO:	Federal Facility Agreement and Consent Order
GAO:	U.S. General Accounting Office
gpm:	Gallons Per Minute
HEIS:	Hanford Environmental Information System
NCP:	National Contingency Plan
NPL:	National Priorities List
OIG:	Office of Inspector General
pCi/L:	Picocuries Per Liter
RCRA:	Resource Conservation and Recovery Act
ROD:	Record of Decision
ug/L:	Micrograms Per Liter

Photo Caption: The K-West Reactor located in Hanford's 100-K Area (*photo by EPA OIG*).

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

OFFICE OF
INSPECTOR GENERAL

November 4, 2002

MEMORANDUM

SUBJECT: Federal Facility Cleanups: EPA Region 10 Needs to Improve Oversight of Remediation Activities at the Hanford Superfund 100-K Area
Report No. 2003-P-00002

FROM: Carolyn Copper
Director, Hazardous Waste Issues
Office of Program Evaluation

TO: John Iani
Regional Administrator
EPA Region 10

Attached is our final report on the Environmental Protection Agency's (EPA's) Oversight of Remediation Activities at the Hanford Superfund 100-K Area. The purpose of our evaluation was to determine whether EPA Region 10's (Region's) oversight of U.S. Department of Energy remediation activities for the 100-K Area's K Basins and groundwater at Hanford has provided adequate protection to human health and the environment.

The report contains findings and recommendations that describe problems the Office of Inspector General (OIG) has identified and the corrective actions the OIG recommends. This report represents the opinion of the OIG and the findings contained in this report do not necessarily represent the final EPA position. Final determinations on matters in this report will be made by EPA managers in accordance with established audit resolution procedures.

ACTION REQUIRED

On August 20, 2002, the OIG issued a draft report to the Region for review and comment. The Region and the OIG discussed the content of the draft report on September 12, 2002. We issued a revised draft report to the Region on October 2, 2002 in order to address concerns expressed by the Region during this meeting. We received the Region's response to the revised draft report on October 11, 2002. With one exception, the Region concurred with the report's recommendations. However, the response to most of the recommendations did not sufficiently describe the corrective actions planned or taken. Specific corrective actions which address all of

the recommendations and milestones for completion of planned actions will be needed to close the final report.

In accordance with EPA Order 2750, you, as the primary action official, are required to provide this office with a written response within 90 days of the final report date. The response should address all recommendations. For corrective actions planned but not completed by the response date, please describe the actions that are ongoing and provide a timetable for completion. Reference to specific milestones for these actions will assist in deciding whether to close this report in our assignment tracking system.

We have no objection to the further release of this report to the public. Should you or your staff have any questions, please have them contact me at (202) 566-0829 or Mike Owen, Assignment Manager, at (206) 553-2542.

Attachment

Executive Summary

The U.S. Environmental Protection Agency (EPA) is responsible for overseeing Superfund activities at Federal facilities. This includes the Hanford Superfund Site, a U.S. Department of Energy (DOE) facility in southeastern Washington State. Between 1943 and 1989, Hanford's principal mission was the production of weapons-grade plutonium. The 586-square-mile site along the Columbia River contains nine deactivated plutonium production reactors. In the 100-K Area, approximately 1,800 metric tons of spent nuclear fuel are stored. DOE officials say Hanford is the world's largest environmental cleanup project.

The purpose of this evaluation was to determine whether EPA Region 10's oversight of DOE's remediation activities for the 100-K Area's K Basins and groundwater at Hanford has provided adequate protection to human health and the environment.

Results in Brief

Although some remediation progress has been made, Region 10 needs to further improve its oversight of Superfund remedial activities pertaining to Hanford's 100-K Area. More than 60 percent of DOE's national inventory of spent nuclear fuel is stored in the K Basins of the 100-K Area. Delays in removing the spent nuclear fuel, as well as sludge, debris, and contaminated water, increase the risk of a release of radionuclides to the air, soil, groundwater, and Columbia River, which can adversely affect human health and the environment. In addition, the remedial action for groundwater contamination within the area's 116-K-2 Trench section is less than effective in reducing ecological risks. A formal assessment to determine whether an interim remedial action is necessary for contaminated groundwater within the area's reactor section has not been completed.

Oversight of K Basins Needs Improvement

Sufficient action has not been taken to ensure that DOE's interim remedial action for the K Basins meets the schedule specified by the Federal Facility Agreement and Consent Order (FFACO). Region 10 has not ensured that timely milestones for the interim remedial action are established, the milestones in place are achievable, and insufficient remediation progress is addressed timely and effectively. The K Basins have already exceeded their design lives by more than 20 years, and an increase in risk is directly proportional to age. Region 10 oversight was insufficient because it did not obtain enough information and did not place sufficient emphasis on resolving problems.

Additional Oversight Necessary for Groundwater Interim Remedial Action

Region 10 has not provided sufficient oversight of DOE's pump-and-treat interim system for groundwater contaminated with hexavalent chromium entering the Columbia River to a level that is protective of human health and the environment. Even though the system was not achieving the cleanup standard specified by the Record of Decision, the Region did not take sufficient actions to ensure DOE operated the system effectively during the 3-year period ending September 2000 and needed upgrades were completed in a timely manner.

Groundwater Remediation Requirements Not Adequately Addressed

Region 10 has not obtained sufficient information from DOE to determine whether an interim remedial action is necessary for contaminated groundwater within the reactor section of the Hanford Site 100-K Area. The Region and DOE concluded, without completing a formal assessment, that an interim remedial action was unnecessary for the reactor section. Also, the Region has not ensured that DOE's groundwater monitoring system has provided sufficient data to enable an adequate assessment of remediation requirements.

Hexavalent chromium contamination levels in the groundwater within the reactor section have continued to significantly exceed State limits, while carbon-14 contamination levels in the groundwater have continued to exceed Federal standards. However, because the Region could not provide us with adequate data, we could not determine whether an interim remedial action to remove hexavalent chromium and carbon-14 from the groundwater within the 100-K Area was necessary for adequate protection of ecological receptors.

An interim remedial action was not necessary for strontium-90, tritium, and nitrate contamination in the groundwater within the 100-K Area. Human health and ecological risk assessments for the strontium-90, tritium, and nitrate contamination in the groundwater were adequate and showed that the risks did not justify an interim remedial action.

Recommendations

We made recommendations to the EPA Region 10 Administrator for improving their oversight of Hanford's 100-K Area. These recommendations include for the Region to monitor DOE's efforts to successfully complete remediation requirements for the K Basins and take action as appropriate under the FFACO if requirements are not met; evaluate performance of the upgraded pump-and-treat system to determine whether it will achieve the remedial action objectives and, if necessary, pursue timely and formal followup on problems; require a formal assessment on the need for an interim remedial action in the area's reactor section;

and have DOE improve its groundwater monitoring system. We noted that enforcement actions should be pursued as appropriate.

Agency Comments and OIG Evaluation

Region 10 generally concurred with the recommendations, with one exception. However, the Region's response to most of the recommendations did not sufficiently describe the corrective actions planned or taken. To resolve and close this report, the Region needs to provide specific actions planned or taken for each recommendation in the final report, along with milestones for completion of the corrective actions.

Region 10 did not concur with our recommendation to improve the groundwater monitoring system for the reactor section of the 100-K Area. Rather, the Region, together with the U.S. Geological Survey, will review DOE's October 4, 2002 groundwater monitoring and assessment plan for the 100-K Area fuel storage basins and then determine if modifications are needed.

The Region stated that it continues to have concerns regarding the overall conclusions of the report with respect to their effectiveness in overseeing DOE's work at Hanford. According to the Region, the report does not fully acknowledge the significant work that has been accomplished in the 100-K Area since EPA assumed the lead oversight agency responsibility for the K Basins in 1998.

We believe that the report clearly acknowledges significant work that has been accomplished since EPA assumed the lead oversight role for the K Basins. Chapter 2 of the report acknowledges and discusses the successful completion of milestones associated with the installation of equipment, construction of facilities, and startup operations, which are critical for remediating the K Basins. In addition, we recognize that the Region's oversight activities have resulted in a pump-and-treat interim remedial action for a groundwater plume contaminated with hexavalent chromium located in the 100-K Area's 116-K-2 Trench section, although the remedy's effectiveness is questionable.

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Chapter 1
Introduction

Purpose

The purpose of this evaluation was to determine whether U.S. Environmental Protection Agency (EPA) Region 10's oversight of U.S. Department of Energy (DOE) remediation activities for the 100-K Area's K Basins and groundwater at the Hanford Superfund Site has provided adequate protection to human health and the environment. The specific objectives were to answer the following questions.

- Has the Region's oversight of the DOE's interim remedial action for the K Basins provided assurance of compliance with the Hanford Federal Facility Agreement and Consent Order milestones that were established to eliminate significant human health and environmental risks?

- Has the Region taken sufficient action to ensure that DOE's pump-and-treat system reduces hexavalent chromium contamination in groundwater entering the Columbia River to a level that is protective to human health and the environment?

- Have human health and ecological risks posed by groundwater contamination within the 100-K Area been adequately assessed?

- Does the groundwater monitoring system for the 100-K Area provide sufficient data to enable the Region to effectively monitor the boundaries and migration of contaminated groundwater and to evaluate human health and environmental risks posed by the contamination?

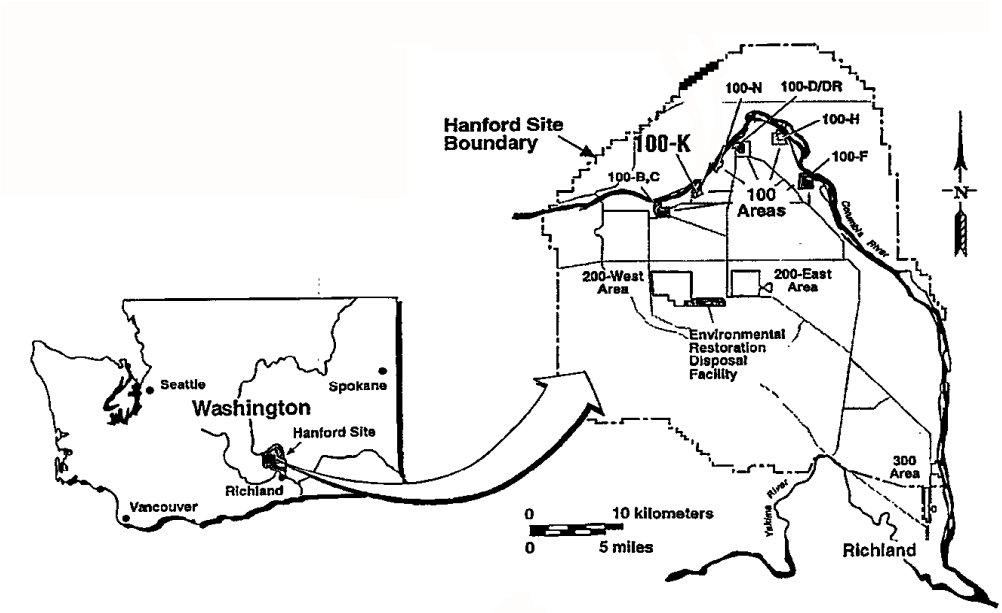
- Is an interim remedial action to remove strontium-90, tritium, carbon-14, and nitrate from the groundwater within the 100-K Area necessary for adequate protection of human health and the environment?

- Was the decision to not require an interim remedial action for groundwater contaminated with carbon-14 protective of human health and the environment?

Background

The Hanford Superfund Site is in southeastern Washington State, near Richland, and occupies about 586 square miles. The Columbia River, one of the largest rivers in the United States, runs through more than 50 miles of the site, as shown in the map.

Figure 1-1: Map of Hanford Superfund Site
(Source: ROD for 100-HR-3 and 100-KR-4 Operable Unit)



The site is the responsibility of DOE. From 1943 to 1989, Hanford's principal mission was the production of weapons-grade plutonium. To produce plutonium, uranium metal was irradiated in a plutonium production reactor. Spent nuclear fuel was cooled and treated in a chemical separations plant, where plutonium was separated from uranium and many other radioactive by-products. This process resulted in several hundred thousand metric tons of radioactive and hazardous waste. DOE officials say Hanford is the world's largest environmental cleanup project.

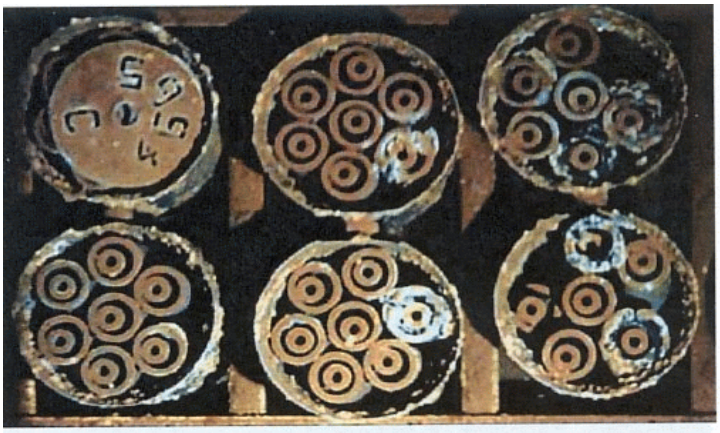
Hanford was added to the National Priorities List (NPL) in 1989 as four sites, including the 100 Area. The 100 Area, situated along the south shore of the Columbia River, contains nine deactivated plutonium production reactors. The 100-K Area consists of the K East and West Reactors and their associated support facilities and waste sites.

100-K Area

The K East and West Reactors and their adjacent spent nuclear fuel storage basins are about 1,400 feet from the Columbia River. The basins are unlined concrete 1.3-million-gallon water pools with an asphaltic membrane beneath each pool. The basins were constructed to collect and temporarily store (nominally 6 to 18 months) irradiated spent nuclear fuel that had been discharged from the reactors prior to reprocessing.

The K East and West Reactors operated from 1955 to 1971 and 1970, respectively, and most of the spent nuclear fuel was removed from the basins when the reactors were shut down. The basins were subsequently used to store spent nuclear fuel from the Hanford N Reactor, starting in 1975 for K East and 1981 for K West. Approximately 1,800 metric tons of spent nuclear fuel, stored for as long as 30 years, remain in the basins. This represents more than 60 percent of the DOE's national inventory of spent nuclear fuel.

The K East Basin is a greater concern where fuel is stored in open canisters. This allows water to come in contact with the fuel elements and cause corrosion. K West Basin fuel is stored in closed canisters. An estimated 1,800 cubic feet of radionuclide-containing sludge has accumulated on the K East Basin floor. The spent nuclear fuel continues to release radioactive materials to the water and presents a radiation hazard. No groundwater monitoring wells were in place while the K East and West Reactors were operating, so it is not known if the basins leaked during that time. However, since the 1970s, DOE officials estimate that approximately 15 million gallons of contaminated water leaked to the soil.



Corroding spent nuclear fuel in open canisters in K East Basin (Source: DOE's Hanford Reach newsletter, April 16, 2001)

A continuous supply of water was essential for reactor operations, to prevent reactor core damage from the heat generated by fission reactions. Cooling water was pumped from the Columbia River and treated with chemicals, including sodium dichromate (hexavalent chromium). While in the reactor, the cooling water became contaminated with radioactive activation and fission products, including: tritium, carbon-14, strontium-90, cesium-137, and plutonium-239/240. The cooling water was discharged to retention basins to cool and let short-lived

radioisotopes decay before release to the Columbia River. During the years of reactor operations, liquid radioactive and chemical wastes were also discharged to various cribs, drains, and trenches, and soil became significantly contaminated. As a result, groundwater contaminant plumes are migrating toward and discharging into the Columbia River.

Regulations and Responsibilities

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) established EPA's hazardous release reporting and cleanup program, known as Superfund. The National Contingency Plan (NCP), or 40 Code of Federal Regulations Part 300, sets forth the process and regulations for conducting CERCLA cleanup actions. EPA's goal, as stated in the NCP, is to select cleanup remedies that are protective of human health and the environment, maintain protection over time, and minimize untreated waste. The NCP provides that the selection of a remedy shall be based on whether it provides overall protection of human health and the environment; compliance with Applicable or Relevant and Appropriate Requirements; long term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; implementability, including technical feasibility; and cost effectiveness.

In 1988, spurred by outstanding compliance problems at the Hanford Site, DOE, EPA Region 10, and the State of Washington's Department of Ecology negotiated a combined Federal Facility Agreement under CERCLA, and a Consent Order under the Resource Conservation and Recovery Act (RCRA) and the State's Hazardous Waste Management Act. The document, known as the Hanford Federal Facility Agreement and Consent Order (FFACO), required DOE to undertake cleanup actions at many existing sites and other actions.

The three parties signed the original FFACO in May 1989. In 1993, they initiated further negotiations to establish an agreed upon technical path to minimize or eliminate the continued endangerment of public health and contamination posed by the K Basins. Milestones were agreed upon and established in the fourth amendment to the FFACO, approved by the parties in January 1994, with removal of all spent nuclear fuel and sludge from the K Basins required by December 31, 2002. As a result of increased concerns, the parties agreed on a new technical path, and in January 1999, the FFACO was revised to require complete removal of spent nuclear fuel, sludge, debris, and water from the K Basins by July 31, 2007. A timeline of major events and FFACO milestones for the K Basins is in Appendix A.

The FFACO defines the regulatory roles and responsibilities for Hanford. The lead regulatory agency is responsible for overseeing DOE activities. EPA is generally the lead for CERCLA units and the Department of Ecology the lead for

RCRA units. Although the State was initially designated the lead for the K Basins, the parties subsequently agreed K Basins cleanup could be addressed most effectively as a CERCLA interim remedial action. Consequently, in June 1998, the FFACO was amended to designate EPA as the lead agency for the K Basins.

Scope and Methodology

We performed this evaluation in accordance with the *Government Auditing Standards*, issued by the Comptroller General of the United States as they apply to performance audits. Our review included tests of program records and other evaluation procedures we considered necessary for the purposes of expressing an opinion based on our objectives. We also reviewed the Federal Managers' Financial Integrity Act reports for Fiscal Years 1999 and 2000. The reports did not identify any material weaknesses or vulnerabilities relating to the issues discussed in this report. See Appendix B for scope and methodology details.

Prior Coverage

The EPA Office of Inspector General (OIG) has not conducted prior reviews of Region 10 oversight of remediation activities for the K Basins and groundwater in the 100-K Area. However, EPA OIG evaluations of Region 4 oversight of cleanup activities at the Savannah River and Oak Ridge facilities have recently been completed (Report Nos. 2002-P-00014 and 2002-P-00013, September 2002).

Our report on the Savannah River Facility concluded that improvements are needed in Region 4's oversight of DOE's implementation of cleanup actions at the facility. From 1996 through 2002, DOE discontinued evaluating or ranking sites on potential risks to the environment and human health. Although such rankings are required, EPA did not ensure they were conducted. We found several instances where cleanup actions at Savannah River sites had been delayed because EPA has provided late responses to DOE cleanup decision documents.

The report on the Oak Ridge Facility concluded Region 4's oversight could be improved by reviewing and evaluating additional studies conducted by Tennessee that identified potential contaminants of concern that may not be accounted for in existing Federal Facility Agreement documents. In 1999, the Tennessee Department of Health issued a series of reports that showed that, in some cases, levels of pollutants being released from Oak Ridge were substantially higher than previously acknowledged by the government. However, neither DOE nor EPA had evaluated the impact the reports may have on current cleanup activities or decisions.

In regard to the Hanford 100-K Area, the U.S. General Accounting Office (GAO) published two reports that identified weaknesses in DOE's management of spent nuclear fuel removal efforts:

- *Management Problems at the Department of Energy's Hanford Spent Fuel Storage Project* (GAO/T-RCED-98-119, May 1998).

- *DOE's Hanford Spent Nuclear Fuel Storage Project - Cost, Schedule, and Management Issues* (GAO/RCED-99-267, September 1999).

DOE OIG has also reviewed the remedial action for the K Basins. DOE OIG's report, *Completion of K Basins Milestones* (DOE/IG-0552, April 2002) identified that equipment problems, process complexities, and planning weaknesses may prevent DOE from meeting FFACO milestones for the K Basins. Details on the GAO and DOE OIG reports are in Chapter 2.

Chapter 2
Oversight of K Basins Needs Improvement

Although EPA Region 10's oversight activities have contributed to DOE's successful completion of certain FFACO milestones critical for removing spent nuclear fuel from Hanford's K Basins, improvement is needed. The Region has not taken sufficient action to ensure that timely milestones for the interim remedial action are established, the milestones in place are achievable, and insufficient remediation progress is addressed timely and effectively. Specifically:

- A May 2000 FFACO amendment delayed the initiation and completion of the removal of the K East Basin's spent nuclear fuel.

- A March 2001 FFACO amendment implemented an Alternate Fuel Transfer Strategy without obtaining reasonable assurance that FFACO milestones would be met, which may result in a delay of approximately 16 months.

- Sufficient interim milestones for removal of spent nuclear fuel were not included in the March 2001 FFACO amendment, even though DOE was behind schedule for meeting due dates specified by the FFACO.

- Response actions to DOE's inability to complete two target milestones by the due dates specified in the FFACO were either ineffective or not initiated.

Region 10 oversight was insufficient because it did not obtain enough information to determine whether revisions were necessary and ensure that sufficient planning had been completed. Also, the Region has not placed sufficient emphasis on resolving DOE's inability to meet FFACO milestones. The K Basins have already exceeded their design lives by more than 20 years, and an increase in risk is directly proportional to the continued aging of the basins. Delays in removing the spent nuclear fuel, sludge, debris, and water from the basins increase the risk of a release of radionuclides to the air, soil, groundwater, and Columbia River, which can adversely impact human health and the environment.

Background

In 1994, the Defense Nuclear Facilities Safety Board expressed concern with the K East Basin in Recommendation 94-1, Improved Schedule for Remediation. According to the board, the continued storage of spent nuclear fuel in the K East Basin posed a threat to human health and the environment, and the board

recommended the removal and stabilization of the spent nuclear fuel and sludge from the basin within 2 to 3 years.

Recognizing that both the K East and West Basins pose risks to human health and the environment, DOE initiated its Spent Nuclear Fuel Project. The project, estimated at a total cost of $1.7 billion, includes the following major objectives:

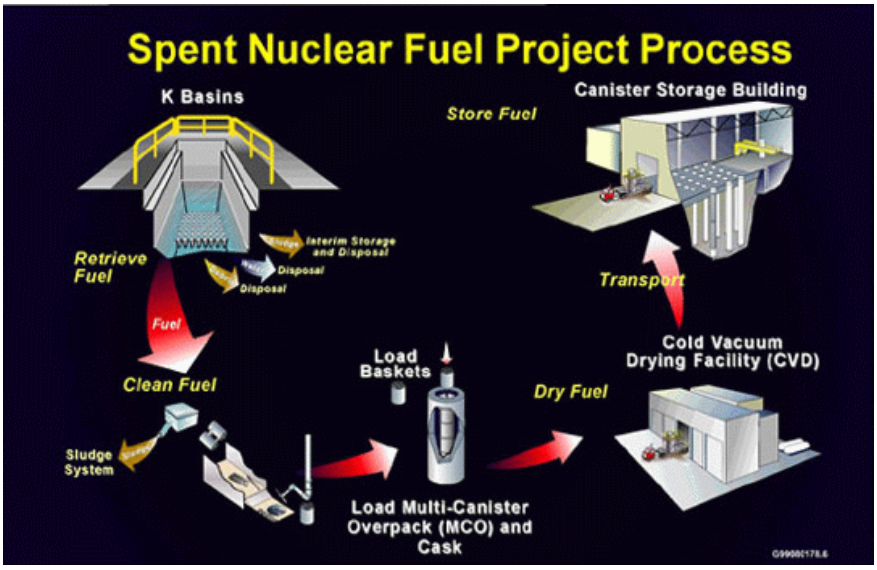
- Removing and repackaging K Basins' spent nuclear fuel into metal containers, called multi-canister overpacks, suitable for safe handling and interim storage of up to 40 years at the Canister Storage Building.

- Drying the spent nuclear fuel at the Cold Vacuum Drying Facility to enable safe transport to the Canister Storage Building.

- Removing sludge and debris collected in the basins for disposition.

- Treating water contained in the basins to maintain safe water quality and conditions and to allow removal of the water for disposition.

Figure 2-1



Source: DOE, see http://www.hanford.gov/doe/snf/fuelprocess.htm

One of the purposes of the Hanford FFACO is to establish a framework and schedule for implementing response actions in accordance with the CERCLA, including milestones. The FFACO includes milestones and a schedule for a CERCLA regulated interim remedial action for the K Basins. The interim remedial action includes construction of the Cold Vacuum Drying Facility and Canister Storage Building; removal of all spent nuclear fuel, sludge, debris, and

water; and decontamination and decommissioning of all buildings and structures within the 100-K Area.

The FFACO includes enforcement provisions for noncompliance with major requirements and milestones, including the options to issue penalties. Under the agreement, EPA, as a lead regulator, is responsible for enforcement of FFACO milestones. In the event DOE fails to comply with a term or condition of the FFACO, a stipulated penalty may be assessed in an amount up to $5,000 for the first week and up to $10,000 for each additional week of noncompliance.

Region's Oversight Resulted in Completion of Some Milestones

Region 10's oversight activities from June 1998 through December 2000 contributed to DOE's completion of milestones associated with installation of equipment, construction of facilities, and startup operations, which are critical for removing the spent nuclear fuel from the basins. Accomplishments included:

- Completion of the Integrated Water Treatment System at the K West Basin in June 1999, for collecting particulate and soluble contaminants and allowing segregation of canister sludge for safe storage.

- Installation of the Fuel Retrieval System at the K West Basin in September 1999, for retrieving, sorting, washing, and placing spent nuclear fuel elements into baskets and multi-canister overpacks for drying and stabilization.

- Completion of the Cold Vacuum Drying Facility in October 1999 to remove water from and around the spent nuclear fuel in the multi-canister overpacks.

- Completion of the Canister Storage Building in May 2000, a 42,000-square-foot structure with three heavily reinforced concrete vaults, each capable of holding 440 multi-canister overpacks.

- Completion of operational readiness reviews for the facilities and "hot" testing with spent nuclear fuel assemblies during October and December 2000.

- Removal of the first multi-canister overpack from the K West Basin in December 2000; the overpack was dried at the Cold Vacuum Drying Facility and placed in interim storage at the Canister Storage Building.

Oversight Improvements Needed

Despite the accomplishments noted, Region 10 needs to improve its oversight of DOE's interim remedial action for the K Basins to ensure milestones are met and risks to human health and the environment are eliminated in a timely manner.

May 2000 Amendment Delayed Removal of Spent Nuclear Fuel

Although the K East Basin is the most contaminated basin and has leaked at least twice in the past, a FFACO amendment was approved in May 2000 that delayed the initiation and completion of the removal of the basin's spent nuclear fuel by 13 and 7 months, respectively.

The amendment was requested by DOE and approved by the Region to implement DOE's "Sludge Acceleration Strategy." According to the justification for the amendment, the FFACO revision would allow the Spent Nuclear Fuel Project to integrate sludge and spent nuclear fuel removal activities to accelerate completion of sludge removal from the basins. The justification also disclosed that the revision would eliminate the overlap in the schedule for spent nuclear fuel removal from the K East and West Basins, thereby eliminating the short-term peak in operations necessary when removal occurs at both basins simultaneously.

The justification included a $16 million reduction in total project cost. A July 1999 letter sent by DOE's Spent Nuclear Fuels Project Division to DOE's contractor for the project disclosed that the primary reason for the amendment request was cost savings. Specifically, the letter stated the new strategy "represents a valuable opportunity to accelerate some aspects of the existing work schedules and more importantly, to identify and optimize actions that could result in substantial savings."

Although the amendment accelerated spent nuclear fuel removal from the K West Basin and sludge removal from both basins, the amendment represented a trade off between cost savings and risk reduction. Specifically, the amendment reduced total project costs, but delayed the removal of spent nuclear fuel from the K East Basin, the milestones most critical for reducing human health and environmental risks. In 1994, the Defense Nuclear Facilities Safety Board expressed concern regarding the continued storage of spent nuclear fuel in the K Basin posing a threat to human health and the environment. Despite the Board's concern, the amendment delayed the start of the spent nuclear fuel removal operations for the K East Basin by 13 months and completion by 7 months, as shown in Table 2-1:

Table 2-1: Milestone Revisions From May 2000 Amendment			
Milestone	**Due Date Prior to Amendment**	**Amendment Due Date**	**(Delay)/ Acceleration**
Initiate removal of K East spent nuclear fuel (M-34-17)	11/30/01	12/31/02	(13 months)
Complete removal of K West Basin spent nuclear fuel (M-34-18A)	4/30/03	12/31/02	4 months
Complete removal of K East Basin spent nuclear fuel (M-34-18B)	12/31/03	7/31/04	(7 months)
Initiate full scale K East Basin sludge removal (M-34-08)	7/31/04	12/31/2002	19 months
Complete sludge removal from K Basins (M-34-10)	8/31/05	8/31/04	12 months
Complete water removal for K East Basin (M-34-24)	10/31/06	10/31/06	No Change
Source: Change Control Form for May 2000 FFACO Amendment			

March 2001 Amendment Approved Without Sufficient Assurances

On March 27, 2001, Region 10 approved a FFACO amendment to implement DOE's Alternate Fuel Transfer Strategy, as well as other project scope changes, without obtaining reasonable assurance that the strategy would enable DOE to meet the milestone due dates specified by the FFACO. This amendment was approved even though DOE was already behind schedule for meeting milestone due dates for removing spent nuclear fuel from the basins.

DOE said the amendment was necessary to assure the remaining Spent Nuclear Fuel Project work could be performed within the approved funding and meet enforceable FFACO milestones. Prior to the amendment, DOE was required to retrieve, clean, package, and remove spent nuclear fuel from each basin and transport it directly to the Canister Vacuum Drying Facility. Under the new strategy, all spent nuclear fuel stored in the K East Basin will be transferred to the K West Basin for temporary storage and, after treatment, transported to the Cold Vacuum Drying Facility. According to DOE, this new strategy streamlines the removal process for the K East Basin. The new strategy also includes other actions to improve the rate of removal from the K West Basin.

If DOE meets the revised remediation schedule established by the March 2001 amendment, the initiation and completion of spent nuclear fuel removal from the K East Basin will be accelerated by 1 and 2 months, respectively. In addition,

both initiation and completion of water removal from the K East Basin will be accelerated by 13 months. However, the amendment does not accelerate the overall completion date for removal of all spent nuclear fuel, sludge, and water from the basins. The amendment also delays the initiation and completion of water removal from the K West Basin by 13 and 11 months, respectively.

Table 2-2: March 2001 FFACO Amendment Revisions

Milestone	Due Date Prior to Amendment	Amendment Due Date	(Delay)/ Acceleration
Complete removal of fuel, sludge, water, and debris from K Basins (M-34-00A)	7/7/07	No change	None
Initiate removal of K East Basin spent nuclear fuel (M-34-17)	12/31/02	11/30/02	1 month
Complete removal of all K Basin spent nuclear fuel (M-34-18B)	7/31/04	No change	None
Initiate K West Basin water removal (M-34-21-T01)	9/30/04	10/31/05	(13 months)
Complete K West Basin water removal (M-34-22)	9/30/05	8/31/06	(11 months)
Initiate K East Basin water removal (M-34-23)	10/31/05	9/30/04	13 months
Complete removal of K East Basin water (M-34-24)	10/31/06	9/30/05	13 months
Complete transfer of K East Basin spent nuclear fuel to K West Basin (M-34-25-T01) *	7/31/04	5/31/04	2 months

* New target milestone that replaced an interim milestone requiring complete removal of spent nuclear fuel from the K East Basin.
Source: Change Control Form for March 2001 FFACO Amendment

Of particular concern was that the Region approved the March 2001 amendment even though DOE had not provided the Region with cost comparison information the Region had requested in January 2001, and also had not developed an adequate technical plan to support the requested strategy and milestone changes.

Approximately 2 months before approving the amendment, the Region expressed concern to DOE about the requested strategy change. During a January 2001 FFACO milestone review meeting, the Region questioned the justification for DOE's proposed strategy change and said DOE needed to provide the costs for

various parts of the strategy. The Region also requested DOE to provide a comparison of the proposed amendment with the May 2000 amendment by dollars, milestones, staff, risk to worker safety, and risk to health and the environment, and said it would not approve any change request until a one-to-one comparison between the existing and proposed baseline was provided.

Although DOE provided the Region with a comprehensive plan in February 2001, the Region acknowledged that the plan did not contain sufficient detail. The Region also said DOE never provided it with the cost and risk information requested in January 2001. Therefore, the Region did not have sufficient technical and scheduling detail to have reasonable assurance that the revised strategy and milestones were achievable. The Region also said that it expressed to DOE a concern that funding may not be sufficient to resolve unanticipated issues because DOE's funding contingency for the project would be eliminated by the amendment. Nonetheless, the Region approved the amendment.

This amendment was approved even though DOE was behind schedule for meeting milestone due dates for removing the spent nuclear fuel. Prior to this amendment, DOE was required under FFACO Interim Milestone M-34-18A to remove all Spent nuclear fuel from the K West Basin by December 31, 2002. DOE's technical schedule supporting compliance with the milestone specified that 51 multi-canister overpacks were required to be removed from the K West Basin by September 2001 in order to meet the due date for completion of the milestone. However, DOE's most current projections at the time the FFACO was amended in March 2001 showed that only 21 of the necessary 51 multi-canister overpacks (41 percent) would be removed by September 2001.

Sufficient Interim Milestones Not Established

Sufficient enforceable interim milestones for removal of spent nuclear fuel were not included in the March 2001 FFACO amendment, even though DOE was behind schedule at the time the amendment was approved. The FFACO specifies that both major and interim milestones are enforceable. Prior to the amendment, spent nuclear fuel removal requirements were established through two interim milestones:

- **Milestone M-34-18A:** This required the removal of all spent nuclear fuel from the K West Basin by December 31, 2002.

- **Milestone M-34-18B:** This required the removal of all spent nuclear fuel from the K East Basin by July 31, 2004.

However, despite the fact that DOE was already behind schedule, the March 2001 amendment did not establish additional interim milestones for the K West Basin

preceding the December 31, 2002 due date. Additional interim milestones would have allowed the Region to undertake enforcement actions at an earlier stage to resolve DOE's inability to meet scheduled due dates.

Region Response to Missed Milestones Not Sufficient

Region 10 did not take sufficient response actions on DOE's inability to complete two target milestones by the due dates specified in the FFACO:

- **Milestone M-34-06-T01:** This milestone required DOE to initiate cleaning operations for spent nuclear fuel canisters in the K West Basin by December 31, 2000. In December 2000, DOE submitted a FFACO change request to delay the milestone until August 31, 2001, in order to complete the engineering design and to procure, fabricate, install, and test the equipment. The Region immediately denied the change request, stating:

  > *The project had already committed itself to miss this target date before approaching the EPA . . . EPA has been concerned with the general pattern of work deferral in the past years, and in particular any work that represents actual cleanup. . . .*

  However, while the Region denied DOE's request to extend the milestone, it did not initiate any formal followup action requesting that DOE ensure timely completion of this work. The Region told us that denying the change request was a formal action and, under the FFACO, milestones do not change if EPA denies a change request. The Region also said that denying a change request puts DOE under formal notice that DOE is expected to comply with the milestones.

  Despite the Region's denial, DOE notified the Region in February 2001 that the milestone would not be completed until August 31, 2001. The work was not actually completed until March 14, 2002, more than 14 months past the milestone due date.

- **Milestone M-34-26-T01:** This milestone required that DOE approve by September 30, 2001, the start of construction of the K East and West Basin facility modifications for the Alternate Fuel Transfer Strategy cask transportation system. On September 27, 2001, 3 days before the milestone due date, DOE notified the Region that design issues made it impossible to meet the milestone, and it hoped to resolve the issues and approve the start of construction by October 31, 2001. Again, the Region did not initiate a followup action. DOE eventually completed the milestone on November 16, 2001, 46 days late. DOE's delay in completing Milestone M-34-26-T01 contributed to DOE's inability to meet Milestone M-34-29, which required

completion of facility modifications for the Alternate Fuel Transfer Strategy by March 31, 2002.

Prior Reports Noted Similar Issues

Weaknesses with DOE's Spent Nuclear Fuel Project have also been identified in recent reviews by GAO and the DOE OIG. In 1998, GAO noted completion of the project had been extended by over 4 years and the original cost estimate had nearly doubled to about $1.4 billion. According to GAO, DOE's contractor did not use consistent and reliable estimating procedures to develop baseline costs, and did not effectively use baseline schedules. In 1999, GAO reported that the latest schedule called for the Spent Nuclear Fuel Project to be complete almost 6 years beyond the original schedule, with project costs about $1 billion more than the original estimate (i.e., $1.7 billion). GAO reported progress had been made in resolving some of the issues cited in its 1998 report, but indicated that achieving the project's long term goals was uncertain. Finally, in April 2002, the DOE OIG reported that persistent equipment problems and process complexities may keep DOE from meeting its planned full production schedule. The DOE OIG said performance of the Spent Nuclear Fuel Project, specifically as it relates to the milestones established by the FFACO, may be in jeopardy unless these issues can be overcome. Furthermore, the DOE OIG said that DOE's planning assumptions appear to be overly optimistic.

Delays Increase Risk of Releases

A delay in remediation of the basins, particularly K East, increases the potential for releases of high levels of radionuclides into the environment. In October 1997, the Defense Nuclear Facilities Safety Board stated in its report, *Review of the Hanford Spent Nuclear Fuel Project* (DNFSB/TECH-17, page 1-1):

> *As long as deteriorating spent nuclear fuel remains in the K-Basins, a serious threat to the health and safety of the public and of on-site workers remains at Hanford. A significant slippage in the schedule for the safe removal, stabilization, and interim storage of this fuel therefore represents a major safety concern.*

According to DOE, the increase in risk posed by the basins is directly proportional to the continued aging of the basins. As a result, the potential for the basins to lose structural integrity and release high levels of radionuclides increases as the basins continue to age. The K Basins have exceeded their 20-year life by more than 20 years. The basins were designed to standards of the 1950s, and were not designed to modern seismic criteria. Consequently, their structural integrity could fail during a seismic event (such as an earthquake) and allow large volumes of

radioactive water to leak into the soil, groundwater, and Columbia River. Also, failure to maintain a sufficient amount of water to cool the spent nuclear fuel and sludge could allow spent nuclear fuel and sludge to dry and heat, resulting in an airborne release of radionuclides.

Tritium concentrations in the basin water measure 3 million picocuries per liter (pCi/L). Further, the groundwater within the 100-K Area is significantly contaminated with radionuclides and other hazardous constituents. In 1998, a groundwater sampling well near the K East Reactor showed a tritium concentration of 2.36 million pCi/L, 118 times the Federal Drinking Water Standard of 20,000 pCi/L. Currently, most of the contaminated groundwater within the 100-K Area is not undergoing remediation, and some of it is discharging into the Columbia River. Further, the K East Basin leaked approximately 15 million gallons of contaminated water to the soil in the 1970s and another 90,000 gallons in early 1993. However, no studies or evaluations were performed to determine the ecological impacts of the leaks.

DOE estimates that 400 multi-canister overpacks will be required for removal of all spent nuclear fuel from the K Basins. As of May 31, 2002, DOE had removed 67 overpacks from the K West Basin. To determine whether DOE will meet the removal due dates specified by the FFACO, we projected the amount of time required to remove the remaining spent nuclear fuel from the basins using DOE's average removal rate for the period from January through August 2002[1]. We projected that there would be delays for the FFACO removal due dates, as shown in Table 2-3[2]:

[1]Although fieldwork was completed in May 2002, we included spent nuclear fuel removal data for the months of June through August 2002 in order to improve the accuracy of our projection.

[2]The projected delays are based on limited data, and removal of the spent nuclear fuel is subject to uncertainties. DOE's ability to maintain or increase the removal rate is dependent upon the initiation and completion of the transfer of spent nuclear fuel from the K East to the K West Basin in accordance with the FFACO schedule. Also, DOE's current removal rate is based on removing K West Basin spent nuclear fuel, which is in better condition than the K East Basin spent nuclear fuel. K East Basin spent nuclear fuel removal, transfer, and subsequent removal from the K West Basin may be more complex because of its poor condition. This complexity may slow down the removal process. The efficiency of spent nuclear fuel removal is also dependent upon equipment reliability and maintaining adequate staffing and funding.

Table 2-3: Projected Spent Nuclear Fuel Removal Delays			
Milestone	**Due Date**	**Projected Completion Date**	**Projected Delay**
M-34-18A: Remove 190 multi-canister overpacks	December 31, 2002	August 2003	9 months
M-34-27T-01: Remove 244 multi-canister overpacks	May 31, 2003	March 2004	10 months
M-34-28: Remove 311 multi-canister overpacks	December 31, 2003	December 2004	12 months
M-34-18B: Remove All Spent Nuclear Fuel	July 31, 2004	November 2005	16 months

Further, removal of the contaminated sludge and water from the basins cannot be completed until after removal of the spent nuclear fuel is completed.

Reasons for Oversight Weaknesses

Region 10 oversight was insufficient because it did not obtain sufficient information to determine whether revisions were necessary and ensure that sufficient planning had been completed. In addition, the Region has not placed sufficient emphasis on resolving DOE's inability to meet FFACO milestones.

Problems With the May 2000 Amendment

Region 10 informed us that the May 2000 amendment was approved because it believed the revised remediation schedule had a better chance of success and would result in lower worker exposure to radiation. However, the Region was unable to provide us with documentation showing that the delay in removing the spent nuclear fuel from the K East Basin was necessary, would significantly reduce worker exposure to radiation, and would not increase risks to human health and the environment.

Problems With the March 2001 Amendment

According to Region 10, it approved the March 2001 amendment based on DOE's assurance that there were no technical obstacles that could adversely affect successful implementation of the Alternate Fuel Transfer Strategy and compliance with the revised FFACO remediation requirements. In addition, the Region said that it approved the amendment because DOE provided assurance that it would not request any changes to major milestones associated with the remediation of the basins. The Region also told us that it believed the amendment was preferable

to continuing to follow the old technical path, which was unlikely to meet the schedule, and that the Alternate Fuel Transfer Strategy had a better chance of success. However, as noted earlier in this chapter, DOE has continued to fall behind schedule for meeting critical FFACO milestones.

Region 10 has not placed sufficient emphasis on resolving DOE's inability to meet the remediation schedule established by the FFACO. The Region told us that it did not include any enforceable interim milestones in the March 2001 amendment because it believed the number of milestones established by the amendment was sufficient to ensure compliance with the FFACO. However, the Region also said that it had not been optimistic about DOE's ability to meet due dates specified by the FFACO at the time of the March 2001 amendment. Because the earliest enforceable milestone requiring the removal of a specific quantity of spent nuclear fuel is not until December 2002, the Region has not been able to initiate a formal enforcement action requiring DOE to improve its removal operations. In our opinion, use of interim milestones for the 21-month period preceding December 2002 would have provided the Region with the ability to initiate an enforcement action.

Problems With DOE's Inability to Meet Target Milestones

The Region said that it did not take any followup actions in response to DOE's inability to meet Target Milestones M-34-06-T01 and M-34-26-T01 because target milestones are designated as unenforceable requirements under the FFACO. We agree that these two target milestones were not enforceable under the FFACO. However, target milestones are incorporated into the FFACO for the purpose of tracking progress toward meeting interim and major milestones. Therefore, a missed target milestone provides the Region with notification that DOE is not making sufficient progress toward meeting enforceable remediation requirements of the FFACO.

We note that the FFACO does not preclude the Region from working proactively with DOE to resolve compliance issues. A more proactive approach by the Region in resolving compliance issues pertaining to target milestones may improve DOE's compliance with enforceable milestones.

Conclusion

Despite concerns raised by the Defense Nuclear Facilities Safety Board in 1994 about continued storage of spent nuclear fuel in the K East Basin, no spent nuclear fuel has been removed from the basin to date, and DOE is now behind schedule for meeting FFACO milestones that are critical to reducing risks to human health and the environment. Additional delays may erode the confidence of Congress,

the general public, and other stakeholders in the achievability and protectiveness of the remedial action. Region 10 needs to be more proactive in its oversight of the remedial action. The Region needs to ensure that priority is placed on reducing the risks posed by the K East Basin, since it poses the greatest risk to human health and the environment. DOE's history of management weaknesses for the project, delays in the remediation schedule for the basins, and the significant human health and environmental risks necessitate improvements in Region 10's oversight activities.

Recommendations

We recommend that the Region 10 Administrator:

2-1. Monitor progress of DOE toward meeting K Basins milestones, including M-34-17, to initiate removal of K East Basin spent nuclear fuel, M-34-08, to initiate full scale K East Basin sludge removal, and M-34-18A[3], to remove spent nuclear fuel equivalent to 957 tons of heavy metal. Reaffirm EPA's expectation that milestones will be met unless a timely request for an extension or change is received and good cause exists for the request as defined by the FFACO. In addition:

a. Place priority on remediating the K East Basin, focusing on removing spent nuclear fuel, sludge, debris, and water.

b. If DOE does not complete the K Basins milestones in a timely manner, the Region should respond, consistent with FFACO enforcement provisions, including penalties, to ensure the work is completed as expeditiously as possible.

2-2. Prior to approval by the Region, ensure that any necessary amendments to the FFACO that revise remediation requirements and/or the remediation schedule for the 100-K Area including the K Basins:

a. Are supported with performance and planning information that provide the Region with reasonable assurance that the revised requirements and schedule are necessary, achievable, and reduce risks to human health and the environment as expeditiously as possible.

[3]A June 11, 2002 amendment to the FFACO revised Milestone M-34-18A. The milestone was revised from a requirement to remove 190 multi-canister overpacks to a requirement to remove 957 metric tons of heavy metal from the K West Basin. According to the amendment, the only effect of the change is to measure the amount of fuel removed in terms of metric tons of heavy metal rather than a specified number of multi-canister overpacks.

b. Include enforceable interim milestones and due dates that enable the Region to more timely resolve insufficient remediation progress by DOE through enforcement actions.

2-3. Require formal followup actions in response to missed target milestone due dates by DOE. These followup actions should establish the Region's expectations on resolving performance issues.

Agency Comments and OIG Evaluation

Region 10 agreed with the recommendations. In response to Recommendation 2-1, the Region said the recommendation reflects its approach to management of K Basin performance. The Region also indicated that it monitors progress through regular contacts with DOE, including FFACO milestone status meetings, site inspections, and multi-agency meetings.

In regard to Recommendation 2-2, the Region said that it does not anticipate receiving any milestone change packages from DOE in the near future. However, it did not explain actions planned or taken to implement the recommendation when these situations exist. The Region also stated in response to Recommendation 2-3 that DOE has been providing via formal letter to EPA an explanation of missed target dates, an analysis of impacts to the project, and a plan for resolution of the performance issue. However, actions planned or taken to implement the recommendation, when these situations do not exist, were not included in the response.

Despite the Region's stated monitoring activities, DOE was behind schedule in meeting milestones that are critical to reducing human health and environmental risks as of the end of May 2002 when our fieldwork was completed. In addition, remediation of the K East Basin, the basin posing the most risk to human health and the environment, has not been started. Therefore, the Region needs to be more proactive in addressing and resolving performance issues associated with the remedial action.

In response to the final report, the Region needs to provide specific actions planned or taken for final resolution of the recommendations presented in this chapter. Also, milestones for completion of planned actions will be needed for resolution of the recommendations.

Chapter 3
Additional Oversight Necessary for Groundwater Interim Remedial Action

Region 10 has not provided sufficient oversight of DOE's pump-and-treat interim remedial action for groundwater contaminated with hexavalent chromium within the Hanford Site 100-K Area. Even though the pump-and-treat system was not achieving the cleanup standard specified by the Record of Decision (ROD), the Region did not take sufficient actions to ensure DOE operated the system effectively during the 3-year period ending September 2000. In addition, the Region did not take sufficient actions to ensure that necessary upgrades were completed timely. Hexavalent chromium has continued to discharge into the Columbia River at levels that exceed State of Washington standards, and may be adversely affecting some young salmon, trout, and other ecological receptors. These conditions occurred because the Region has not placed sufficient emphasis on timely resolution of remediation system performance issues and enforcement.

Background

Groundwater Contamination Poses Ecological Risk

In 1994, DOE completed its Qualitative Risk Assessment (risk assessment) for the 100-KR-4 Groundwater Operable Unit. The risk assessment identified that hexavalent chromium potentially posed unacceptable ecological risks and potentially required an interim remedial action. Chromium, a metallic element, may be converted to the hexavalent state under strongly oxidizing conditions, making it highly soluble in water and thus mobile in the aquatic environment.

Hexavalent chromium has continued to discharge into the Columbia River at levels that exceed 10 micrograms per liter (ug/L), the State of Washington's Chronic Ambient Water Quality Standard for the Protection of Freshwater Aquatic Life for the contaminant. Under the Endangered Species Act, the Columbia River spring chinook salmon and steelhead trout have been listed as endangered. The risk assessment for 100-KR-4 Operable Unit concluded that groundwater from the 100-K Area discharging into the Columbia River exceeded acute and chronic ecological-based risk thresholds and posed risks to young chinook salmon and trout living in the river. The risk assessment also disclosed that the 100 Area is a known area of chinook spawning.

The ecological risks posed by the 100-K Area were explained in more detail in DOE's proposed plan for remediation of the 100-K Area groundwater. DOE

disclosed in the proposed plan that sampling results during a limited field investigation indicated that hexavalent chromium concentrations in monitoring wells near the river and riverbank seepage pose potential risks to ecological receptors. The proposed plan also stated (DOE/RL-94-113 Rev.0, page 5):

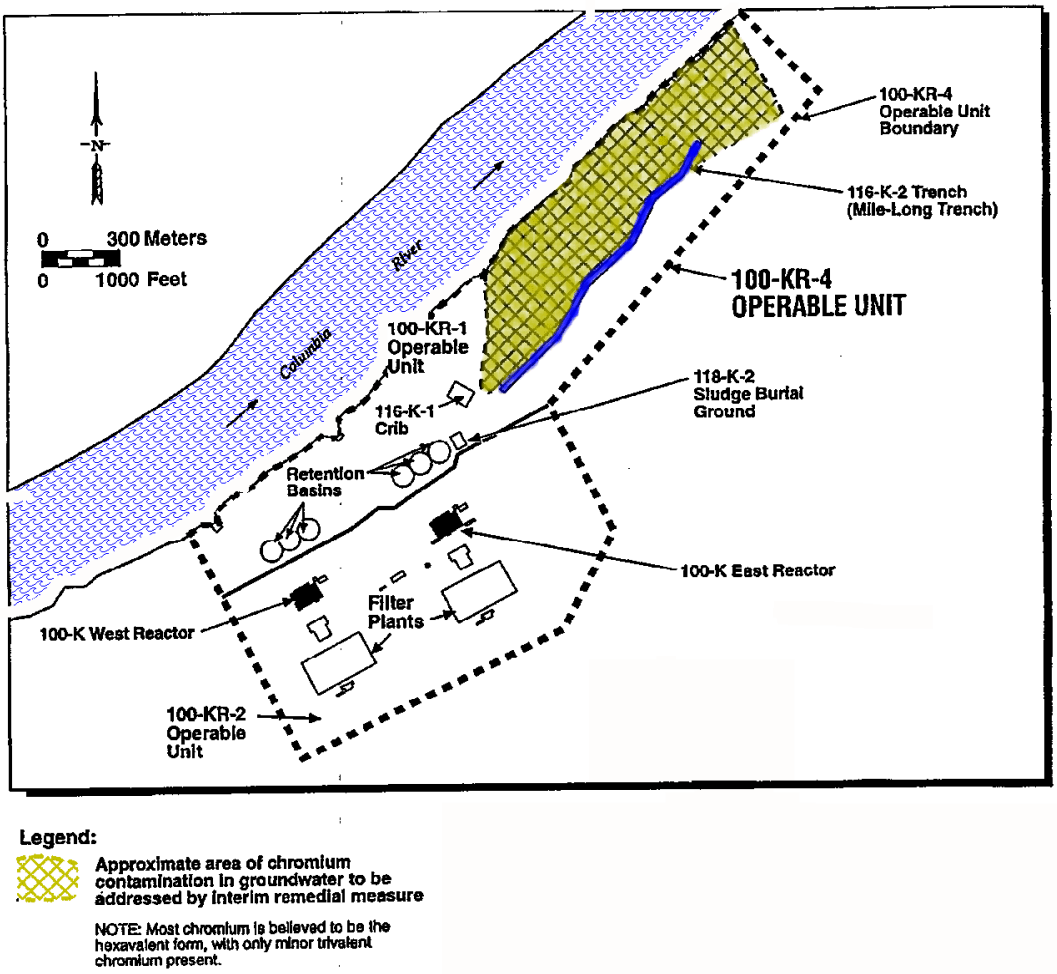
> *Potential ecological receptors along the Hanford Reach of the Columbia River, where the groundwater from the 100-KR-4 Operable Unit discharges, include fish and other organisms that live and spawn in the river, on the river bottom, and along the shoreline; birds and other animals that use the river and adjacent wetlands; and predators, such as the herons, that consume aquatic organisms. Receptors may come in contact with chromium-contaminated groundwater as it discharges into and mixes with water in the river, or as it issues from riverbank seepage before flowing into the river.*

DOE stated in the proposed plan that 100-K Area riverbed sediments were an especially sensitive region of potential exposure to aquatic organisms.

Groundwater Pump and Treat System Installed in the 100-K Area

The ROD between DOE and EPA for the Hanford 100-HR-3 and 100-KR-4 Operable Units requires interim remedial actions for the Hanford Site's 100-K Area. The ROD requires DOE to perform an interim remedial action for a groundwater plume contaminated with hexavalent chromium located between the area's 116-K-2 Trench and the Columbia River (see Figure 3-1). The ROD required DOE to install a pump-and-treat remediation system to remove the hexavalent chromium from the groundwater. The ROD specifies the system achieve a cleanup (removal) standard for hexavalent chromium of 22 ug/L in compliance wells used to measure the effectiveness of the interim remedial action.

Figure 3-1: Pump and Treatment System Capture Zone
(Source: ROD for 100-HR-3 and 100-KR-4 Operable Units)



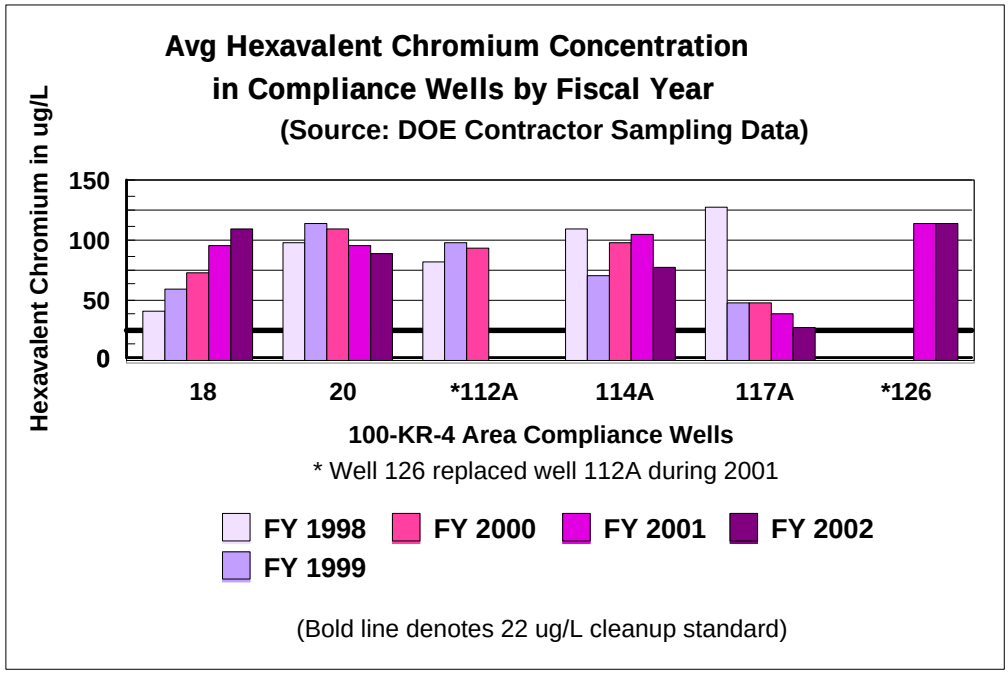
Requests to Improve System Not Effective

Even though the pump-and-treat system was not achieving the cleanup standard specified by the ROD, the Region did not take sufficient actions to ensure DOE operated the system effectively during the 3-year period ending September 2000. During this period, the composite withdrawal rate for the system's extraction wells was not increased, as had been recommended in DOE's annual performance summary reports for calendar years 1998 through 2000.

System Not Meeting Cleanup Standard

Sampling results from October 1997 through December 2001 showed that the average hexavalent chromium levels in four of the wells have significantly exceeded the ROD's cleanup standard. These data indicate that the system has not been effective in reducing the contamination levels. Figure 3-2 shows how the average hexavalent chromium levels generally exceeded the 22 ug/L limits by large amounts.

Figure 3-2



In its annual performance reports covering the operations of the pump-and-treat system for calender years 1998 through 2000, DOE acknowledged that the system was not achieving the cleanup standard specified by the ROD. The annual performance reports for 1998 through 2000 estimated that the system only captured about 70 to 76 percent of the groundwater plume each year.

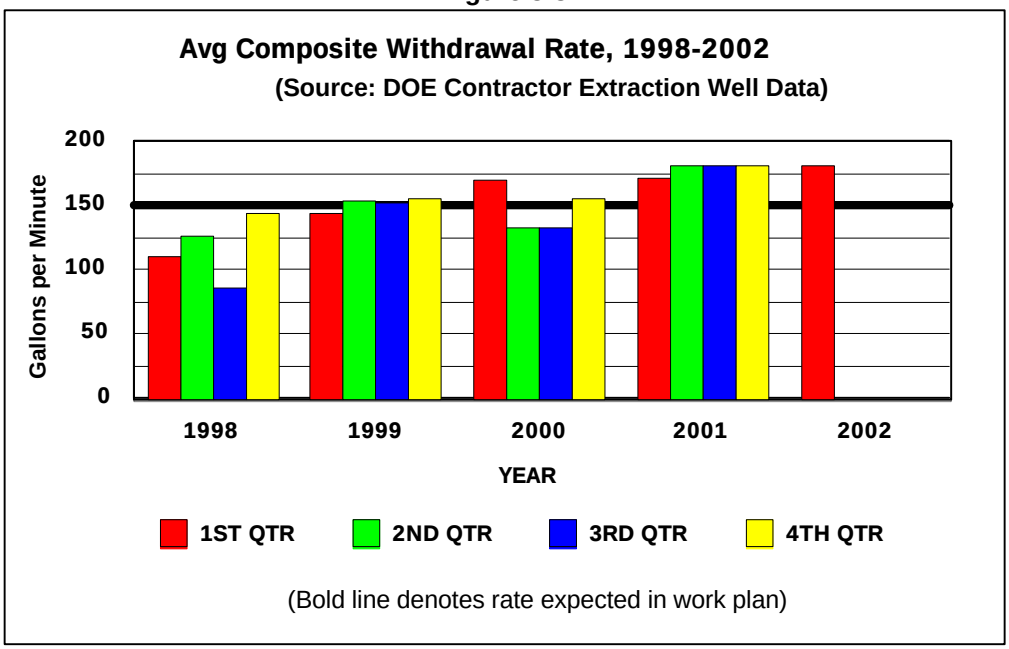
Pumping Rates Not Increased To Improve System Effectiveness

DOE's Remedial Design Report/Remedial Action Work Plan (work plan) identified that a pump-and-treat system consisting of six extraction wells would sufficiently capture the hexavalent chromium groundwater plume and achieve the cleanup standard specified by the ROD. The work plan specified that the withdrawal rate for each extraction well was expected to average 25 gallons per minute (gpm) and that the composite withdrawal rate for the system was expected to total 150 gpm. The work plan also disclosed that the system was designed to operate at a maximum composite withdrawal rate of 200 gpm.

Although the system was not making substantial progress toward meeting the 22 ug/L cleanup standard, DOE did not increase the composite withdrawal rate, as recommended in its annual performance summary reports for 1998 through 2000. The 1998 report recommended increasing the rate to 200 gpm and the 1999 and 2000 reports recommended increasing the rate to 195 gpm. Furthermore, DOE operated the extraction wells at rates that resulted in composite withdrawal rates that fell below the 150 gpm rate specified by the work plan for 7 of the 12 quarters covering the 3-year period ending September 2000.

The failure of one of the six extraction wells in September 1997 during system acceptance testing contributed to the low withdrawal rates for Fiscal 1998. Based on five operating extraction wells and the average nominal withdrawal rate of 25 gpm specified by the work plan, DOE should have been able to achieve a composite withdrawal rate of at least 125 gpm for Fiscal 1998. However, the 125 gpm composite rate was met or exceeded for only 2 of the 4 quarters of Fiscal 1998. Details on withdrawal rates are in Figure 3-3.

Figure 3-3



A replacement for the extraction well that failed in 1997 became operational during October 1998. However, the composite withdrawal rate remained below the 150 gpm rate specified by the work plan until the second quarter of Fiscal 1999. The composite rate fell below 150 gpm again for the second and third quarters of Fiscal 2000. DOE and the Region attributed the drop to scheduled and unscheduled maintenance; system modifications; and outages associated with weather, power loss, and other acts of nature. In addition, the Region said DOE did not always operate all the wells continuously because it considered the system

to be fully operational as long as at least one well was in operation. We acknowledge that maintenance, modifications, and unforseen events may temporarily reduce the system's treatment capacity. However, the ROD specified that the system shall be designed to run on a continuous basis such that routine procedures and mechanical maintenance can be conducted with minimal impact to system operations.

Region's Actions Not Sufficient

Even though the pump-and-treat system was not making measurable progress toward the cleanup standard specified by the ROD, the Region did not take sufficient actions to ensure DOE operated the system effectively during the 3-year period ending September 2000. During this period, the Region made requests to DOE for system improvements primarily through comments to work plans, e-mails, and meetings with DOE. Despite the low composite withdrawal rates and high contamination levels in the compliance wells, the Region did not escalate its response to an enforcement action.

In October 2000, the Region issued a memo to DOE requesting that the system be optimized and run more reliably and capture a much higher percentage of the plume. DOE subsequently added a seventh extraction well. The addition of this well increased the composite withdrawal rate to 182 gpm (a 26 gpm average per well). However, the rate was still below the 195 gpm rate recommended by the 1999 and 2000 annual performance summary reports.

In our view, the Region should have initiated an enforcement action in Fiscal 1998 when it first became apparent that DOE was having difficulty meeting a composite withdrawal rate based on the 25 gpm individual well rate. Furthermore, the Region should have required DOE to implement the recommended composite withdrawal rates specified in the annual performance summary reports.

Actions Not Sufficient to Ensure That Upgrades Were Timely

Region 10 did not take sufficient actions to ensure that the upgrades necessary for improving the pump-and-treat system's effectiveness were completed timely. These upgrades involved installation of two additional extraction wells so that a higher percentage of the contamination plume could be captured.

Seventh Extraction Well Not Placed In Operation Timely

Although the Region requested in June 1998 that DOE upgrade the system with a seventh extraction well, the Region did not take sufficient action to ensure that an

additional well was placed in operation by the Fall of 1999. The well did not become fully operational until March 2001, or 33 months after it was requested.

Based on its evaluation of DOE's April 1998 performance report covering the interim remedial actions for both the 100-H and 100-K Areas, the Region recommended in a May 1998 memo to DOE that it install an additional extraction capable well at the east end of the pump-and-treat system. The Region had determined that the system was not capturing the eastern edge of the contamination plume. In June 1998, the Region followed up with another memo, informing DOE that the additional well should be installed and operated during the first part of Fiscal 1999. However, a specific enforceable deadline was not specified in the memo. The Region also stated in the memo:

> *Performance data should be collected for enough months during FY99 such that the next issue of the Performance Evaluation Report in September '99 documents the effect of this extraction well on the plume and capture zone.*

The Region discovered in August 1999, over 10 months into Fiscal 1999, that the additional extraction well was installed but was not connected to the pump-and-treat system. According to the Region, the well was not connected because DOE's contractor redirected the funding intended for the well connection to other projects. The Region responded by issuing to DOE an August 1999 memo requesting that it ensure the well connection was funded and performed in early Fiscal 2000. However, the Region did not establish a specific enforceable deadline. The Region did not follow up on its request until October 2000, more than 1 year later, at which time it issued a memo to DOE requesting again that the well be connected to the pump-and-treat system. This memo also did not establish a specific enforceable deadline. DOE finally connected the well and made it fully operational on March 4, 2001, or 33 months from the Region's June 1998 request.

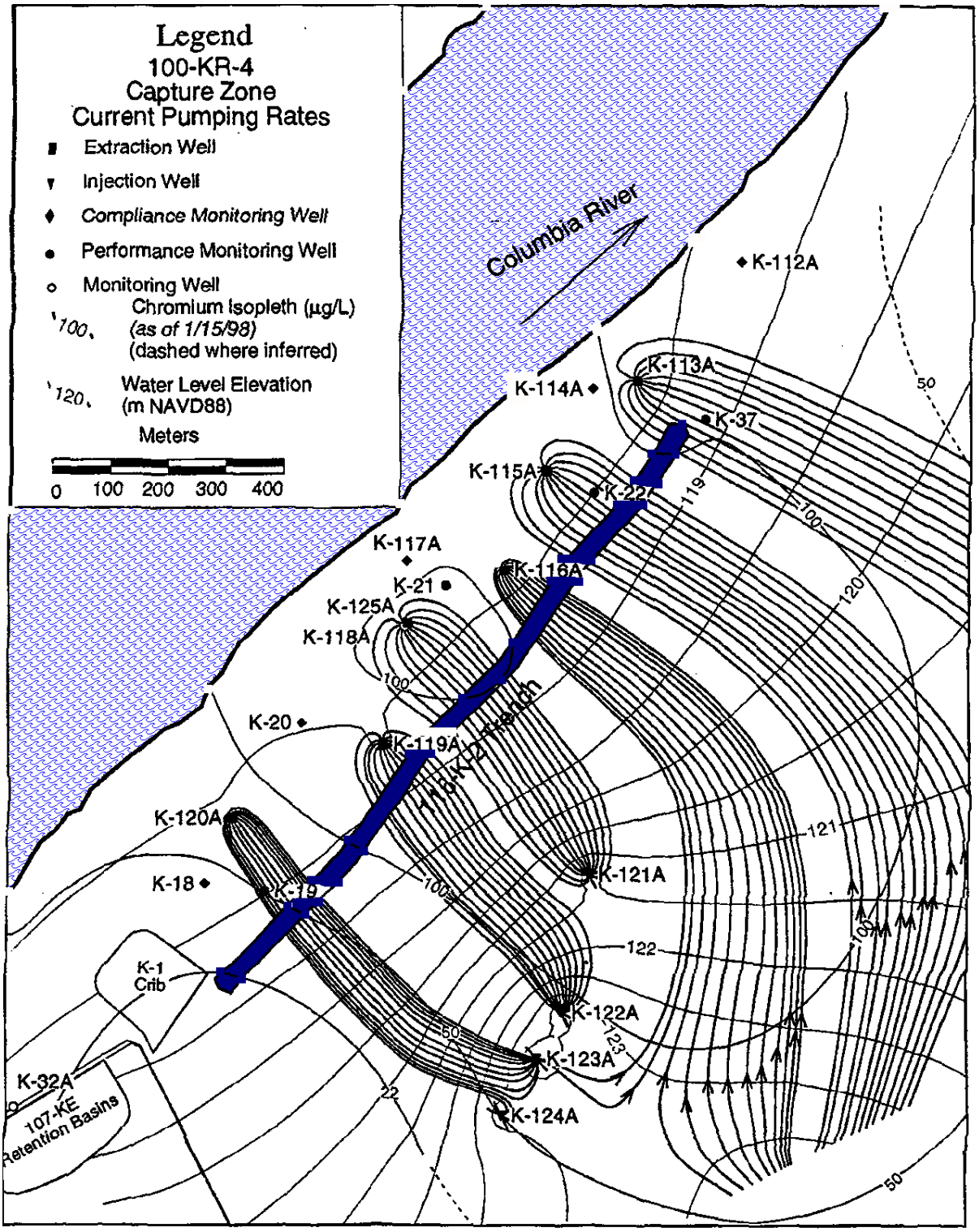
Request For An Eighth Extraction Well Was Untimely

The Region did not request that DOE upgrade the system with an eighth extraction well and other system modification until April 2001, even though it was aware since October 1997 that the western end of the system was not capturing a sufficient percentage of the plume to meet the cleanup standard specified by the ROD. Consequently, the upgraded system did not become fully operational until June 2002, almost 5 years after the Region was aware that the additional well in this area may be necessary.

The Region became aware in October 1997, the first month of operations for the pump-and-treat system, that the two extraction wells (K-119A and K-120A) on

the western end of the remediation system were not capturing a sufficient amount of the contamination plume (see Figure 3-4). To increase the percentage of the plume capture between the two wells, DOE recommended in its 1998 annual summary performance report that the withdrawal rate for each of the two wells be increased to 40 gpm, although the report noted care needed to be taken to not disturb a culturally sensitive area at the location. Despite the recommendation, the wells were operated during 1999 at an average withdrawal rate of 27 and 21 gpm, respectively. In its 1999 summary performance report, DOE revised the recommended withdrawal rate for each of the two wells to 25 gpm.

Figure 3-4: Chromium Capture Zone for System's Extraction Wells
(Source: 1998 Annual Summary Report, February to December 1998, for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations and Operable Units)



The Region told us that DOE agreed in Fiscal 2000 to install an additional extraction well between Wells K-119A and K-120A. According to the Region, DOE initially identified that the well should be placed within the sensitive area, and negotiations were necessary during 2000. In early Fiscal 2001, DOE decided the extraction well could be placed between Wells 119A and 120A without disturbing the culturally sensitive area.

In April 2001, the Region formalized the need to increase the effectiveness of the pump-and-treat system after completing its first Five-Year Review of the remedial actions at the four NPL sites at Hanford. In the review, the Region included a request that DOE install an extraction well to bridge the gap between existing extraction Wells K-119A and K-120A.

The Region acknowledged that the addition of the eighth extraction well and other system modifications could have been accomplished sooner, and indicated it took a conservative approach because of the culturally sensitive area. Consideration of replacing the pump-and-treat system (eventually dismissed because of high cost) also contributed to the delay. We agree that the Region and DOE need to take reasonable and appropriate precautions, but the Region needs to ensure that all feasible remediation alternatives are addressed timely. It took the Region from October 1997 to April 2001, or more than 3 years, just to request that DOE add the eighth extraction well. According to the Region, the eighth extraction well did not become fully operational until June 2002, or almost 5 years after the Region was aware that the additional well may be necessary.

Insufficient Emphasis Placed on Resolution of Issues

These conditions occurred because the Region has not placed sufficient emphasis on timely resolution of remediation system performance issues and enforcement of the requirements specified by the ROD.

During the period from October 1997 through December 2001, the Region generally addressed performance issues pertaining to the pump-and-treat system by providing DOE with corrective action requests and recommendations, but did not establish enforceable requirements and deadlines. For example, the Region told us that on several occasions it recommended that DOE increase extraction well withdrawal rates in order to capture a higher percentage of the contamination plume. According to the Region, most of these recommendations were made informally to DOE. The Region also said DOE did not comply with its recommendations for increasing the withdrawal rates.

The Region's followup actions have not resulted in timely upgrades and resolution of performance issues for the pump-and-treat system. Although the pump-and-

treat system had been in operation for more than 4 years as of the end of December 2001, the system had not made significant progress toward meeting the cleanup standard of 22 ug/L specified by the ROD.

Conclusion

DOE's work plan identified that six extraction wells operating at a composite withdrawal rate of 150 gpm would achieve the cleanup standard specified by the ROD. Although these specifications established a remediation system that has not proved capable of achieving the cleanup standard specified by the ROD, the Region's response actions did not result in timely resolution of system operation and design weaknesses. Consequently, hexavalent chromium has continued to discharge into the Columbia River at levels that exceed 10 ug/L, the State of Washington's Chronic Ambient Water Quality Standard for the Protection of Freshwater Aquatic Life for the contaminant. Hexavalent chromium poses an ecological threat to some fish species living in the Columbia River. Therefore, Region 10 needs to place more emphasis on timely followup of requested corrective actions and enforcement of the remediation requirements specified by the ROD to ensure timely resolution of performance issues.

Recommendations

We recommend that the Region 10 Administrator:

3-1. Evaluate the performance of the upgraded 100-K Area pump-and-treat system that went on-line in May 2002 to determine if it achieves the remedial action objectives of the ROD. If remedial action objectives are not being met, pursue timely and formal followup and/or enforcement actions that include specific corrections, actions, and deadlines to ensure that:

a. Pump-and-treat system downtime is minimized and the composite withdrawal rate for extraction wells is maintained at a rate that maximizes the system's effectiveness with capturing and remediating the contaminated groundwater.

b. Any future upgrades to the pump-and-treat system that are necessary for achieving the ROD's cleanup standard are completed by specific enforceable due dates.

c. DOE evaluates remediation alternatives to the pump-and-treat system if hexavalent chromium levels in compliance wells do not meet the ROD's cleanup standard by the end of Fiscal 2003.

Agency Comments and OIG Evaluation

The Region agreed with the recommendation. The Region stated that it plans to ask the U.S. Geological Survey to recommend any operational changes that may be appropriate to facilitate achievement of remedial action objectives. The Region also said that the pump-and-treat system has been operating nearly continuously at about 260 gpm since the May 2002 expansion. If future upgrades to the system are necessary, the Region said specific enforceable dates for completion would be pursued. The Region said that evaluation of alternatives to the pump-and-treat system has been an ongoing part of the remedial action, rather than an activity to commence by the end of fiscal year 2003. The Region acknowledges that the remedial action objectives have yet to be achieved in monitoring wells downgradient of the groundwater recover and treatment system and the groundwater being recovered continues to have high levels of chromium.

The Region needs to provide specific actions planned for final resolution Recommendation 3-1 (a) and (c). Furthermore, milestones for completion of planned actions will be needed for resolution of these recommendations. We consider the Region's planned action for implementation of Recommendation 3-1 (b) to be satisfactory.

Chapter 4
Groundwater Remediation Requirements Not Adequately Addressed

Region 10 has not obtained sufficient information from DOE to determine whether an interim remedial action is necessary for contaminated groundwater within the reactor section of the Hanford Site 100-K Area. Specifically:

- The Region and DOE concluded, without completing a formal assessment, that an interim remedial action was unnecessary for the reactor section.

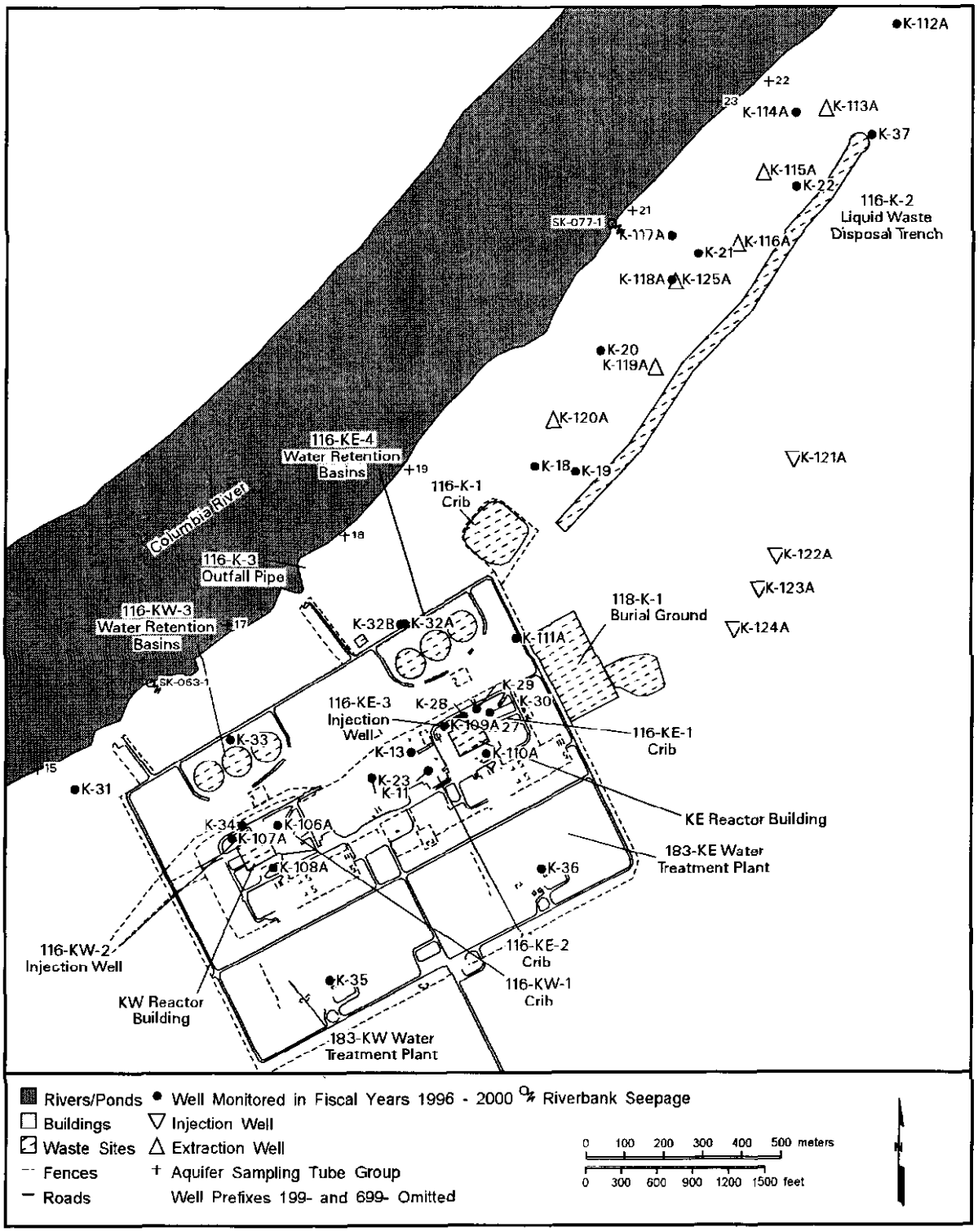
- The Region has not ensured that DOE's groundwater monitoring system has provided sufficient data to enable an adequate assessment of remediation requirements.

The noted conditions mainly occurred because the Region has not placed sufficient emphasis on ensuring that DOE has assessed remediation requirements for the reactor section. Hexavalent chromium contamination levels in the groundwater within the reactor section have continued to significantly exceed State limits, and carbon-14 contamination levels in the groundwater have continued to exceed the Federal drinking water standards for radionuclides. However, because of the inadequate data, we could not determine whether an interim remedial action to remove hexavalent chromium and carbon-14 from the groundwater within the reactor section was necessary for adequate protection of ecological receptors.

Background

The Hanford FFACO states that one of the purposes of the agreement is to "ensure that the environmental impacts associated with past and present activities at the Hanford Site are thoroughly investigated and appropriate response action taken as necessary to protect the public health, welfare and the environment." The FFACO also specifies that the Applicable or Relevant and Appropriate Requirements for the Hanford Site include all Federal and State laws and standards that pertain to protection of human health and the environment. The 100-KR-4 Operable Unit includes the contaminated groundwater within the 100-K Area, as well as surface water, saturated sediments and aquatic biota impacted by operations associated with the K East and K West Reactors. Figure 4-1 shows the groundwater monitoring system for the operable unit.

Figure 4-1: 100-K Area Groundwater Monitoring Wells and Aquifer Sampling Tubes
(Source: Hanford Site Groundwater Monitoring for Fiscal Year 2000)



Formal Assessment to Determine Remediation Need Not Conducted

Region 10 and DOE concluded, without completing a formal assessment, that an interim remedial action was unnecessary for the 100-K Area's reactor section. This was despite the fact that DOE's risk assessment for the 100-KR-4 Groundwater Operable Unit concluded that hexavalent chromium and carbon-14 contamination to the groundwater posed unacceptable ecological risks.

DOE completed the risk assessment for the 100-KR-4 Groundwater Operable Unit in June 1994 to determine whether an interim remedial action for contaminated groundwater within the 100-K Area was necessary. Based on a comparison of groundwater sampling data to risk based benchmark concentrations, the risk assessment identified that hexavalent chromium, carbon-14, and zinc contamination to the 100-K Area's groundwater potentially posed unacceptable risks to freshwater aquatic life, particularly to young chinook salmon, steelhead trout, and fish-eating ducks.

In October 1994, DOE submitted a draft plan to the Region for an interim remedial measure for the 100-K Area's contaminated groundwater. DOE identified that its preferred alternative was to not remediate the groundwater, but to restrict access to the area through institutional controls and to continue monitoring. DOE said that high cleanup costs, generation of wastes, and potential ecosystem damage did not appear warranted by the potential ecological risks posed by the contaminated groundwater. In contradiction with the risk assessment, the plan stated that carbon-14 contamination to the groundwater posed only a risk to individual fish-eating ducks but not populations of ducks and the ecosystem as a whole.

The Region disagreed with DOE's proposed plan and, as a result, negotiated with DOE over the period from October 1994 to September 1995 to implement an interim remedial action for the contaminated groundwater. After reaching agreement, DOE, Region 10, and the State of Washington Department of Ecology released the Proposed Plan for Interim Remedial Measure at the 100-KR-4 Operable Unit for public comment. This proposed plan identified that the preferred alternative for remediating the groundwater was to remove hexavalent chromium, carbon-14, and zinc from the groundwater using an ion exchange pump-and-treat system.

Although the risk assessment identified that all groundwater contamination levels in excess of risk based benchmark concentrations potentially posed unacceptable risks to ecological receptors, the proposed remedial action only addressed the groundwater between the 100-K Area's 116-K-2 Trench and the Columbia River. The proposed plan's interim remedial action did not address the groundwater

contamination within the remainder of the 100-K Area located within the reactor section.

After review and evaluation of comments on the proposed plan, the ROD for the interim remedial action was signed by the three parties in April 1996. The ROD requires DOE to operate an ion exchange pump-and-treat system to remove hexavalent chromium from the groundwater between the 116-K-2 Trench and the Columbia River. Inconsistent with the proposed plan, the ROD does not require removal of carbon-14 and zinc from the groundwater. According to the ROD, detailed analysis showed that zinc and carbon-14 contamination in the groundwater did not warrant inclusion in the interim action. The ROD indicated the elevated zinc data used in the risk assessment was caused by a zinc-plated screen installed in the monitoring well where the sampling data was obtained, and the data was therefore not representative of a zinc-contaminated groundwater plume. However, groundwater sampling data used for the risk assessment showed that significant groundwater contamination exists in both the 116-K-2 (Trench) and the reactor sections of the 100-K Area, as shown in Table 4-1.

Table 4-1: 100-K Area Contamination Levels from Risk Assessment		
Monitoring Well	**Highest Cr [3] Sample (unfiltered ug/L)**	**Highest C-14 [4] Sample (pCi/L)**
Allowable levels	10[5]	2000[5]
K-23 (R[1])	**159**	51
K-30 (R)	Not Detected	**23000**
K-32A (R)	**140**	450
K-33 (R)	**25.7**	**16000**
K-34 (R)	**156**	**13000**
K-36 (R)	**1950**	310
K-19 (T[2])	**128**	16
K-20 (T)	**261**	630
K-21 (T)	**125**	8.6
K-22 (T)	**187**	236

[1]Monitoring well located in the reactor section.
[2]Monitoring well located in the 116-K-2 section.
[3]Chromium (Bold denotes above standard).
[4]Carbon-14 (Bold denotes above standard).
[5]State of Washington Chronic Ambient Water Quality Standard for the Protection of Freshwater Aquatic Life.
[6]Federal drinking water quality standard.
Source: DOE's Qualitative Risk Assessment for the 100-KR-4 Groundwater Operable Unit

Even though the sampling data used for the risk assessment showed that the groundwater within the reactor section was contaminated with high levels of chromium and carbon-14, the Region was unable to provide us with documentation showing that an interim remedial action was not necessary for protection of the ecological receptors. Consequently, we were unable to verify that the decision to remediate only the groundwater between the 116-K-2 Trench and the river provided sufficient protection to the Columbia River's ecosystem.

Groundwater Monitoring System Does Not Provide Sufficient Data

Region 10 has not ensured that DOE's groundwater monitoring system has provided sufficient data to assess whether an interim remedial action is necessary for groundwater contaminated by hexavalent chromium and carbon-14 within the 100-K Area's reactor section. Specifically, the current configuration of the

groundwater monitoring system has not provided sufficient groundwater assessment data, and groundwater sampling has been too infrequent.

Groundwater Monitoring System Not Adequately Configured

The current configuration of the groundwater monitoring system for the reactor section does not provide sufficient data to assess: (a) the current ecological risks posed by the hexavalent chromium and carbon-14 groundwater contamination; and (b) whether an interim remedial action is necessary to protect the river's ecosystem. The reactor section's groundwater monitoring system consists of 19 groundwater monitoring wells, 4 aquifer sampling tubes, and 1 riverbank seepage sample point. Four of the 19 wells are near the river (approximately 75 to 275 meters from the river's edge). The approximate spacing between the aquifer tubes ranges from 225 to 600 meters.

To determine whether DOE's groundwater monitoring system for the reactor section provided sufficient data to assess ecological risks and whether an interim remedial action is necessary, we reviewed groundwater sampling data for the 100-K Area from January 1994 to December 2001, DOE's groundwater monitoring reports for Fiscal 2000 and 2001, and other DOE documents.

Our review showed that the locations of groundwater monitoring wells for the reactor section do not provide sufficient characterization of the contamination levels, boundaries, and migration of the groundwater plumes. Furthermore, the review showed that there are an insufficient number of aquifer tubes along the river to ensure that all discharge points for groundwater plumes and contaminant concentrations entering the river are identified. Weaknesses in the monitoring system have been acknowledged by DOE in the past. For example, DOE's Fiscal 2001 report on groundwater monitoring stated (Hanford Site Groundwater Monitoring for Fiscal Year 2001, pages 2.33 and 2.34):

> *Monitoring wells in the 100K Area do not provide extensive and uniform coverage, so the configuration of the water table cannot be described with a high degree of confidence for all portions of the area.…*
>
> *…The western extent of this plume is uncertain because monitoring wells do not cover that area.*

Based on our review of the sampling data and other groundwater documents, we concluded that the existing groundwater monitoring system for the reactor section was not adequate to determine the spatial distribution of contaminants, particularly near the river where ecological impacts are the primary concern. The

data clearly show that there continues to be severe contamination of the aquifer in the vicinity of the K East and K West Reactor facilities.

To obtain sufficient data to assess the current ecological risks posed by the groundwater contamination and whether an interim remedial action is necessary, the Region needs to require DOE to install additional aquifer sampling tubes along the river at the reactor section. Our review indicates that these sampling points should be spaced 100 meters apart. If the sampling results from the additional aquifer tubes show that additional groundwater monitoring wells are necessary for characterizing and assessing the ecological risks posed by the groundwater plumes, the Region should require DOE to install the additional wells.

Groundwater Sampling Frequency Not Adequate

Groundwater sampling for the reactor section has been too infrequent to enable an accurate assessment of the current ecological risks posed by the hexavalent chromium and carbon-14 contamination to the groundwater and the need for an interim remedial action.

Groundwater sampling for hexavalent chromium contamination within the 116-K-2 Trench section has been conducted monthly for compliance wells and semiannually for monitoring wells. However, groundwater sampling during Fiscal 1997 through 2001 for chromium and carbon-14 near the river in the reactor section has been less frequent and consistent. Specifically, groundwater sampling for hexavalent chromium in near river wells of the reactor section has been limited to an annual basis, and even less frequent and consistent for the aquifer sampling tubes and the riverbank seepage sampling point. Furthermore, groundwater sampling coverage for carbon-14 near and along the river of the reactor section has been even less frequent and less consistent than the chromium sampling for the section. Details are in Table 4-2.

Table 4-2: Sampling Conducted for Reactor Section, 1997-2001

Sample Point	1997		1998		1999		2000		2001	
	Cr	C-14	Cr	C-14	Cr	C-14	Cr	C-14	Cr	C-14
K-31	X[2]	–[3]	X	–	X	–	X	–	X	–
K-32A	X	X	X	X	X	X	X	X	X	X
K-32B	X	–	X	–	X	–	X	–	X	–
K-33	X	X	X	X	X	X	X	X	X	X
AT15[1]	N/A[4]		X	X	–	–	–	–	–	–
AT17[1]			X	X	X	X	X	X	–	–
AT18[1]			X	–	X	X	X	X	–	–
AT19[1]			X	–	–	–	–	–	X	X
Seep	–	–	–	–	–	–	–	–	X	–

[1]Aquifer sampling tube
[2]X indicates sampling was conducted
[3]– indicates sampling was not conducted
[4]Not Applicable because aquifer sampling tubes were installed late in Fiscal 1997
Source: HEIS and DOE Groundwater Monitoring Reports

We believe the sampling frequency for hexavalent chromium and carbon-14 groundwater contamination for the groundwater monitoring wells should be at least semiannually until a formal assessment of the current ecological risks and need for remediation is completed. The sampling frequency for hexavalent chromium and carbon-14 contamination in the aquifer sampling tubes and the riverbank seepage point should be at least annually, in the Fall, since high river levels at other times of the year may render the tubes and seeps inaccessible.

During our review of groundwater sampling data we found that hexavalent chromium sampling results for aquifer sampling tubes have not been routinely entered in DOE's Hanford Environmental Information System (HEIS). Specifically, Fiscal 1998 hexavalent chromium sampling results for Aquifer Sampling Tubes 15, 17, 18, and 19, and Fiscal 2000 hexavalent chromium sampling results for Aquifer Sampling Tubes 17 and 18 were not included.

The Region and State use HEIS to assist them with monitoring and evaluating environmental conditions and remedial activities at the Hanford Site. Because some sampling results have not been input into HEIS, the Region and State have no assurance that the sampling data they obtain from the data base is complete for a specific CERCLA operable unit; RCRA Treatment, Storage, Disposal unit; or remedial action. Sampling data can eventually be obtained through monitoring reports periodically published by DOE. However, a complete and accurate electronic data base containing sampling results for the Hanford Site would

provide the Region and State with a single information source that is readily available.[4]

Unremediated Groundwater May Pose Significant Ecological Risks

Hexavalent chromium and carbon-14 contamination levels in the groundwater within the reactor section have continued to exceed State and Federal standards by significant amounts, and discharge of these contaminants to the river at levels that exceed the standards may adversely affect the Columbia River's ecosystem.

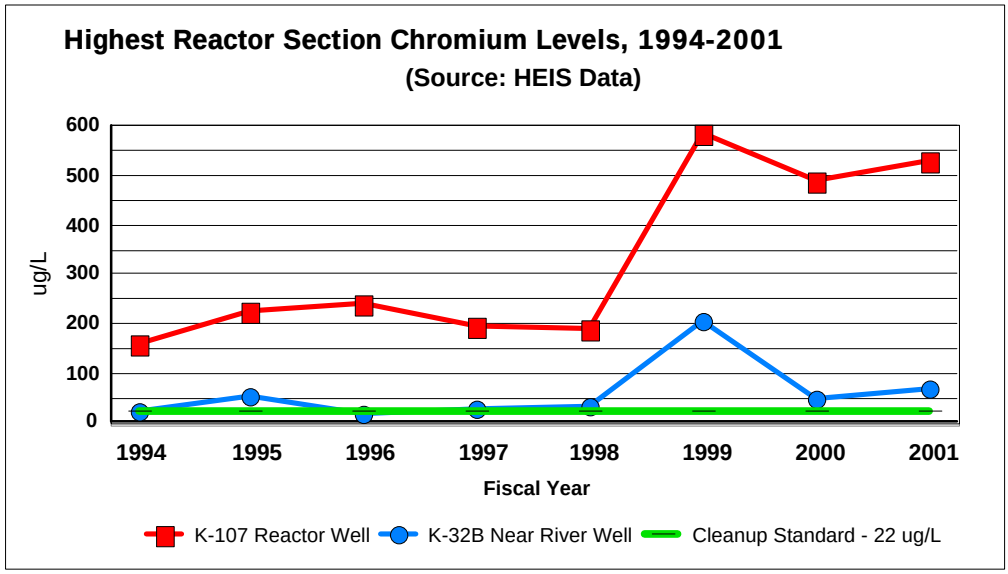
A 1998 DOE report, based on sampling data from riverbank seeps from about 1991 through 1995, was consistent with the conclusion of the DOE's risk assessment for the 100-KR-4 Operable Unit, and stated that the chromium contamination to the groundwater within the 100-K Area posed unacceptable risks to aquatic organisms, including young salmon. It also specifically identified that the groundwater contamination within both 116-K-2 Trench and reactor sections of the 100-K Area posed unacceptable risks to aquatic organisms, primarily because of chromium's toxicity to embryonic and young salmon.[5]

Our review of groundwater sampling data covering the period from 1994 to 2001 for the reactor section confirmed that contamination levels for chromium and carbon-14 have remained high since the completion of the risk assessment in 1994 and DOE's 1998 report. For example, Fiscal 2001 groundwater sampling results for the reactor section showed that chromium contamination in the groundwater was as high as 66.4 ug/L in a monitoring well near the river and as high as 529 ug/L in a monitoring well near the K West Reactor Building (see Figure 4-2).

[4]Our review of HEIS was limited to sample data for the 100-K Area. We did not project the error rate for the entire data base and are not making recommendations to improve HEIS.

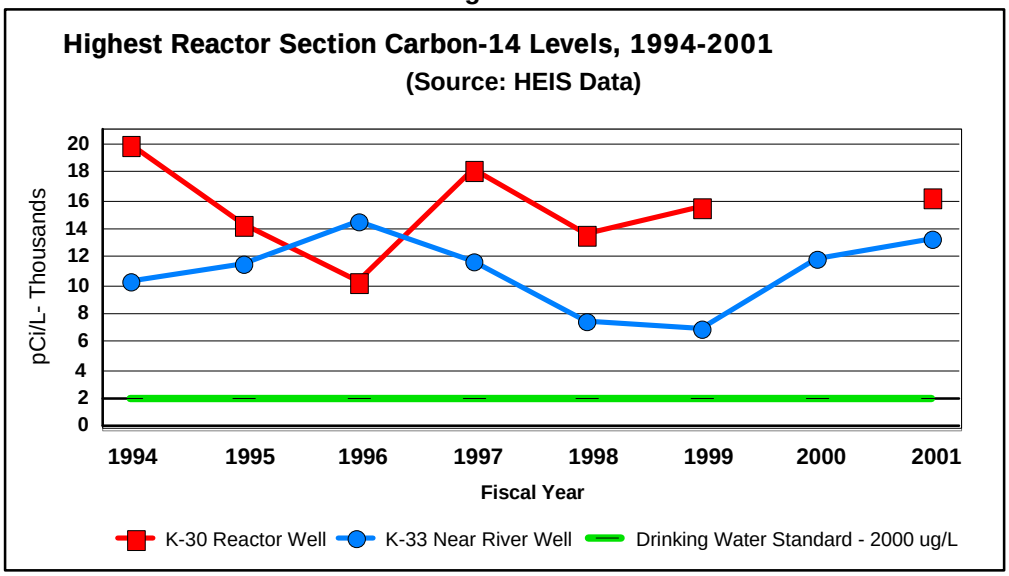
[5]DOE, *Screening Assessment and Requirements for a Comprehensive Assessment, Columbia River Comprehensive Impact Assessment,* March 1998.

Figure 4-2



The Fiscal 2001 groundwater sampling results for the reactor section also showed that carbon-14 contamination to the groundwater was as high as 13,400 pCi/L in a monitoring well near the river and as high as 16,300 pCi/L in a monitoring well near the K East Reactor Building (see Figure 4-3).

Figure 4-3



Sufficient Emphasis Not Placed on Remediation Assessment

The noted conditions mainly occurred because the Region has not placed sufficient emphasis on ensuring that DOE has assessed remediation requirements

for the contaminated groundwater within the 100-K Area's reactor section. The Region told us it did not consider groundwater contamination within the 100-K Area or reactor section as significant as at other areas of the Hanford Site and, as a result, more emphasis has been placed on remediation in those areas. The Region also said that the carbon-14 contamination to the groundwater was not included in the interim remedial action because the risk assessment's ecological risk assessment was too conservative, and it did not believe that carbon-14 contamination posed risks to individual or populations of fish eating ducks.

Conclusion

DOE's risk assessment for the 100-KR-4 Operable Unit identified that hexavalent chromium and carbon-14 contamination to the 100-K Area's groundwater potentially posed unacceptable risks to freshwater aquatic life. The Region was unable to provide us with documentation showing that the decision to not remediate the groundwater contamination within the reactor section was based on a formal assessment. Consequently we were unable to verify that remediation of hexavalent chromium and carbon-14 contamination to the groundwater within the reactor section is unnecessary for protection of the Columbia River's ecosystem. Furthermore, the current groundwater monitoring system and sampling coverage for the reactor section do not provide sufficient data to assess risk. An adequate assessment to determine whether an interim remedial action is necessary cannot be completed until groundwater data that sufficiently identifies the current ecological risks posed by the contaminated groundwater is obtained.

Recommendations

We recommend that the Region 10 Administrator:

4-1. Require DOE to conduct a formal assessment to determine whether an interim remedial action for removal of carbon-14 and/or hexavalent chromium within the reactor section of the 100-K Area is necessary for protection of the Columbia River's ecosystem. Ensure that the assessment is based on groundwater monitoring data that sufficiently identifies the current ecological risks posed by the contaminated groundwater.

4-2. Require DOE to continue to monitor for carbon-14 and hexavalent chromium in the 100-K Area groundwater to determine if expansion of the pump-and-treat system for chromium is necessary in the interim to protect the Columbia River.

4-3. Require DOE to improve the groundwater monitoring system for the reactor section of the 100-K Area. Consider including as part of the system:

a. Additional aquifer sampling tubes along the Columbia River, such as an aquifer sampling tube every 100 meters.

b. Additional groundwater monitoring wells if sampling results from the additional aquifer tubes show that the monitoring wells are necessary for characterizing and assessing the current ecological risks posed by the groundwater plumes within the reactor section.

c. A sampling frequency of at least semiannually for all groundwater monitoring wells within the reactor section for hexavalent chromium and carbon-14.

d. A sampling frequency of at least annually for the aquifer sampling tubes and the riverbank seepage sample point within the reactor section for hexavalent chromium and carbon-14.

Agency Comments and OIG Evaluation

Region 10 agreed with Recommendation 4-1 with comment, agreed with Recommendation 4-2, and disagreed with Recommendation 4-3.

In response to Recommendation 4-1, the Region stated that a formal assessment of the need for an interim remedial action in the area's reactor section has been conducted. It said that formal assessments have been conducted and have indicated that contaminated soil, pipelines, and the K Basins pose a risk to groundwater and meet the criteria in the FFACO for interim remedial actions. The Region also said that formal assessments for the groundwater documented that the groundwater did not meet the criteria for interim remedial action. However, it proposed to develop, in conjunction with DOE, a technical memorandum to the file which clearly documents the rationale for not requiring an interim action in the reactor section.

The Region indicated in response to Recommendation 4-2 that monitoring for these contaminants has been included in the groundwater monitoring network for many years and will continue to be included. It said that the results will be evaluated at least annually with DOE as part of the annual program reviews. In addition, the Region stated that any significant change in conditions would be considered in determining expansion of the pump-and-treat interim action where appropriate.

The Region said that the specific groundwater monitoring system changes outlined in Recommendation 4-3 were not appropriate at this time. However, the Region also stated: "…on October 4, 2002, EPA received a groundwater monitoring and assessment plan for the 100 K Area fuel storage basins that will be reviewed by EPA and the U.S. Geological Survey to determine if modifications in the groundwater monitoring system are needed for an evaluation of remedial action effectiveness, or to further refine implementation strategies for ongoing remedial actions."

We agree that formal assessments were conducted to determine the potential risks posed by the hexavalent chromium and carbon-14 contamination to the groundwater within the 100-K Area. The risk assessment for 100-KR-4 Groundwater Operable Unit, completed in 1994, concluded that hexavalent chromium and carbon-14 contamination to the groundwater potentially posed unacceptable risks to freshwater aquatic life. Furthermore, DOE's *Screening Assessment and Requirements for a Comprehensive Assessment, Columbia River Impact Assessment*, completed in 1998, concluded that chromium contamination to the groundwater within the 100-K Area posed unacceptable risks to aquatic organisms. We also note that the 1998 assessment did not evaluate risks posed by the carbon-14 contamination because sufficient groundwater sampling data was not available.

During the evaluation, the Region told us that the decision process used to assess the need for an interim remedial action for the contaminated groundwater within the 100-K Area was documented, including the proposed plan for an interim remedial measure for the 100-K Area's contaminated groundwater and the ROD. However, the remediation decision documents made available to us by the Region did not sufficiently explain and support the Region's and DOE's conclusion that an interim remedial action was unnecessary for the contaminated groundwater within the reactor section.

We agree that the Region needs to adequately document the remediation decision process for groundwater within the reactor section. As discussed in this chapter, the Region needs to ensure that the remediation decision is based on sufficient groundwater sampling data. In response to the final report, the Region needs to provide the specific action planned and the completion date for final resolution of Recommendation 4-1.

We consider the Region's planned actions and implementation schedule for Recommendation 4-2 to be satisfactory.

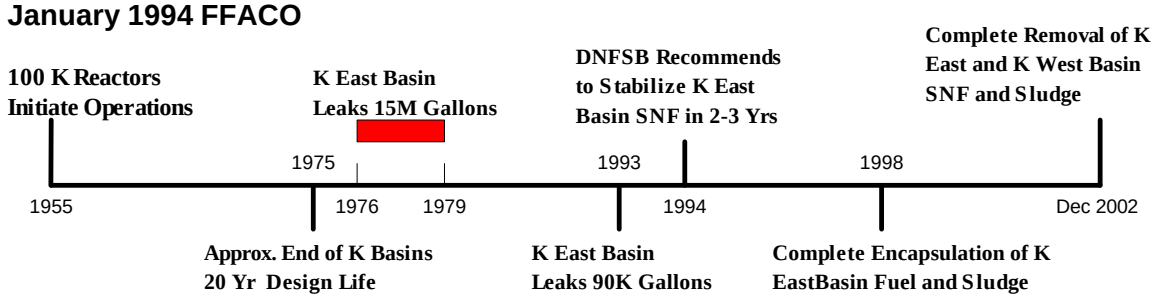
In regard to the Region's response to Recommendation 4-3, it is not clear that their plan to evaluate DOE's groundwater monitoring and assessment plan for the 100 K Area fuel storage basins specifically addresses weaknesses in groundwater

monitoring for hexavalent chromium and carbon-14. Our evaluation of the adequacy of the groundwater monitoring system for the reactor section included a review of the system by an independent expert in groundwater hydrology and groundwater contaminant transport. This review concluded that there continues to be severe contamination of the aquifer in the vicinity of the K East and K West Reactor facilities, inadequacies in the spatial and temporal coverage of sampling in this area make it difficult to determine if contaminants are reaching the Columbia River and, therefore, the existing groundwater monitoring system for the reactor section needs to be improved to determine the spatial distribution of contaminants, particularly near the river where ecological impacts are the primary concern.

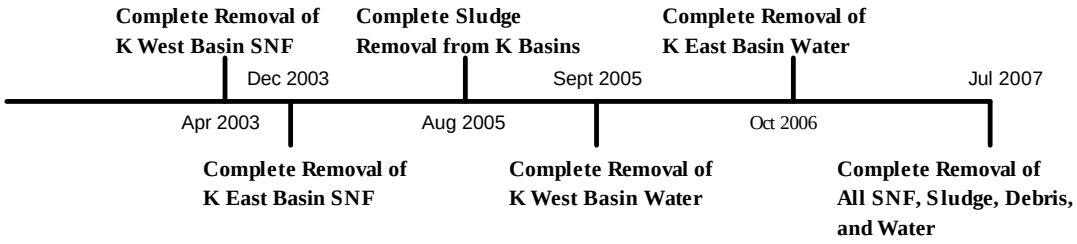
The Region's plan to evaluate DOE's groundwater monitoring and assessment plan for the 100 K Area fuel storage basins does not specifically address weaknesses in groundwater monitoring for hexavalent chromium and carbon-14. In order to resolve Recommendation 4-3, the Region needs to either: (1) determine monitoring system modifications that will provide sufficient data to assess remediation requirements for hexavalent chromium and carbon-14 contamination to the groundwater; or (2) provide an analysis which clearly shows that the current monitoring system provides sufficient data to assess whether an interim remedial action is necessary in the reactor section. If the Region determines that the monitoring system requires modification, it will also need to ensure that the necessary modifications are made to the system.

Timeline of K Basins Major Events and FFACO Milestones

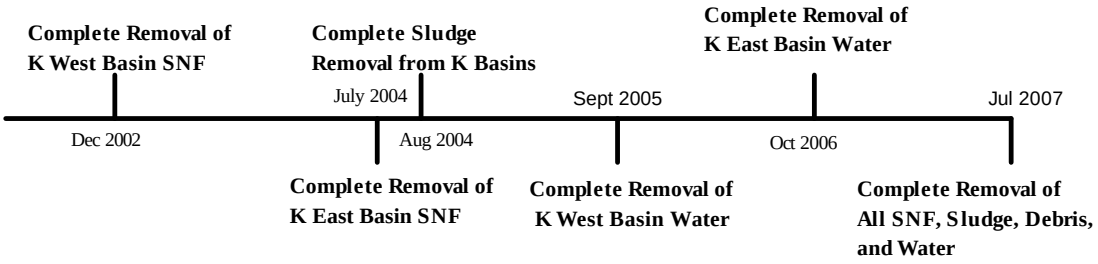
January 1994 FFACO



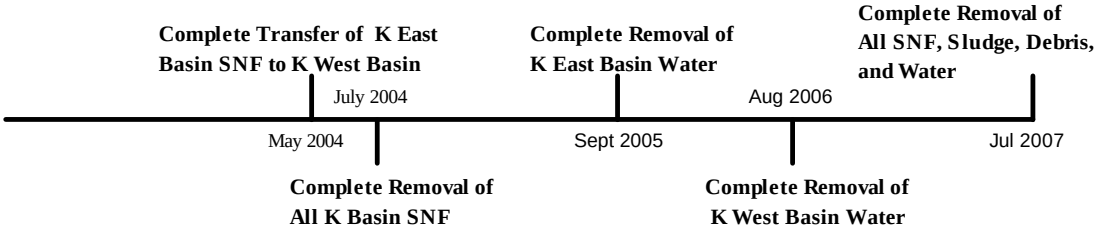
January 1999 FFACO Amendment



May 2000 FFACO Amendment



March 2001 FFACO Amendment



SNF: Spent Nuclear Fuel
DNFSB: Defense Nuclear Facilities Safety Board

Appendix B

Details on Scope and Methodology

We performed our evaluation in accordance with the *Government Auditing Standards*, issued by the Comptroller General of the United States. Fieldwork was performed between November 2001 and May 2002. The evaluation generally covered EPA Region 10's management controls in effect from January 1994 through May 2002. We also reviewed relevant oversight and enforcement records maintained by the Region from before and after that period as necessary. Our evaluation was coordinated with the DOE Office of Inspector General's audit of DOE's remediation activities for the Hanford Site's K Basins. The DOE OIG's audit was performed between April 2001 and January 2002, and a final report on the audit results was issued in April 2002 (*Completion of K Basins Milestones*, DOE/IG-0552).

We interviewed officials in EPA Region 10 's Hanford Project Office, EPA's Office of Solid Waste and Emergency Response, and the State of Washington's Department of Ecology. In addition, we interviewed officials from the State of Oregon's Office of Energy and the Yakama Indian Nation, stakeholders of the Hanford Site.

We reviewed applicable laws, regulations, and records maintained by the Region. The scope included a review of the Region's management controls associated with oversight and enforcement of: (a) FFACO milestones associated with the interim remedial action for the 100-K Area's K Basins; and (b) DOE compliance with CERCLA requirements applicable to remediation of the 100-K Area's contaminated groundwater. We obtained an understanding of management controls through inquiries, observations, and inspections of documents and records. We assessed the control environment and policies and procedures. In addition, we reviewed the Region's annual Federal Managers' Financial Integrity Act assurance letters to the Administrator for Fiscal 1999 and 2000. Management control deficiencies identified are discussed in the various chapters in this report.

FFACO Milestones for Remediation of the K Basins

We focused on FFACO milestones for removal of spent nuclear fuel, sludge, debris, and water from the K Basins. We reviewed all FFACO amendments revising major Milestone M-34-00, as well as supporting interim milestones from January 1994 to May 2002. In addition, DOE planning and justification documents submitted to the Region as support for the approved FFACO amendments were reviewed. We also selected key interim milestones to evaluate compliance with FFACO requirements, and reviewed the Region's enforcement activities and records for missed milestones.

Compliance with CERCLA Requirements

To evaluate oversight and enforcement of DOE's compliance with CERCLA remediation requirements applicable to the contaminated groundwater within the 100-K Area, we reviewed

the: (a) effectiveness of the pump-and-treat remediation system for a contaminated groundwater plume within the area; (b) effectiveness of the groundwater monitoring system for the area's reactor section; (c) process used for assessing the risks posed by the contaminated groundwater within the area; and (d) process used for determining interim remediation decisions for the area's contaminated groundwater.

Pump-and-Treat Remediation System

We reviewed the ROD for the Hanford Site's 100-HR-3 and 100-KR-4 Operable Units. We also reviewed work plans and operation documents for the 100-K Area's pump-and-treat system covering October 1997 through December 2001. In addition, sampling results for monitoring and compliance wells used to measure the effectiveness of the interim remedial action were reviewed for the same period. We also evaluated actions taken by the Region during that period to resolve compliance issues associated with the ROD requirements for the pump-and-treat remediation system.

Groundwater Monitoring System

We focused on 100-K Area groundwater monitoring data from January 1994 through December 2001. Our review included groundwater sampling data, monitoring reports, aquifer sampling reports, and monitoring plans covering the period. We also obtained a review on the adequacy of groundwater monitoring in the 100-K Area from an independent groundwater expert.

Risk Assessment Process

We evaluated the risk assessment for the 100-KR-4 Groundwater Operable Unit against EPA risk assessment guidance. We compared the risk assessment results to the results of the *Screening Assessment and Requirements for a Comprehensive Assessment, Columbia River Comprehensive Impact Assessment* to determine whether conclusions on the risks posed by the 100-K Area's groundwater were consistent. We also reviewed proposed plans, environmental reports, salmon reports, a recent risk assessment for the groundwater within the 100-N Area, and the Region's recent CERCLA Five-Year Review Report for Hanford. We obtained a review on the adequacy of DOE's risk assessments addressing the groundwater contamination within the 100-K Area from an independent groundwater expert.

Remediation Decision Process for Contaminated Groundwater

We evaluated the planned groundwater remediation for the 100-K Area and the potential need for additional interim remedial actions for tritium, strontium-90, carbon-14, nitrate, and hexavalent chromium. We obtained groundwater sampling results for the 100-K Area from HEIS and groundwater monitoring reports in order to identify contamination trends over the 8-year period from January 1994 through December 2001. Finally, a review of the need for additional interim remedial actions in the 100-K Area was obtained from an independent groundwater expert.

Agency Response

Following is the full agency response to the draft report.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue
Seattle, WA 98101
OCT 10 2002

Reply To
Attn Of: ECL-117

MEMORANDUM

SUBJECT: Response to Draft Evaluation Report 2001-000954, dated October 2, 2002

FROM: L. John Iani
Regional Administrator

TO: Michael Owen
Project Manager
EPA Office of Inspector General

Attached for your consideration is EPA Region 10's response to the above-referenced draft report. The Region appreciates the opportunity to review an earlier draft and provide comments for your consideration in developing the October 2 draft. With the exception of recommendations regarding expansion of the groundwater monitoring system in the reactor section of the 100 K Area, the Region generally concurs with the specific recommendations outlined in the Draft Evaluation Report; most are consistent with actions already taken or are consistent with ongoing oversight activities at Hanford. However, the Region continues to have concerns regarding the overall conclusions of the Report with respect to Region 10's effectiveness in overseeing Department of Energy (DOE) work at Hanford. The report does not fully acknowledge the significant work that has been accomplished in the 100 K Area since EPA assumed lead oversight agency responsibility for the K Basins in 1998.

Ultimately our success is measured by our progress in protecting public health and the environment by facilitating the implementation of effective cleanup measures across the Hanford Site. In that regard we are proud of the work that has been conducted in the 100 K Area. As of September 30, 2002, 623 metric tons of heavy metal of spent nuclear fuel have been removed from the 100 K West Basin. This represents over 30 percent of the inventory at Hanford. Removal of the fuel from the K East Basin is on schedule to begin before the end of this calendar year; this is a major step in addressing the risks posed by the K East Basin. These activities represent a significant step in reducing environmental and human health risk posed by the Hanford Site.

Addressing chromium releases to groundwater in the 100 K Area is an important element of EPA's strategy for reducing environmental risks posed by historic operations at Hanford. As of September 30, 2002, 1.5 billion liters of contaminated groundwater have been intercepted and treated before reaching the Columbia River. A major upgrade to the system was completed in May 2002. Since then the eight extraction wells have been removing about 260 gallons per minute (gpm). This pumping rate is approximately 30 percent greater than the 195 gpm rate

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recommended by DOE's consultants in 2000 and is nearly 70 percent greater than the average extraction rate from September 1997 - September 2000. As of September 30, 2002, 173 kg of chromium have been recovered and treated. Efforts to optimize the effectiveness of the system to meet Record of Decision requirements are an ongoing element of work in the 100 K Area.

In response to Office of Inspector General (OIG) concerns about the adequacy of information available to make determinations regarding interim remedial actions in the reactor section of the 100 K Area, the Region believes that the decision not to require an interim action for carbon-14 and hexavalent chromium was based on adequate information. However, on October 4, 2002, EPA received a transmittal from the Department of Energy that outlines a groundwater monitoring and assessment plan for the 100 K Area fuel storage basin. EPA will review this document, with the assistance of the U.S. Geological Survey, to determine if modified monitoring in the area is necessary to support future remediation decisions in the 100 K Area reactor section.

Specific comments on the Draft Evaluation Report Recommendations are attached to this memorandum. After review of those comments, the OIG is encouraged to contact Nick Ceto, Program Manager for the Hanford Project Office, at 509-376-9529, if there are any questions regarding the Region 10 response.

Attachment

EPA Region 10 Response to IG Recommendations in the Draft Evaluation Report 2001-000954, dated October 2, 2002

Executive Summary Recommendation:

The Inspector General (IG) recommended EPA monitor DOE's efforts to successfully complete remediation requirements for the K Basins and take action as appropriate under the Federal Facility Agreement and Consent Order (FFACO) if requirements are not met.

Region Response:

The region concurs. Region 10 participates in bi-weekly meetings with DOE and the Defense Nuclear Facility Safety Board as part of EPA's oversight responsibilities at Hanford. Each quarter the K Basins project is discussed with DOE management and the State. The EPA also monitors progress through regular contacts with DOE, including Tri-Party Agreement milestone status review meetings, site inspections, and multi-agency project manager meetings. Progress on remediation requirements will continue to be tracked through these mechanisms. The EPA expects that milestones will be met unless a timely request for an extension or change is received and good cause exists for the requested change or extension (see FFACO Article XL, "Good Cause for Extensions"and Section 12 of the Action Plan, "Changes to the Agreement").

Executive Summary Recommendation:

The IG recommended EPA evaluate performance of the upgraded pump-and-treat system to determine if it will achieve the remedial action objectives and if necessary pursue timely and formal followup on problems.

Region Response:

The Region concurs. The EPA directed DOE to upgrade the pump-and-treat system, and that upgraded system went on-line in May 2002. EPA will continue to review monitoring and performance reports to assess system effectiveness in meeting remedial action objectives and to require modifications as appropriate.

Executive Summary Recommendation:

The IG recommended EPA require a formal assessment on the need for an interim remedial action in the area's reactor section.

Region Response:

The Region concurs with this recommendation with comments. The Region believes that a formal assessment of the need for an interim action in the area's reactor section has been conducted. Formal assessments have been conducted in the reactor area and have indicated that contaminated soil, pipelines, and the K Basins pose a risk to groundwater

and meet the criteria in the FFACO for interim remedial actions. The interim action for the K Basins has been removing waste for several years; the interim action for soil and pipelines begins next month. The formal assessments determined that groundwater within the reactor area did not meet the criteria for an interim remedial action. The Region proposes to develop, in conjunction with DOE, a technical memorandum to the file that clearly documents the rationale for not requiring an interim action in the reactor area, referencing previously issued documents as appropriate.

Executive Summary Recommendation:

The IG recommended that EPA have DOE improve its groundwater monitoring system.

Region Response:

The Region does not concur with the recommendation. The Region does not believe that it is appropriate to recommend the specific changes in the groundwater monitoring system outlined in the draft IG report at this time. However, on October 4, 2002, EPA received a groundwater monitoring and assessment plan for the 100 K Area fuel storage basins that will be reviewed by EPA and the U.S. Geologic Survey to determine if modifications in the groundwater monitoring system are needed for an evaluation of remedial action effectiveness, or to further refine implementation strategies for ongoing remedial actions.

Executive Summary Recommendation:

The IG noted that enforcement actions should be pursued as appropriate.

Region Response:

The Region concurs. Enforcement will be conducted in accordance with the FFACO, including Article XX "Stipulated Penalties."

IG Recommendation 2-1:

Monitor progress of DOE toward meeting K Basins milestones, including M-34-17, to initiate removal of K East Basin spent nuclear fuel, M-34-08, to initiate full scale K East Basin sludge removal, and M-34-18A, to remove 190 multi-canister overpacks. Reaffirm EPA's expectation that milestones will be met unless a timely request for an extension or change is received and good cause exists for the request as defined by the FFACO. In addition:

a) Place priority on remediating the K East Basin, focusing on removing spent nuclear fuel, sludge, debris, and water.

b) If DOE does not complete the K Basins milestones in a timely manner, the Region should respond, consistent with FFACO enforcement provisions, including penalties, to ensure the work is completed as expeditiously as possible.

Region Response:

The Region concurs. The IG recommendations reflect the Region's approach to management of K Basin performance. Removal of fuel from the K East Basin is expected to begin in November 2002. EPA will closely track progress during formal Tri-Party Agreement (TPA) milestone meetings, as well as field visits and regular status briefings with DOE project managers. Note that milestone M-34-18A is to remove spent nuclear fuel equivalent to 957 metric tons of heavy metal, not 190 multi-canister overpacks.

IG Recommendation 2-2:

Prior to approval by the Region, ensure that any necessary amendments to the FFACO that revise remediation requirements and/or the remediation schedule for the 100-K Area including the K Basins:

a. Are supported with performance and planning information that provide the Region with reasonable assurance that the revised requirements and schedule are necessary, achievable, and reduce risks to human health and the environment as expeditiously as possible.

b. Include enforceable interim milestones and due dates that enable the Region to more timely resolve insufficient remediation progress by DOE through enforcement actions.

IG Recommendation 2-3:

Require formal followup actions in response to missed target milestone due dates by DOE. These followup actions should establish the Region's expectations on resolving performance issues.

Region Response:

The Region concurs with these recommendations. The EPA does not anticipate receiving any milestone change packages from DOE in the near term. The DOE has been providing via formal letter to EPA an explanation for missed target dates, an analysis of impacts to the project, and a plan for resolution of the performance issue. Recent TPA milestone status briefings indicate that milestone M-34-17 is on schedule to be completed by November 30, 2002. Milestones M-34-08 and M-34-18A, scheduled to be completed on December 31, 2002, are anticipated to be completed in February 2003.

IG Recommendation 3-1:

Evaluate the performance of the upgraded 100-K Area pump-and-treat system that went on-line in May 2002 to determine if it achieves the remedial action objectives of the ROD. If remedial action objectives are not being met, pursue timely and formal followup and/or enforcement actions that include specific corrections, actions, and deadlines to ensure that:

a. Pump-and-treat system downtime is minimized and the composite withdrawal rate for extraction wells is maintained at a rate that maximizes the system's effectiveness with capturing and remediating the contaminated groundwater.

b. Any future upgrades to the pump-and-treat system that are necessary for achieving the ROD's cleanup standard are completed by specific enforceable due dates.

c. DOE evaluates remediation alternatives to the pump-and-treat system if hexavalent chromium levels in compliance wells do not meet the ROD's cleanup standard by the end of Fiscal 2003.

Region Response:

The Region concurs with this recommendation. EPA has been monitoring the performance of the pump and treat system since the earliest days of operation. The May 2002 modifications to the system reflect the most recent efforts to enhance system performance. Since the expansion of May 2002, the system has been operating nearly continuously at about 260 gallons per minute. If future upgrades to the system are necessary, the EPA will pursue specific enforceable dates for their completion. Regarding item "c," DOE, the State, and EPA continue to evaluate alternatives to the pump-and-treat system. The 1996 Record of Decision for 100-KR-4 included "evaluation of other technologies" in the remedial action objectives. The EPA has made this an ongoing part of the interim remedial action rather than an activity to commence by the end of fiscal year 2003. Remedial action objectives have yet to be achieved in monitoring wells downgradient of the groundwater recover and treatment system and the groundwater being recovered continues to have high levels of chromium. This system will continue to be operated by DOE to recover chromium in the groundwater system and protect the Columbia River. EPA plans to ask the U.S. Geological Survey to review system performance and to recommend any operational changes that may be appropriate to facilitate achievement of remedial action objectives.

IG Recommendation 4-1:

Require DOE to conduct a formal assessment to determine whether an interim remedial action for removal of carbon-14 and/or hexavalent chromium within the reactor section of the 100-K Area is necessary for protection of the Columbia River's ecosystem. Ensure that the assessment is based on groundwater monitoring data that sufficiently identifies the current ecological risks posed by the contaminated groundwater.

Region Response:

The Region concurs with this recommendation, with comments. The Region believes that a formal assessment of the need for an interim action in the area's reactor section has been conducted. Formal assessments have been conducted in the reactor area and have indicated that contaminated soil, pipelines, and the K Basins pose a risk to groundwater and meet the criteria in the FFACO for interim remedial actions. The interim action for the K Basins has been removing waste for several years, and the interim action for soil and pipelines begins next month. The formal assessments for groundwater documented that groundwater did not meet the criteria for interim remedial action. The Region proposes to develop, in conjunction with DOE, a technical memorandum to the file which clearly documents the rationale for not requiring an interim action in the reactor area, referencing previously issued documents as appropriate (including those documenting ecological risk).

IG Recommendation 4-2:

Require DOE to continue to monitor for carbon-14 and hexavalent chromium in the 100-K Area groundwater to determine if expansion of the pump-and-treat system for chromium is necessary in the interim to protect the Columbia River.

Region Response:

The Region concurs with this recommendation. Monitoring these contaminants has been included in the groundwater monitoring network for many years and will continue to be included. Results will be evaluated at least annually with DOE as part of annual program reviews. Any significant change in conditions would be considered in determining whether expansion of the pump and treat interim action were appropriate.

IG Recommendation 4-3:

Require DOE to improve the groundwater monitoring system for the reactor section of the 100-K Area. Consider including as part of the system:

a. Additional aquifer sampling tubes along the Columbia River, such as an aquifer sampling tube every 100 meters.

b. Additional groundwater monitoring wells if sampling results from the additional aquifer tubes show that the monitoring wells are necessary for characterizing and assessing the current ecological risks posed by the groundwater plumes within the reactor section.

c. A sampling frequency of at least semiannually for all groundwater monitoring wells within the reactor section for hexavalent chromium and carbon-14.

d. A sampling frequency of at least annually for the aquifer sampling tubes and the riverbank seepage sample point within the reactor section for hexavalent chromium and carbon-14.

Region Response:

The Region does not concur with the recommendation. The Region does not believe that it is appropriate to recommend the specific changes in the groundwater monitoring system outlined in the draft IG report at this time. However, on October 4, 2002, EPA received a groundwater monitoring and assessment plan for the 100 K Area fuel storage basins that will be reviewed by EPA and the U.S. Geologic Survey to determine if modifications in the groundwater monitoring system are needed for an evaluation of remedial action effectiveness, or to further refine implementation strategies for ongoing remedial actions.

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