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Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

Groundwater Monitoring and Assessment Plan for the 100-K Area Fuel Storage Basins

R. E. Peterson

September 2002

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RL01830

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Summary

The 100-K Fuel Storage Basins (K Basins) contain irradiated nuclear fuel from past operations at the N Reactor. The fuel is in the process of being removed, stabilized, and transported to a Central Plateau location for interim storage under the Spent Nuclear Fuels Project. The various remediation activities and schedule associated with the K Basins are described in Tri-Party Agreement Milestone M-34-00. Groundwater monitoring and impact assessment are conducted as a task within the Hanford Groundwater Monitoring Project, which is managed by Pacific Northwest National Laboratory. The regulatory driver for this task is DOE Order 5400.1, which implements requirements of the Atomic Energy Act of 1954 with respect to environmental monitoring.

This document updates an existing groundwater monitoring and assessment plan for the K Basins to reflect current conditions and revises the monitoring strategy to reflect changing information needs. The goals and purpose associated with this updated plan are:

- Characterize groundwater conditions between the K Basins and the Columbia River—to provide a periodic status of current conditions and the attenuation of plumes.

- Distinguish between groundwater contamination associated with K Basins and contamination from other past-practices sources—to help guide operational and remedial action decisions.

- Maintain a strategy for the potential expansion of monitoring capabilities—to respond to future basin-related issues.

The principal elements of the revised strategy include characterizing groundwater movement, monitoring groundwater quality characteristics, identifying evidence for basin shielding water leakage, evaluation and interpretation of results, potential expansion of monitoring location coverage, and earthquake seismicity monitoring. Specific objectives are included in this plan for each of these elements.

Primary changes to the sampling and analysis schedule involve increases to the number of wells monitored, addition of several key indicator constituents, and a decrease in frequency of sampling for wells adjacent to each basin. Sampling is now conducted on a quarterly or semiannual basis, depending on well location. Monitoring locations near the river have been added to the schedule; these locations are sampled annually and include riverbank seepage sites and aquifer sampling tubes.

Data evaluation, interpretation, and reporting subtasks continue as in previous years. A biweekly review of all new analytical results for the 100-K Area is performed. The Hanford Groundwater Monitoring Project provides quarterly interpretive reports via electronic mail to personnel at the Spent Nuclear Fuels Project and the U.S. Department of Energy. A comprehensive description of groundwater conditions is prepared annually as part of the Hanford Groundwater Monitoring Project's fiscal year report.

Acronyms

CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
DaVE	Data Viewer and Evaluator (user interface to HEIS)
DOE/RL	U.S. Department of Energy, Richland Operations, Washington
EPA	U.S. Environmental Protection Agency
FY	Fiscal Year (October 1 to September 30)
HEIS	Hanford Environmental Information System
PNNL	Pacific Northwest National Laboratory
QA/QC	Quality Assurance/Quality Control
RCRA	*Resource Conservation and Recovery Act*
RDR	Request for Data Review

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1.0 Introduction

The Spent Nuclear Fuels Project represents a challenging and expensive cleanup activity for the Hanford Site. The concrete basins that contain the irradiated nuclear fuel are located in the 100-K Area, in the northern portion of the Hanford Site (Figure 1.1). These two basins, each containing 4.9 million liters (1.3 million gallons) of highly radioactive shielding water, are located within 400 meters (1,312 feet) of the Columbia River.

Because of the potential impact to groundwater and the river in the event of a catastrophic loss of shielding water, groundwater monitoring and impact assessment are integral parts of the project. An understanding of the direction and rate of groundwater movement beneath the basins is essential for predicting the movement of current and future potential contaminants in groundwater toward the river. Knowing the chemical and radiological characteristics of the underlying groundwater provides information on the sources of contaminants, and also whether various water quality standards (e.g., maximum contaminant level for drinking water supplies) are being met. This information establishes a technical basis for decisions involving basin operations, fuel removal, facility decontamination, response to off-normal events, and environmental restoration.

This groundwater monitoring plan presents a strategy for (a) sampling and analysis, (b) data interpretation, and (c) reporting of conditions related to the subsurface environment in the vicinity of the KE and LW Fuel Storage Basins (K Basins).

1.1 Background

Fuel storage basins are integral parts of the KE and KW Reactor buildings. They were originally used to temporarily store irradiated fuel from the K Reactors prior to transport to the Central Plateau and chemical separations plants. The basins are currently used to store irradiated fuel produced by the final operation of the N Reactor. Some miscellaneous fuel debris resulting from the recent cleanup of storage basins at other reactor areas also is currently stored in K Basins. Removal of the fuel from the K Basins, processing to make the fuel less reactive, and interim storage at a Central Plateau location, are a high priority of the Hanford Site cleanup (EPA 1999a). Removal of fuel elements began in December 2000 and is planned for completion by 2004. Removal of shielding water, sludge, and debris will continue to 2007, followed by "cocooning" of each reactor complex (TPA Milestone M-34-00; Ecology et al. 1998).

Radionuclides have contaminated the shielding water in each fuel storage basin, with the KE Basin being the more contaminated of the two. Groundwater monitoring is underway near each basin to assess the consequences of past and potential future leakage on groundwater quality and to support leak detection efforts. This document presents an updated strategy for groundwater monitoring and characterization activities; the plan builds on experience gained under previous monitoring schedules. The list of wells, frequency of sampling, and suite of analyses have all been modified from the original monitoring plan (Johnson et al. 1995).

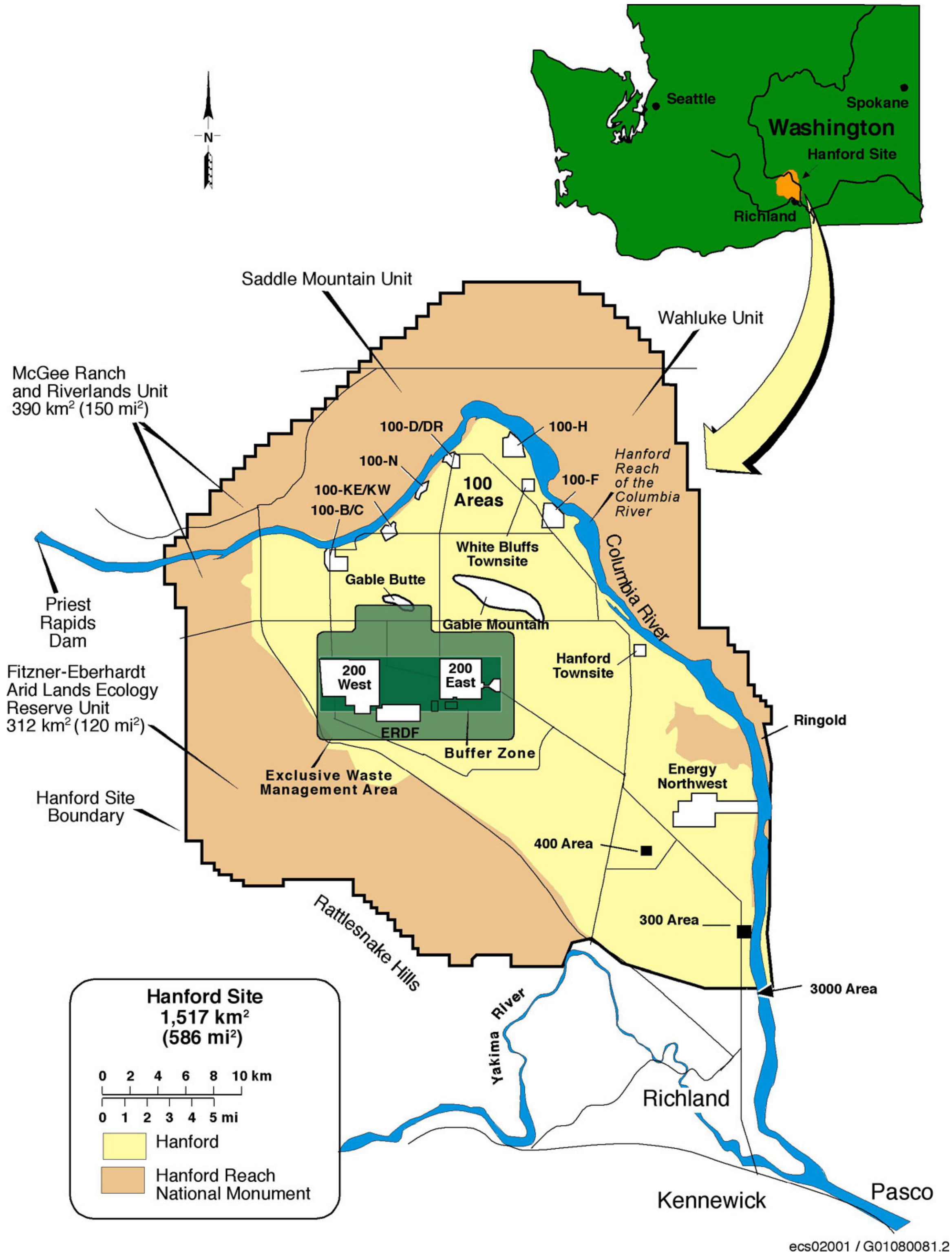


Figure 1.1. Area Map for the Hanford Site

An aerial photograph of the 100-K Area during the operating years is shown in Figure 1.2 and an index map is provided in Figure 1.3. The fuel storage basins are located within each of the reactor buildings on the side facing the Columbia River. Many of the other facilities visible in Figure 1.2 have been removed during decontamination and decommissioning activities. However, several past-practices waste sites are located near the K Basins. These include the reactor atmosphere gas condensate cribs located at the east side of each reactor building, the fuel storage basin drain fields/injection wells located at the northwest corner of each reactor building, and miscellaneous liquid waste sites such as septic systems and small cribs associated with lab facilities (see Figure 1.3). The 100-K Burial Ground, located to the east of the KE Reactor, has recently been implicated as a waste site that possibly is contributing tritium to the underlying groundwater. Because of uncertainty in the source for tritium in groundwater at well 199-K-111A located near the burial ground, this facility will be included with the other nearby waste sites for the purposes of this plan.

Figure 1.2. Aerial Photo of the 100-K Area During Operations (1965)

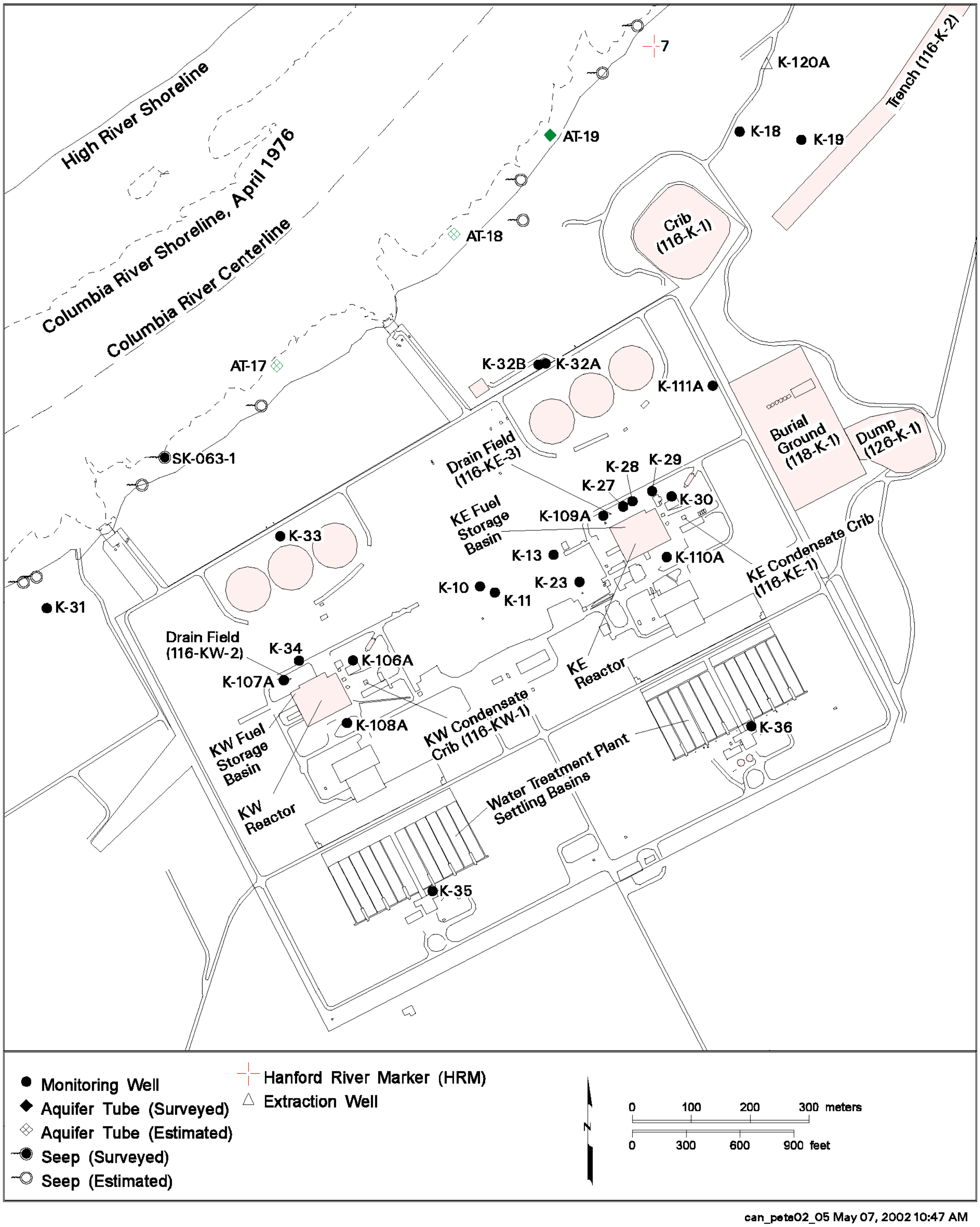


Figure 1.3. 100-K Area Facilities, Waste Sites, and Monitoring Sites

Information on historical operations of the K Basins are nearby waste sites is summarized in Chapter 4 of this document. More detailed information on reactor operations and waste sites in the 100-K Area is provided in a technical baseline report prepared for the Environmental Restoration program (Carpenter and Coté 1994). A description of reactor design and operations can be found in an operations report prepared by General Electric Company (HAPO 1963).

The hydrologic setting and current distribution of contaminants in groundwater are described in Chapter 5. Additional updated information on groundwater beneath the 100-K Area is presented annually in the Hanford Groundwater Monitoring Project annual report (e.g., Peterson and McMahon 2002).

Groundwater monitoring is conducted at the 100-K Area to meet objectives associated with multiple regulatory drivers. These include a) K Basins Interim Remedial Action under the Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA], b) Environmental Restoration Program operable unit activities under CERCLA (100-KR-2 and 100-KR-4), and c) sitewide environmental surveillance associated with the Atomic Energy Act of 1954. Sampling and analysis schedules for all these projects are coordinated through the Hanford Groundwater Monitoring Project by Pacific Northwest National Laboratory (PNNL) to provide efficient and cost-effective use of field and laboratory resources. A report that shows the integration of groundwater monitoring activities is prepared annually (e.g., Hartman et al. 2001).

1.2 Monitoring Project Goals

The goals and their purpose for the K Basins groundwater monitoring task were contained in the initial groundwater monitoring and assessment plan for this facility (Johnson et al. 1995). They are restated in this updated monitoring plan with minor changes, although their basic intent remains essentially the same:

- Characterize groundwater conditions between the K Basins and the Columbia River—to provide a periodic status of current conditions and the attenuation of plumes.

- Distinguish between groundwater contamination associated with K Basins and contamination from other past-practices sources—to help guide operational and remedial action decisions.

- Maintain a strategy for the potential expansion of monitoring capabilities—to respond to future basin-related issues.

Achieving these goals will provide information that is relevant to operational decisions at the K Basins, which might include a need to anticipate the environmental consequences of future hypothetical loss of shielding water. The groundwater quality data and new interpretations of contaminant movement in the area will also contribute to the technical basis for a future record-of-decision (ROD) for groundwater remedial action.

Specific data collection and interpretation objectives to attain these goals are described in Chapter 2. Implementation of the strategy is presented in Chapter 3.

1.3 Regulatory Basis

The activities described in this plan will facilitate compliance with the U.S. Department of Energy's (DOE) requirements for groundwater protection and monitoring at DOE facilities. DOE Order 5400.1 lists the following required activities (quoted verbatim), which are considered drivers for the K Basins' monitoring strategy:

- Obtain data for determining baseline conditions of groundwater quality and quantity.
- Demonstrate compliance with and implementation of all applicable regulations and DOE Orders.
- Provide data to allow early detection of groundwater pollution or contamination.
- Identify existing and potential sources for groundwater contamination and maintain surveillance of these sources.
- Provide a reporting mechanism for detected groundwater pollution or contamination.
- Provide data to support decisions concerning land-disposal practices, and the protection and management of groundwater resources.

Implementation of DOE Order 5400.1 is described in *Environmental Monitoring Plan, United States Department of Energy, Richland Operations Office* (DOE/RL 2000). The Environmental Monitoring Plan is revised every three years. This document provides a comprehensive description of activities related to (1) effluent monitoring and (2) environmental surveillance, and also summarizes drivers and regulatory requirements for monitoring. Additional detailed description of regulatory compliance can be found in the most recent version of the *Hanford Site Environmental Report* (Poston et al. 2001).

1.4 Previous Monitoring Plans and Assessment Reports

This plan supercedes a monitoring plan that was prepared earlier to support groundwater data collection activities associated with the K Basins (Johnson et al. 1995). The earlier plan included a comprehensive description of fuel storage basin issues and the outcome of the EPA Data Quality Objectives process that was followed to develop the plan. The data quality objectives as described in the earlier plan are still valid for current data collection efforts.

Groundwater monitoring plans for other 100-K Area projects, key groundwater assessment reports for the 100-K Area, and key reports involving the Spent Nuclear Fuels Project include:

Monitoring Plans and Schedules

Groundwater Monitoring and Assessment Plan for the K Basins (Johnson et al. 1995)

Facility Effluent Monitoring Plan for K Area Spent Fuel Storage Basin (Hunacek 2000)

Modifications to the Groundwater Sampling and Analysis Schedules for the 100-KR-4 Operable Unit Groundwater Sampling Project. Tri-Party Agreement National Priorities List Change Control Form No. 108, Appendix E (TPA 1996)

Groundwater Monitoring Implementation Plan for the 100-BC-5, 100-KR-4, 100-HR-3, and 100-FR-3 Operable Units, Hanford Site (Peterson and Raidl 1996)

Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units (DOE/RL 1997)

Key Groundwater Assessment Reports

Limited Field Investigation Report for the 100-KR-4 Operable Unit (DOE/RL 1994)

Groundwater Monitoring Results for the 100-K Area Fuel Storage Basins: January 1 to March 31, 1994 (Peterson 1994)

Groundwater Monitoring Results for the 100-K Area Fuel Storage Basins: March to December 1994 (Johnson and Chou 1995)

Groundwater Monitoring Results for the 100-K Area Fuel Storage Basins: January to June, 1995 (Johnson and Evelo 1995)

Conceptual Site Models for Groundwater Contamination at 100-BC-5, 100-KR-4, 100-HR-3, and 100-FR-3 Operable Units, Hanford Site (Peterson et al. 1996)

Groundwater Monitoring for the 100-K Area Fuel Storage Basins: July 1996 Through April 1998 (Johnson et al. 1998)

Annual reports prepared by the Hanford Groundwater Monitoring Project (e.g., Peterson and McMahon 2002)

Key Reports Associated with the Spent Nuclear Fuels Project

K Basins Environmental Impact Statement Technical Input (Bergsman et al. 1995)

Management of Spent Nuclear Fuel from the K Basins at the Hanford Site, Richland, Washington. Draft Environmental Impact Statement (DOE/RL 1995)

Management of Spent Nuclear Fuel from the K Basins at the Hanford Site, Richland, Washington. Addendum: Final Environmental Impact Statement (DOE/RL 1996)

Focused Feasibility Study for the K Basins Interim Remedial Action (DOE/RL 1999a)
Proposed Plan for the K Basins Interim Remedial Action (DOE/RL 1999b)

Alternate Fuel Transfer for the 105-KE Basin Spent Nuclear Fuel, 100-K Area, Hanford Site, Richland, Washington. Supplemental Analysis to the Final Environmental Impact Statement (DOE/RL 2001)

Record of Decision for the USDOE Hanford 100-KR-2 Operable Unit K Basins Interim Remedial Action (EPA 1999a)

2.0 Monitoring and Characterization

This Chapter provides a description of the various groundwater monitoring and characterization activities that have been defined to achieve the goals stated in Chapter 1.0. Each activity description includes a statement of objectives and a discussion of the strategy to accomplish the objective. The information in this Chapter offers a technical argument for the detailed sampling schedules, analytical procedures, and evaluation activities listed in Chapter 3.0.

The principal region of interest is the groundwater flow field beneath the KE and KW Reactor complexes; the region extends to the Columbia River. Additional background information on the facilities and waste sites that are potential sources for groundwater contamination, and on the geohydrologic setting, is provided in Chapters 4.0 and 5.0, respectively.

2.1 Groundwater Movement

Objective: Describe the direction, rate, and variability of groundwater flow between the K Basins and the Columbia River.

This objective will be met by obtaining periodic measurements of water-table elevation. Measurements will be obtained during each sampling event and during an annual survey conducted to prepare an updated water-table map. Water-table elevation data will be used to characterize the orientation, magnitude, and seasonal variability of hydraulic gradients in the groundwater flow field that contains the K Basins. Elevation data from various locations will be analyzed using trend-surface analysis to provide gradient direction and steepness, as required to meet information needs.

Additional capabilities to observe water-table variability are available and will be deployed if contaminant conditions warrant other than routine information on direction and rate of groundwater movement. Pressure transducers and specific conductance probes are available for installation in wells to provide more frequent data than planned under routine monitoring, as needed. An in situ borehole flow meter is available for spot measurements of water movement through a monitoring well and to characterize the vertical distribution of movement through the well's open interval.

Where characteristic constituent trends can be positively tracked from one well to a downgradient well, plume transport rate estimates will be determined. For example, monitoring data show that the tritium plume created by the 1993 leakage from the KE Basin has arrived at downgradient well 199-K-32A, suggesting an approximate 6-year travel time (see Section 5.3). If this pathway is consistent to the river, a total travel time of 10 to 12 years to the Columbia River is indicated for the arrival of the most mobile constituents from leakage of KE Basin shielding water (i.e., tritium and technetium-99). Travel times for radionuclides that are adsorbed onto solids in the vadose zone and aquifer (e.g., cesium-137, plutonium-239/240, and strontium-90) are considerably longer. Plume travel times between the KW Basin and the river appear to be shorter than travel time associated with the KE Basin (see Section 5.3).

2.2 Groundwater Quality

Objective: Obtain data on basic water quality parameters and contamination indicators that are characteristic of basin shielding water and effluents disposed to nearby waste sites.

Objective: Identify radiological and/or chemical signatures for plumes originating at various contaminant source locations.

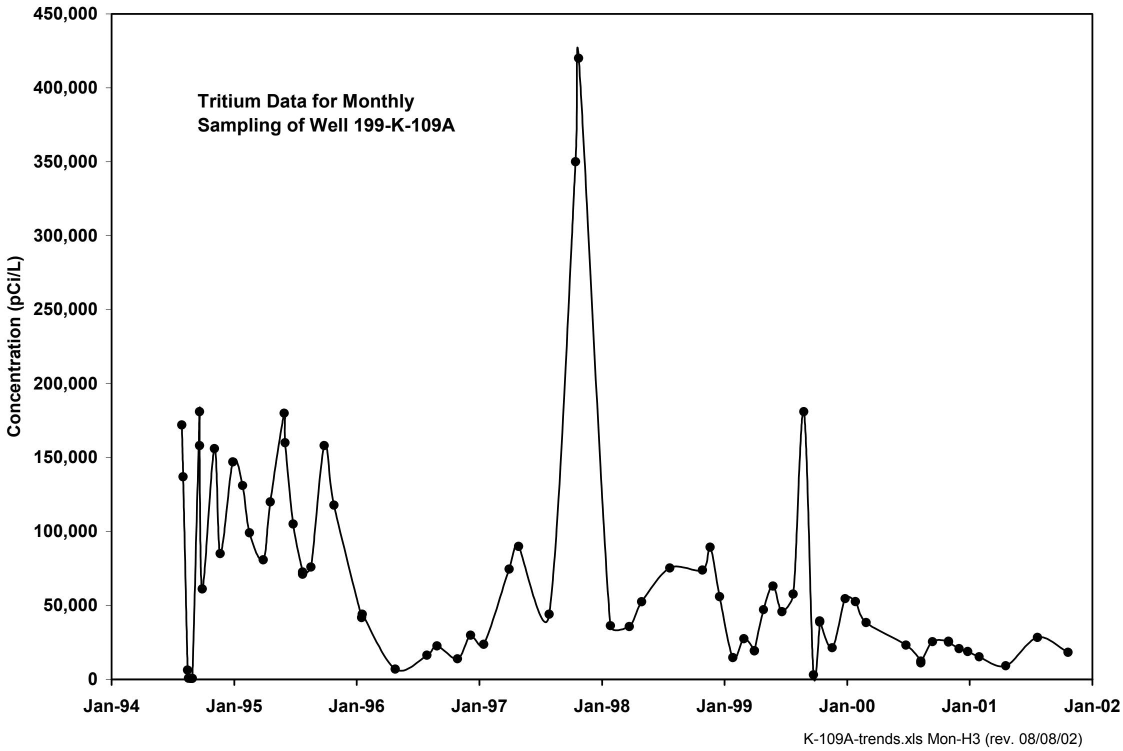
The K Basins task will maintain a baseline schedule for collecting field data that is designed to support all objectives under this monitoring plan. During routine basin operations, this allows the project to optimize the sampling frequency and number of wells involved to meet variable information needs as they arise. In the event of non-routine occurrences, such as unexpected loss of shielding water, the schedule can be modified to provide additional data appropriate for the occurrence. Field sampling facilities/locations available include monitoring wells, aquifer tubes located along the rivershore, river-bank seepage, and near-shore river water. The required level-of-effort will be revisited annually as part of the detailed work plan prepared for the fiscal year.

The frequency of baseline monitoring will be primarily quarterly. Several wells will be sampled less frequently (i.e., semiannual events) to provide supplementary information on upgradient and distant downgradient conditions. A quarterly frequency is deemed sufficient to identify significant changes in contaminant plume characteristics that are brought on by seasonal variability in water-table elevation and river discharge. Review of historical data collected at monthly intervals supports the contention that while some details on variability are lost, major changes are not overlooked. Figures 2.1 and 2.2 provide examples of the level of detail provided by monthly and quarterly sampling schedules at well 199-K-109A, which is located near the KE Basin and its former drain field.

The baseline analysis will include anions, metals, gross alpha/beta, and tritium, along with field parameters measured at the time of sampling (temperature, pH, specific conductance, turbidity, and depth-to-water). Data for these constituents provide basic information on water quality that is used to determine the cause for changes in trends when they occur. Tritium is used as a primary, though not unique, indicator for basin shielding water.

Analyses for additional constituents that are associated with specific contaminant sources will be included for samples from some wells. Information to date suggests that plumes from the various sources contain at least some unique indicators. Examples are technetium-99 along the flow path downgradient of the fuel storage basins; carbon-14 at wells downgradient from the KE and KW Condensate Cribs; and strontium-90 at wells near the fuel storage basin drain fields. These data will be used to help distinguish among the various sources for the relatively widespread tritium plume.

In addition to collecting samples from monitoring wells, samples will be collected annually from aquifer sampling tubes located near the Columbia River. These small diameter polyethylene tubes are implanted in the aquifer at multiple depths near the low river stage shoreline (Peterson et al. 1998). Data from these tubes represent groundwater quality at a location close to the area of discharge into the river.



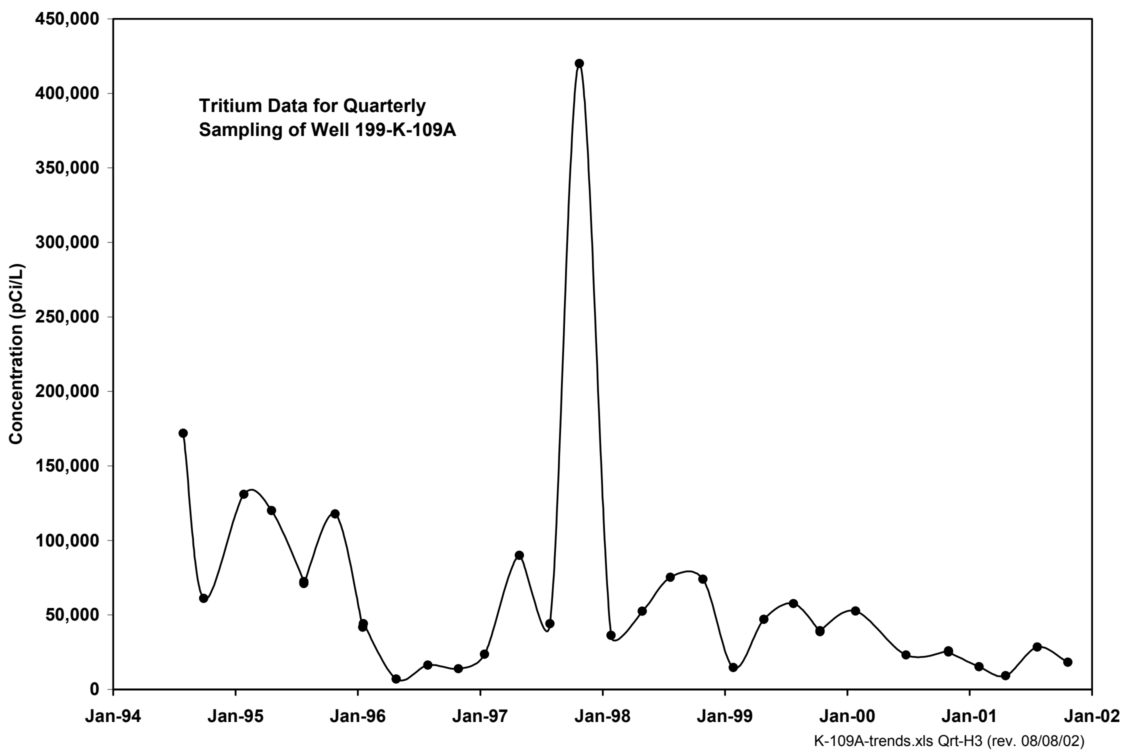
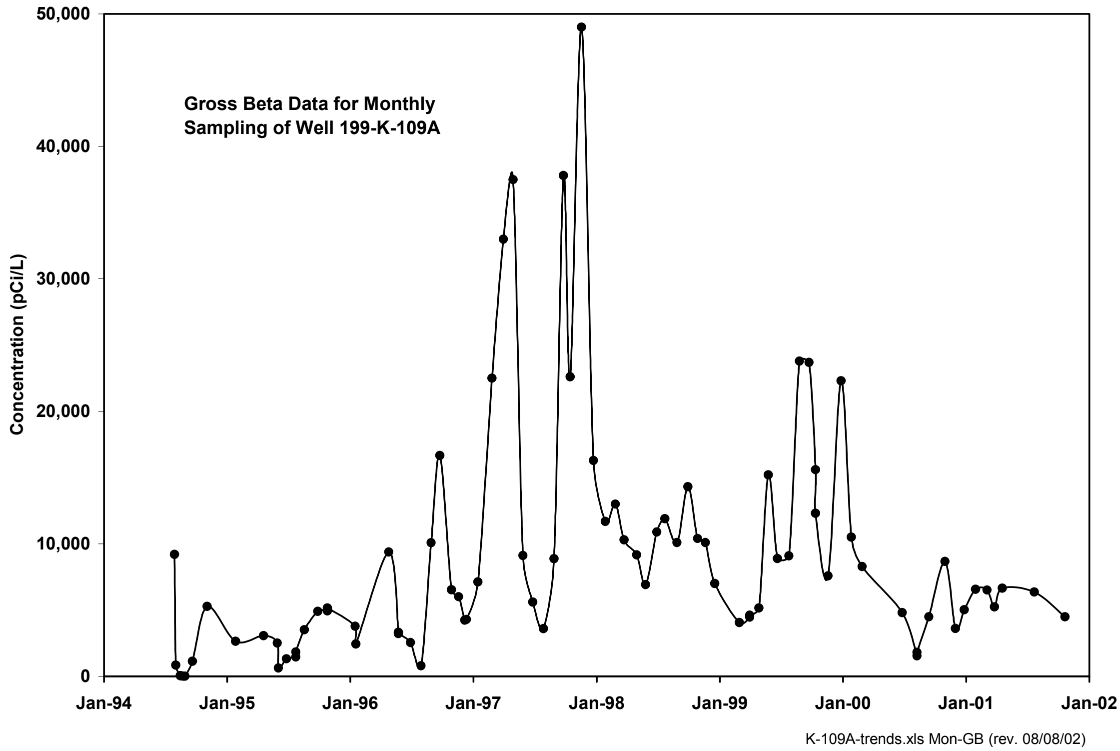


Figure 2.1. Comparison of Monthly Versus Quarterly Sampling Frequencies for Tritium



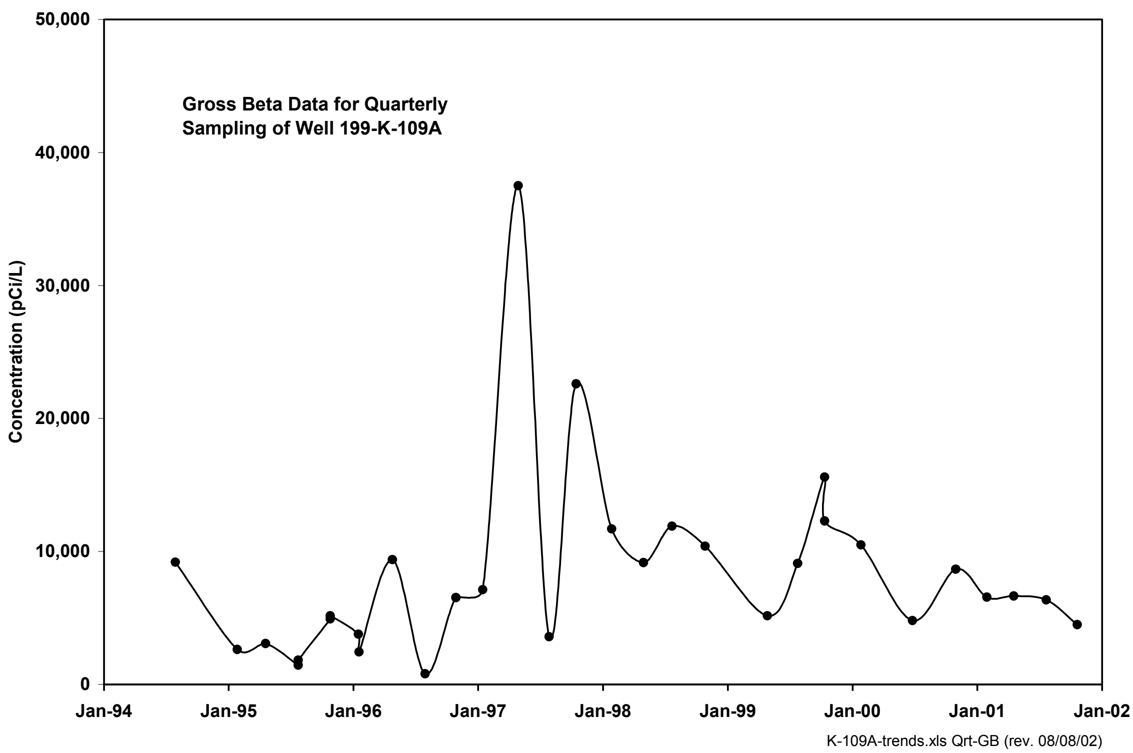


Figure 2.2. Comparison of Monthly Versus Quarterly Sampling Frequencies for Gross Beta

Water samples also will be obtained from riverbank seepage, which is typically comprised of return flow of river water that has infiltrated the banks during high river stage and groundwater approaching the river via the aquifer. Riverbank seepage represents a potential human and ecological exposure pathway. Because aquifer tubes and riverbank seepage are sampled by other projects (e.g., Bisping 2001), field activities will be coordinated through those projects. Analyses to be conducted on aquifer tube samples and riverbank seepage samples will typically include the baseline analyses described above for samples from monitoring wells.

2.3 Basin Leakage

> **Objective:** Detect changes in groundwater for basin shielding water indicators that would signify renewed leakage from the KE Basin or new leakage from the KW Basin.

Shielding water loss from either fuel storage basin is likely to be first be identified by monitoring activities associated with basin operations. Because of the time involved in transport though the vadose zone and aquifer, changes in water quality detected at the nearest monitoring well could occur months following leakage from a basin, although this is highly dependent on the location of leakage within the basin where leakage occurs. A brief summary of the shielding water monitoring strategy followed by the operations at the K Basins is included here to provide a more complete picture of leak detection capabilities for the Spent Nuclear Fuels Project.

2.3.1 Basin Shielding Water Monitoring

Several indications of basin shielding water loss are available to provide an earlier warning of leakage than is possible from groundwater monitoring. These include

- drop in basin water level that cannot be attributed to evaporation or operations
- change in rate of makeup water supply to maintain basin water levels
- change in rate of liquid accumulation in sumps associated with basin drainage and sub-basin moisture collection systems.

Procedures to calculate the rate of shielding water loss for the basins are described in Spent Nuclear Fuels Project technical procedures.[1] Current requirements call for performing a water loss rate calculation at least once per 92 calendar days. Key parameters in the calculation are basin water level changes and water temperature. Some water loss is expected because of evaporation, which is dependent primarily on water temperature and atmospheric conditions. Historical measurements indicate that evaporation accounts for loss in the range of negligible amounts up to 114 liters (30 gallons) per hour,

[1] CP-07-003. *K Basin Water Loss Rate Calculation*. Internal technical procedures, Spent Nuclear Fuels Project, Fluor Hanford, Inc., Richland, Washington.

when basin temperatures are highest.[2] Basin water levels and sump accumulations are reviewed daily as part of routine shift operations. If levels are outside of specified limits, a further assessment of the cause is initiated.[3]

Methods to detect leaks of basin shielding water are described in Spent Nuclear Fuel Operations Procedures.[4] Typical leakage scenarios include loss of containment caused by (a) an earthquake, (b) dropping a multi-canister overpack and rupturing the concrete flooring, and (c) breaking a basin floor drain valve. Methods and equipment to stop leakage, once it is located, are also described in the procedure. They include initial application of bentonite pellets, canvas breach plugs, sandbags, and concrete/grout mixtures.

Response to loss of basin shielding water is also described in Spent Nuclear Fuel Operations Procedures.[5] Symptoms of water loss as listed in that procedure include (a) basin low water level alarms, (b) increasing radiation levels in the area, (c) sump high water level alarms, and (d) increasing water levels in construction joint test wells.

The radiological characteristics of the shielding water in each basin are periodically monitored by the Spent Nuclear Fuels Project. Analyses are conducted for americium-241, antimony-125, cerium-144, cesium-137, cobalt-60, europium-152, europium-154, europium-155, niobium-94, plutonium-238, plutonium-239/240, ruthenium-103, strontium-90, tin-113, tritium, uranium-234, uranium-235, uranium-238, zinc-65, and gross alpha/gross beta. A summary of shielding water characteristics is presented in Section 4.1.3.

2.3.2 Groundwater Monitoring for Indications of Leakage

In the event that water loss beyond that expected for evaporation is indicated, the monitoring well sampling and analysis schedule will be revised to provide more detailed information on the impact to groundwater conditions. The response will be tailored to the specific basin involved and to the location of the suspected leak within the basin. The most mobile and easily identifiable indicator of shielding water is tritium (half-life 12.3 years), which is at relatively high concentrations in the basins compared to concentrations in groundwater. Antimony-125 (half-life of 9.5 months) and technetium-99 (half-life 213,000 years) also are mobile constituents of shielding water that would be measured in samples collected to assess leakage. Less mobile radionuclides, such as cesium-137 (half-life 30.17 years) and strontium-90 (half-life 28.8 years), might also be measured to provide an indication of how direct the pathway from the leakage point to groundwater might be.

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[2] Ibid.

[3] Personal communication from D. J. Watson to R. E. Peterson (PNNL), *Groundwater Monitoring Frequency for K Basins*, dated March 14, 2001.

[4] OP-06-008. *Detect and Mitigate Basin Leaks*. Internal operations procedures, Spent Nuclear Fuels Project, Fluor Hanford, Inc., Richland, Washington.

[5] ER-SNF-013. *Emergency Response Loss of K Area Fuel Storage Basin Water*. Internal Operations Procedures, Spent Nuclear Fuels Project, Fluor Hanford, Inc., Richland, Washington.

A key assumption in deciding the frequency to sample monitoring wells located adjacent to the K Basins is that the first indication of water loss from either basin will come from the facility operators. Regular exchange of information on shielding water volume calculations and radiological characteristics between the Spent Nuclear Fuels Project and the Groundwater Monitoring Project is essential if appropriate groundwater monitoring actions are to be taken to monitor potential effects to the environment.

2.4 Evaluation and Interpretation

Objective: Determine whether the levels of groundwater contamination associated with operation of the K Basins and nearby waste sites are changing with time.

Objective: Characterize potential shifts in plume positions relative to monitoring wells that may be caused by (a) seasonal changes in water-table elevation and/or (b) injection of treated effluent from remedial actions at 100-K Trench and the resulting mound buildup.

All new data obtained from sampling and analysis activities will be evaluated with respect to representativeness of field conditions (see Sections 3.3 and 3.4). Inferences will be made regarding whether the level of groundwater contamination that can be attributed to the fuel storage basins is changing with time by examining concentration histories (i.e., "trend charts") for indicator constituents in each well monitored.

The insight gained will subsequently contribute to a more detailed analysis of a) the volume of contaminated groundwater, and b) the mass of contaminants in the plumes. This analysis may be performed to demonstrate the effectiveness of natural attenuation—a remedy which is likely to be included in a future record-of-decision for the 100-KR-4 operable unit; the analysis is not included in the current K Basins groundwater monitoring and assessment task.

Concentration trends at a well can change not only because of changes in the level of contamination present, but also because of shifting plume boundaries. Where distinctive changes in trends are revealed by new monitoring data, a check will be made to determine if there is a corresponding shift in hydraulic gradients. Trend-surface analysis of water level data will be used to reveal potential changes in hydraulic gradient direction and steepness.

2.5 Monitoring Well Coverage

Objective: Maintain a strategy to position new monitoring wells if future basin-related events warrant their installation.

During spring 1999, DOE requested that the Hanford Groundwater Monitoring Project identify monitoring well needs for the Hanford Site. For the 100-K Area, where monitoring wells serve the objectives associated with monitoring the K Basins, environmental restoration activities, and sitewide environmental surveillance, three areas of uncertainty were identified:

1. The current network of wells does not provide sufficient coverage to accurately define the direction and rate of groundwater movement beneath the area, although general movement characteristics are known.

2. Significant geographic coverage gaps exist that hinder accurate three-dimensional depiction of the areal extent, volume of contaminated groundwater, and mass of contaminant in each plume. These characteristics are used to determine the rate of natural attenuation of plumes.

3. Older wells may not produce samples that are representative of aquifer conditions; some are not in compliance with Washington State standards (WAC 173-160) for resource protection wells.

Following identification of uncertainties, a data quality analysis was completed in February 2000 using the EPA protocol (EPA 1994). An internal PNNL report[6] was prepared that described the results of that analysis. For the 100-K Area, this initial report contained the following problem statement and associated decision statements:

Problem Statement

- *The current distribution of monitoring wells in the vicinity of the K Basins is insufficient to achieve several information needs at a level of understanding that will support a credible analysis of catastrophic water loss from the basins.*

Decision Statements (i.e., applications for observational data from new wells)

- *Can estimates for the nature and extent of groundwater contamination plumes originating from either KE or KW Basin because of leakage be made with levels of uncertainty that are acceptable to regulators, stakeholders, and the general public?*

- *Do observational data on contaminants of concern in groundwater beneath the K Basins provide a sufficient technical basis for decisions involving soil and groundwater remediation activities?*

- *Assuming that long-term groundwater monitoring will be required regardless of the specific remediation activities that are undertaken, what is the appropriate network of monitoring locations to provide effective coverage of potential plumes from the areas beneath the basins?*

The data quality process culminated in estimates of the number and locations for potential additions to the existing monitoring well network (locations are shown in Figure 2.3). New information developed

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[6] Internal report, *Proposed FY 2000 New Well Data Quality Objectives Process to Prioritize Installation of RCRA and AEA Groundwater Monitoring Wells*, Pacific Northwest National Laboratory, Richland, Washington, dated February 9, 2000.

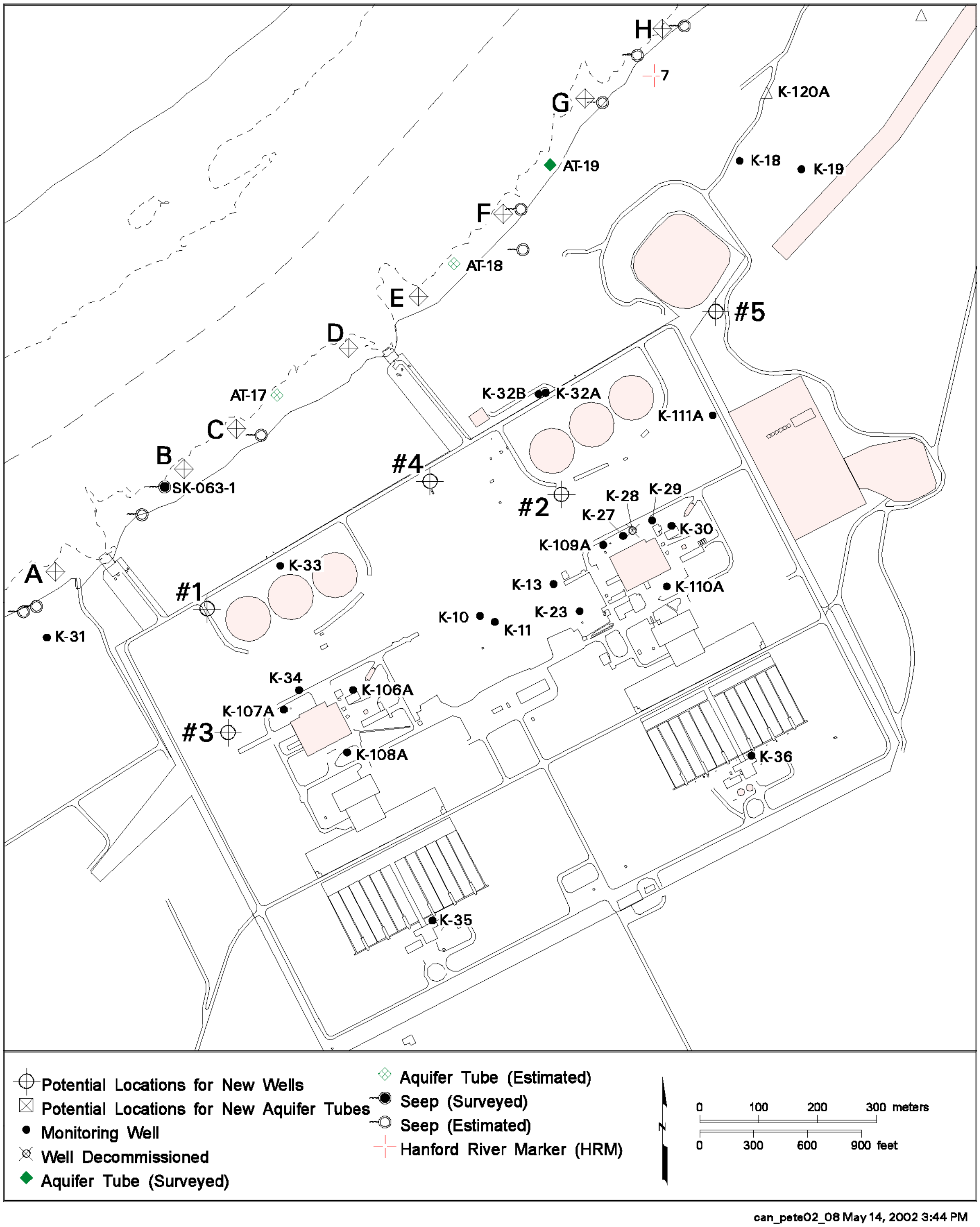

Figure 2.3. Potential Locations for Additional Monitoring Locations at 100-K Area

since the data quality session has caused minor modifications to the original estimates for new coverage; the current fiscal year 2002 estimates for new monitoring wells are as follows:

New Wells to Support Spent Nuclear Fuels Project Objectives (Atomic Energy Act). A new monitoring well could be installed along the flow path downgradient from the sub-basin drainage sump area for each basin (wells #1 and #2 on Figure 2.3). These wells will improve the ability to detect basin water loss that could potentially occur via basin floor drains, or contamination remobilized from the vadose zone beneath past-practice waste sites, i.e., basin drain field/injection wells. Their locations would contribute to an improved description of the groundwater flow path between the basins and the Columbia River. The need for information associated with new wells at these locations would be balanced against the time remaining during which there is a risk of basin operations affecting groundwater. Fuel is scheduled to be out of the basins by 2004, and shielding water and sludge by 2007 (TPA Milestone M-34-00A).

New Wells to Support Environmental Restoration Program Objectives (CERCLA). Environmental restoration shares the Spent Nuclear Fuels Project objectives for the two new wells described above, because of the past-practice disposal to K Basins' drain field/injection wells. Additional new wells to augment environmental restoration objectives include a new well (#3, Figure 2.3) located to the west-southwest of the KW Reactor to better define a chromium plume in that area. A second new well (#4, Figure 2.3) would be centered between the reactors and the Columbia River to provide information on where past leakage from the KE Basin has migrated and to improve definition of the flow field characteristics. A third well (#5, Figure 2.3) would be installed between the 100-K Burial Ground and the river, along the flow path downgradient from the KE Basin and the 100-K Burial Ground, which has been recently implicated as a potential source for tritium. Eight new aquifer sampling tube sites (A-H, Figure 2.3) would be equipped with three sampling tubes each along the 100-K Area shoreline. These tubes permit collection of groundwater samples from three different depths in the aquifer at locations close to where groundwater discharges into the river channel.

2.6 Seismic Monitoring

Objective: Operate a strong motion accelerometer at a location near the K Basins to provide early warning of seismic activity (earthquakes) that might affect the integrity of the basins.

Earthquake activity affecting the Hanford Site is monitored using the Hanford Seismic Network and the Eastern Washington Seismic Network. The Hanford and Eastern Washington Networks are maintained and operated by PNNL staff, who coordinate with the University of Washington. Approximately twenty stations are designed to provide high sensitivity for earthquakes at the Hanford Site. The university is responsible for monitoring earthquakes for the entire state.

Five strong motion sensors (accelerometers) also are installed on the Hanford Site; one is located at the 100-K Area. These instruments are free-field sites and record ground motion data that are relevant to the structural design of buildings and facilities. They are maintained and operated by PNNL staff from the Applied Geology and Geochemistry Group. An annual report is prepared that describes the seismic network and newly collected data (e.g., Hartshorn et al. 2001).

The strong motion sensor at 100-K Area is currently operating. The instrument is located in two 114-liter (30-gallon) drums set in the ground south of the 100-K Area fence. The Washington State Plane coordinates for the site are: 145,839.683 northing and 569,498.782 easting (46E 38.51' north latitude, 119E 35.53' east longitude). The instrument is set to trigger at acceleration levels lower than the trigger levels set for instruments within facilities at the fuel storage basins. This is done to obtain data on small, relatively frequent seismic events, thus providing information that can be used to estimate the ground motion expected from larger, potentially damaging earthquakes.

2.6.1 Earthquake Notification Procedures

The strong motion accelerometer network for the Hanford Site is designed to provide ground motion data for locations where there is hazardous material and/or a high density of people (DOE Order 420.1 and DOE Order G420.1-1, Section 4.7). If a magnitude 3 or larger earthquake is detected within the entire seismic network, the Washington State Emergency Services is notified automatically by the University of Washington. In turn, the Hanford Patrol and PNNL seismologists are notified. If an earthquake occurs at the Hanford Site, the Hanford Seismic Network triggering system sends a message via e-mail to the PNNL staff. The PNNL staff then connect to the strong motion accelerometer sensors, download the data for the event, and process the records. The results are then forwarded to the Hanford Emergency Services Patrol Operations Center. This service is currently provided during normal working hours; communications facilities are not available to provide continuous coverage by PNNL seismic monitoring staff.

Facility operator response to indications of an earthquake are described in Spent Nuclear Fuel Operations Procedures,[7] which includes an earthquake as a possible leak-generating event.

2.6.2 Alternatives for Improving the Ground Motion Notification Process

The reliability of the strong motion accelerometer and the ability to communicate with it in the event of an earthquake could be significantly improved with the installation of electrical power drops and telephone lines. This would allow implementation of a pager notification system whereby PNNL seismic monitoring staff could be made aware of a seismic event at all hours. An additional pager for the 100-K Area strong motion sensor could be arranged for the K Basins' facilities duty room, thus providing the most rapid notification possible for starting facility operator response.

[7] OP-06-008. *Detect and Mitigate Basin Leaks*. Internal operations procedures, Spent Nuclear Fuels Project, Fluor Hanford, Inc., Richland, Washington.

3.0 Sampling, Analysis, and Evaluation

This section describes the sampling and analysis schedule, protocols, methods used to evaluate new monitoring data, and quality assurance/quality control issues. The monitoring schedule and evaluation methods presented in this plan are intended to satisfy the objectives described in Chapter 2 for groundwater monitoring associated with the K Basins.

3.1 Schedule

The sampling and analysis schedule involves a blend of data collection to support (a) current operations at the basins and (b) assessment of past basin leakage on groundwater conditions. The capability to distinguish among various potential sources for contaminants currently detected in 100-K Area groundwater is a key objective of the monitoring program. Because of this objective, the sampling and analysis schedule supports a combination of objectives involving an operating facility and past-practice waste disposal sites.

3.1.1 Sampling and Analysis: K Basins

The list of wells to be sampled, their role in the monitoring network, and the analyses to be performed are presented in Table 3.1. The table represents the level of effort deemed appropriate for supporting the project objectives under conditions that exist during fiscal year 2002 (October 1, 2001 to September 30, 2002). At each basin, the wells most likely to detect new or renewed leakage are shown in bold, as are the key constituents that identify shielding water.

Because sufficient time has passed for plumes created by past leakage from the fuel storage basins to reach the Columbia River, samples also will be collected from shoreline monitoring sites, i.e., riverbank seepage and aquifer sampling tubes. The schedule for this sampling is shown in Table 3.2.

3.1.2 Sampling and Analysis: Other Projects

There are two additional monitoring schedules for projects in the 100-K Area: (1) performance evaluation and compliance monitoring associated with the interim remedial action for chromium near the 100-K Trench (DOE/RL 1997) and (2) long-term monitoring of past-practices waste sites associated with the 100-KR-4 Operable Unit (TPA 1996). Some overlap in objectives for the latter project exists with the project objectives defined for the K Basins. An integrated list of sampling and analysis activities for the 100-K Area is included as Appendix A.

Table 3.1. Sampling and Analysis Schedule for K Basins Project Wells (Quarterly Sampling)

Well Name (Install date)	Strategic Position and Monitoring Objective	Quarter 1 (Oct-Dec)	Quarter 2 (Jan-Mar)	Quarter 3 (Apr-Jun)	Quarter 4 (Jul-Sep)
KE Fuel Storage Basin					
199-K-27 (Sep 1979)	Adjacent to KE Basin – downgradient from KE Basin and pickup chute construction joint	Anions (IC) Metals (ICP-f) Alpha/**beta, H3**, Sr90, Tc99	Anions (IC) Alpha/**beta, H3**	Anions (IC) Metals (ICP-f) Alpha/**beta, H3**	Anions (IC) Alpha/**beta, H3**
199-K-29 (Sep 1979)	Adjacent to KE Basin – downgradient from KE Condensate Crib; parallel to flow path beneath KE Basin	Anions (IC) Alpha/beta, C14, H3	Anions (IC) Alpha/beta, H3	Anions (IC) Alpha/beta, H3	Anions (IC) Alpha/beta, H3
199-K-30 (Oct 1979)	Alongside KE Basin – downgradient of KE Condensate Crib; parallel to flow path beneath KE Basin	Anions (IC) Metals (ICP-f) Alpha/beta, C14, H3	Anions (IC) Alpha/beta, H3	Anions (IC) Metals (ICP-f) Alpha/beta, H3	Anions (IC) Alpha/beta, H3
199-K-32A (Aug 1992)	Between KE Reactor complex and river – downgradient extent of contamina-tion	Anions (IC) Alpha/beta, C14, H3, Tc99	Anions (IC) Alpha/beta, H3	Anions (IC) Alpha/beta, H3	Anions (IC) Alpha/beta, H3
199-K-109A (Aug 1994)	Adjacent to KE Basin – downgradient of basin and south loadout pit; adjacent to moisture collection sump and drain field/ injection well	Anions (IC) Metals (ICP-f) Alpha/**beta, H3**, Sr90, Tc99	Anions (IC) Alpha/**beta, H3**	Anions (IC) Metals (ICP-f) Alpha/**beta, H3**	Anions (IC) Alpha/**beta, H3**
199-K-110A (May 1994)	Upgradient of KE Basin – local background conditions	Anions (IC) Metals (ICP-f) Alpha/beta, H3	NS	Anions (IC) Alpha/beta, H3	NS
199-K-111A (Jul 1994)	Between KE Reactor complex and river – downgradient extent of contamina-tion	Anions (IC) Metals (ICP-f) Alpha/beta, C14, H3, Tc99	Anions (IC) Alpha/beta, H3	Anions (IC) Alpha/beta, H3	Anions (IC) Alpha/beta, H3
KW Fuel Storage Basin					
199-K-33 (Aug 1992)	Between KW Reactor complex and river – downgradient extent of contamination	Anions (IC) Metals (ICP-f) Alpha/beta, C14, H3	NS	Anions (IC) Metals (ICP-f) Alpha/beta, H3	NS
199-K-34 (Aug 1992)	Adjacent to KW Basin – downgradient from KW Basin	Anions (IC) Metals (ICP-f) Alpha/**beta**, C14, **H3**, Sr90, Tc99	Anions (IC) Alpha/**beta, H3**	Anions (IC) Metals (ICP-f) Alpha/**beta, H3**	Anions (IC) Alpha/**beta, H3**
199-K-106A (Feb 1994)	Alongside KW Basin – downgradient of KW Condensate Crib; parallel to flow path beneath KW Basin	Anions (IC) Metals (ICP-f) Alpha/beta, C14, H3	Anions (IC) Alpha/beta, H3	Anions (IC) Metals (ICP-f) Alpha/beta, H3	Anions (IC) Alpha/beta, H3
199-K-107A (Mar 1994)	Adjacent to KW Basin – downgradient of basin and south loadout pit; adjacent to moisture collection sump and drain field/ injection well	Anions (IC) Metals (ICP-f) Alpha/**beta, H3**, Sr90, Tc99	Anions (IC) Alpha/**beta, H3**	Anions (IC) Metals (ICP-f) Alpha/**beta, H3**	Anions (IC) Alpha/**beta, H3**
199-K-108A (Mar 1994)	Upgradient of KW Basin – local background conditions	Anions (IC) Metals (ICP-f) Alpha/beta, H3	NS	Anions (IC) Metals (ICP-f) Alpha/beta, H3	NS
Abbreviations: IC = ion chromatography; ICP-f = inductively coupled plasma analysis for metals (filtered samples only for routine monitoring); NS = sampling not scheduled at this time. Radionuclides: Alpha/beta = gross alpha and gross beta; Gamma = gamma scan; C14 = carbon-14; H3 = tritium; Sr90 = strontium-90; and Tc99 = technetium-99.					
Notes: Field parameters (i.e., pH, temperature, specific conductance, turbidity, and depth-to-water) are measured during each sampling event. Wells and analytes in **bold** provide key data for leakage detection, while remainder support leakage impact assessment objectives.					

Table 3.2. Sampling and Analysis Schedule for K Basins Project Shoreline Sites (Annual Sampling)

Location Name	Strategic Position and Monitoring Objective	Quarter 1 (Oct-Dec)	Quarter 2 (Jan-Mar)	Quarter 3 (Apr-Jun)	Quarter 4 (Jul-Sep)
Shoreline Aquifer Sampling Tubes[(a)]					
AT-15 (15-M)	Along shoreline – downgradient of KW Reactor complex	Anions (IC) Metals (ICP-f) Alpha/beta, H3, Sr90, Tc99	NS	NS	NS
AT-17 (15-M, 15-D)	Along shoreline – downgradient of KW Reactor complex	Anions (IC) Alpha/beta, H3, C14	NS	NS	NS
AT-18 (18-S)	Along shoreline – downgradient of KE Reactor complex	Anions (IC) Metals (ICP-f) Alpha/beta, H3, C14	NS	NS	NS
AT-19 (19-M, 19-D)	Along shoreline downgradient of KE Reactor complex	Anions (IC) Alpha/beta, H3, Tc99	NS	NS	NS
Riverbank Seepage Sites[(b)]					
SK-063-1	Along shoreline – downgradient of KW Reactor complex	Anions (IC) Metals (ICP-f) Alpha/beta, H3, C14	NS	NS	NS
(unnamed site between HRM 6.6 and 6.8)	Along shoreline – downgradient of KE Reactor complex	Anions (IC) Metals (ICP-f) Alpha/beta, H3, C14, Sr90, Tc99	NS	NS	NS

Abbreviations: IC = ion chromatography; ICP-f = inductively coupled plasma analysis for metals (filtered samples only for routine monitoring); NS = sampling not scheduled at this time. Radionuclides: Alpha/beta = gross alpha and gross beta; Gamma = gamma scan; C14 = carbon-14; H3 = tritium; Sr90 = strontium-90; and Tc99 = technetium-99.

(a) Small diameter sampling tubes at multiple depths in the near-river aquifer. "-S" = shallow; "-M" = mid-depth; "-D" = deep.
(b) Riverbank seepage is the natural return flow from the banks during low river stage.
** Field parameters (i.e., pH, temperature, specific conductance, and turbidity) are measured during each sampling event.

3.2 Protocols

Groundwater monitoring at K Basins is a part of the larger Hanford Groundwater Monitoring Project. Procedures for groundwater sampling, documentation, sample preservation, shipment, and chain-of-custody requirements are described in PNNL procedures[8] or subcontractor manuals[9] used in support of the project. Analytical methods are specified in contracts with laboratories; most are standard methods as described in *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods* (EPA 1986a).

[8] PNL-MA-567. *Procedures for Groundwater Investigations*, Pacific Northwest National Laboratory, Richland, Washington.
[9] DFSNW-SSPM-001. *Sampling Services Procedure Manuals,* Duratek Federal Services Northwest, Richland, Washington.

Alternative procedures meet the guidelines of SW-846, Chapter 10. Analytical methods are described in Hartman (2000). Quality requirements, as well as the Quality Control Plan, are provided in the Hanford Groundwater Monitoring Project Quality Assurance Plan.[10]

Samples generally are collected after three casing volumes of water have been purged from the well and/or after field parameters (pH, temperature, specific conductance, and turbidity) have stabilized. Depth-to-water is measured during each sampling event. For routine groundwater samples, preservatives are added to the collection bottles before their use in the field. Samples to be analyzed for metals are usually filtered in the field (0.45 micron in-line filter) so that results are representative of dissolved metals. Procedures for field measurements are specified in the subcontractor's or instrument manufacturer's manuals. For samples sent to offsite, contracted laboratories, the turnaround time for results is normally 45 days from the sample collection date, although quicker turnaround capability is available.

3.3 Data Management

All analytical results for samples are reviewed upon receipt by the project for quality assurance/ quality control (QA/QC) purposes, and to determine how representative the results are of aquifer conditions. The data are stored electronically and are available to the public via a request to DOE.

3.3.1 Hanford Environmental Information System (HEIS)

Laboratories contracted to perform analyses on groundwater samples report analytical results in an electronic format. The results data are loaded into the Hanford Environmental Information System (HEIS) database. Field-measured parameters are entered manually or through electronic transfer. Paper data reports and field records are considered to be the record copies and are stored at PNNL.

The data undergo a validation/verification process according to a documented procedure, as described in the project QA plan.[11] QC data are evaluated against the criteria listed in the project QA plan and data flags are assigned when appropriate.

3.3.2 Data Viewer and Evaluator (DaVE)

The Hanford Groundwater Monitoring Project maintains a user interface with HEIS that allows project scientists to view water quality and water level data for each well. This interface, which is referred to as the Data Viewer and Evaluator (DaVE), is used to screen new data as they are acquired and to attach review comments to records as appropriate. New data are evaluated by a project scientist who is familiar with (a) the hydrogeology of the area, (b) the history of operations and waste sites, and (c) contaminant trends. Additional evaluations of new data may include comparison of general water quality parameters to specific counterparts associated with waste site contaminants, calculation of charge balances, and comparison of calculated vs. measured specific conductance.

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[10] ETD-012, Rev. 2. 2000. *The Hanford Groundwater Monitoring Project Quality Assurance Project Plan*, Pacific Northwest National Laboratory, Richland, Washington.
[11] Ibid.

Suspect or out-of-trend results are submitted for further review via the Request-for-Data-Review process using the DaVE interface. Occasionally, a laboratory may be asked to re-check calculations, re-analyze the sample, or the well may be re-sampled. Current requirements call for a project scientist review of all newly loaded groundwater data on at least a biweekly schedule.

3.3.3 Virtual Library

The Virtual Library is a relatively new user interface to various databases on the Hanford Site, including the HEIS (Connelly and Delamare 2001). It was originally developed under Bechtel Hanford, Inc., and is currently maintained by Fluor Hanford, Inc. It is available to Hanford Site personnel via internal networks but is not available outside of the Hanford system (Intranet address is: http://vlprod.rl.gov/index.cfm). The Virtual Library is an easy-to-use and versatile interface for viewing historical groundwater data. Among its advantages are multiple methods to search for data from a geographic area; capability for saving well lists and constituent lists for repeated searches; and trend charting of constituent concentrations and water levels. The Virtual Library interface can also connect the user with databases other than the HEIS.

3.4 Data Interpretation

Interpretation of new data involves various methods to view and manipulate the data, and consideration of whether the data represent aquifer conditions. Conclusions drawn must include some analysis of the uncertainty associated with various aspects of the interpretation.

3.4.1 Methods

Methods typically used to help interpret newly acquired groundwater data for the purposes of this monitoring project may include the following:

- Hydrographs – Graphs of water level elevation versus time to determine magnitude of fluctuations caused by seasonal precipitation cycles and/or human activities (e.g., remedial actions involving pump-and-treat operations).

- Water-Table Maps – Contour lines of equal water-table elevation provide information on the direction of flow and hydraulic gradients, which are used to estimate groundwater flow velocity.

- Trend Plots – Graphs showing the concentration of chemical or radiological constituents versus time to determine increases, decreases, and variability. Combinations of multiple constituents and/or water-table elevation may reveal information for explaining variability or consistent trends.

- Plume Maps – Contour lines that represent equal concentrations of chemical or radiological constituents illustrate the areal distribution and approximate boundaries of plumes. Changes in plume shape over time can be used to infer preferential flow pathways. Changes in areal extent, plume volume, and mass of contaminants can be used to demonstrate the degree of natural attenuation (EPA 1999b).

- Contaminant Ratios – Ratios of various groundwater constituents can often be diagnostic of a particular waste site or facility contaminant source.

3.4.2 Sample Representativeness and Uncertainty

The credibility of interpretations is determined by (a) how representative sample data are of actual aquifer conditions and (b) uncertainties associated with the various processes that influence the movement and concentrations of contaminants. Some uncertainty can be quantified, such as that associated with analytical methods; other causes for uncertainty are subjective.

The accuracy and details associated with maps that portray the water table and contaminant plumes are limited by the availability of monitoring wells. The total number of wells that cover a particular plume and the layout of the well network are the key parameters. For the region between the K Reactors and the Columbia River, monitoring well coverage is poor with respect to delineating contaminant plumes, but adequate for detection monitoring downgradient of suspected contaminant sources. Well construction characteristics play a role also, in that the length of the screened or perforated interval relative to the thickness of the contaminated zone will influence the contaminant concentration measured in a sample.

Variability in concentration trends detected in groundwater at a well can be caused by processes other than simple passage of a plume of varying concentration. If the contaminant is layered in the aquifer or has a strong vertical concentration gradient, samples collected during different periods of water-table elevation may show a variable concentration, because the pump inlet stays at a fixed elevation. This may occur in wells located close to the Columbia River. For wells located near the river, contaminant concentrations also may be reduced by mixing between groundwater and river water that infiltrates the banks during high river stage. Finally, where the overlying vadose zone contains contaminants, a temporarily elevated water table may cause contaminant remobilization, with a subsequent rise in groundwater concentrations.

Because some areas of the vadose are still contaminated by past-practices disposal of radiological and chemical effluents, infiltration of moisture from the ground surface must be controlled to prevent further mobilization of those contaminants. Clues to whether this is occurring can be found in basic water chemistry (e.g., changes in specific conductance); increases in constituents associated with surface water (e.g., calcium increases because of salt applied to roads for ice control); and correlation of concentration changes with heavy rainfall or snow melt events. Flushing of fire hydrants, application of dust control water, and water utility line breaks have all occurred in the past in the 100-K Area, thus creating the potential to remobilize contaminants held in the vadose zone.

Since October 1997, groundwater extraction and injection operations have taken place as part of interim remedial actions. Extraction and injection create localized changes in the groundwater flow field, causing a redistribution of contaminants. Radial flow toward extraction wells, and outward from injection wells, can alter flow sufficiently to displace previously undetected plumes to locations where they may now be detected in monitoring wells, or vice versa (i.e., away from wells).

3.5 Reporting

The frequency of reporting for the K Basins monitoring project will generally follow the frequency of acquiring new field data on aquifer conditions (i.e., quarterly). Periodic status reports will be prepared to describe new analytical results and their implications with respect to monitoring objectives. The Hanford Groundwater Monitoring Project will distribute these reports to contractor and DOE staff associated with the Spent Nuclear Fuels Project via e-mail.

A full description of groundwater conditions and remediation activities at the 100-K Area will be prepared annually as part of the Hanford Groundwater Monitoring Project fiscal year report (e.g., Hartman et al. 2002, Section 2.3).

3.6 Quality Assurance and Quality Control

The Hanford Groundwater Monitoring Project's quality assurance/quality control (QA/QC) program is designed to assess and enhance the reliability and validity of groundwater data. The primary quantitative measures or parameters used to assess data quality are accuracy, precision, completeness, and the method detection limit. Qualitative measures include representativeness and comparability. Goals for data representativeness for groundwater monitoring projects are addressed qualitatively by the specification of well locations, well construction, sampling intervals, and sampling and analysis techniques in the groundwater monitoring plan for each facility being monitored.

Comparability is the confidence with which one data set can be compared to another. The QC parameters are evaluated through laboratory checks (e.g., matrix spikes, laboratory blanks), replicate sampling and analysis, analysis of blind standards and blanks, and inter-laboratory comparisons. Acceptance criteria have been established for each of these parameters, based on guidance from the U.S. Environmental Protection Agency (EPA 1986b). When a parameter is outside the criteria, corrective actions are taken to prevent a future occurrence and affected data are flagged in the database.

4.0 Facility Description

This section describes facility features and operations associated with the KE and KW Fuel Storage Basins. It summarizes the technical information on which the groundwater monitoring strategy is based. A map showing the locations of various facilities, waste sites, monitoring sites, and geographic features of significance to the groundwater monitoring project is shown in Figure 1.3.

4.1 Fuel Storage Basin Characteristics

The K Basins currently store irradiated fuel elements from past operations of the N Reactor. Comprehensive descriptions of the facilities and stored fuel are provided in Bergsman et al. (1995) and Praga (1998). Those reports were prepared to provide technical information for an environmental impact statement about the management of spent nuclear fuel (DOE/RL 1995) and a focused feasibility study for interim remedial action (DOE/RL 1999a). The interim remedial action is described in a record of decision for the K Basins (EPA 1999a), which are facilities within the 100-KR-2 Operable Unit. The following brief description is derived primarily from the focused feasibility study (DOE/RL 1999a).

4.1.1 Facility Design and Operations

The principal features of the K Basins are illustrated in Figure 4.1. They are concrete structures that were originally designed for temporary storage of irradiated fuel from the K Reactors prior to transport to the 200 Areas for chemical processing to recover plutonium. The original design for the shielding water system provided open circuit circulation, i.e., water was added and discharged on a frequent basis so that the radiation level was controlled. In 1975, the K Basins were modified to a closed circuit circulation system. The closed system circulates water through chillers for temperature control and through resin exchange columns to remove radionuclides. Following these modifications, irradiated fuel from the N Reactor was placed in the basins.

KE Basin initially contained approximately 1,150 metric tons (1,268 tons) of irradiated NR reactor fuel. Much of that fuel has deteriorated because of damage to the cladding and from being stored in open canisters. The deterioration has resulted in high concentrations of radionuclides in the shielding water and accumulation of radioactive sludge on the basin floors. Approximately 953 metric tons (1,050 tons) of fuel were initially stored at KW Basin in closed containers, so any fuel corrosion debris is contained. Consequently, the shielding water at KW Basin is less contaminated, and the accumulation of sludge on the basin floor is less than at the KE Basin.

The interim remedial action to remove the spent nuclear fuel is underway, with the first actual removal of fuel having occurred on December 7, 2000, at the KW Basin. The Tri-Party Agreement (Ecology et al. 1998) lists July 31, 2004 as the interim milestone date by which all fuel will be removed, with the remaining radioactive sludge, debris, and shielding water scheduled for removal by 2007 (TPA Milestone M-34-00A).

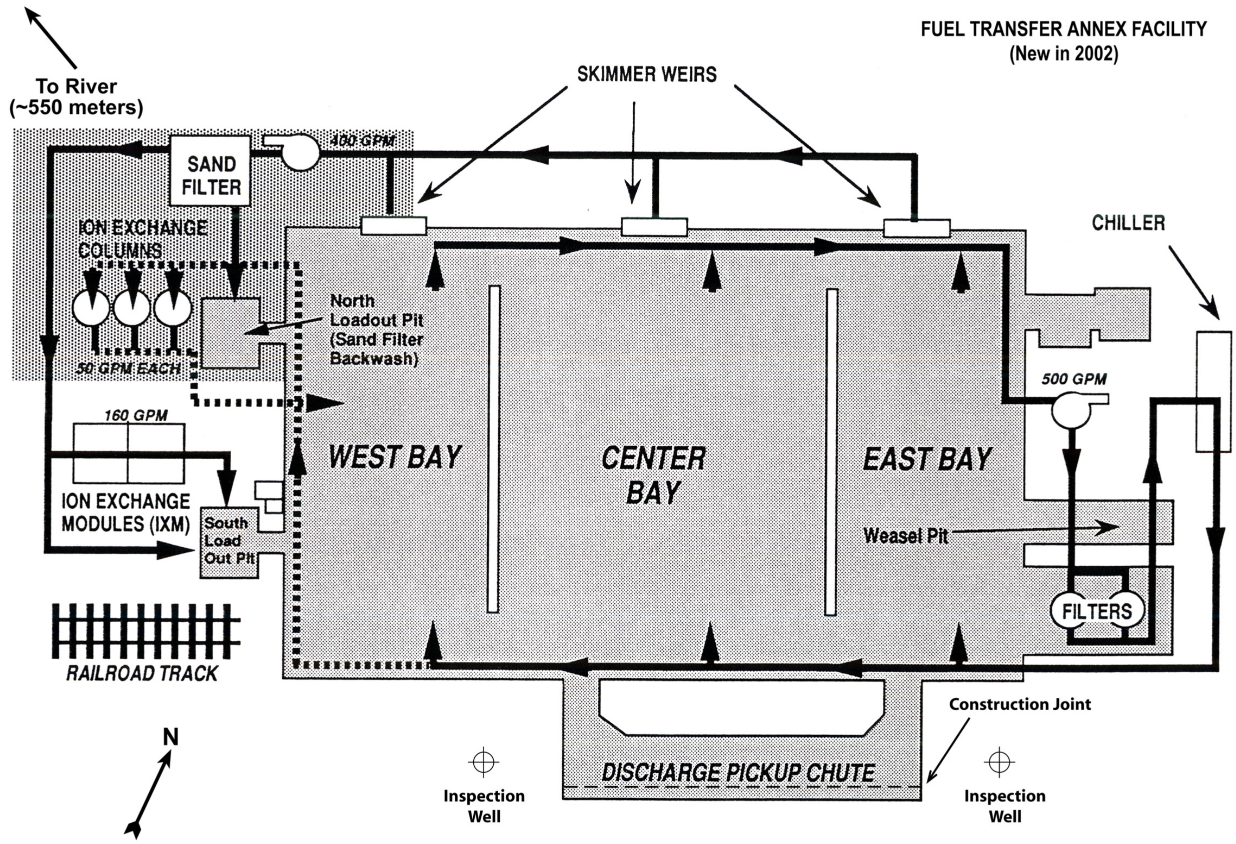

Figure 4.1. Principal Features of 100-K Fuel Storage Basins

4.1.2 Basin Shielding Water Levels and Water Loss Monitoring

The K Basins are concrete structures that are integral parts of the KE and KW reactor buildings. Each basin has an approximate shielding water capacity of 4.9 million liters (1.3 million gallons). During upgrade activities in the 1970s to accommodate storage of N Reactor fuel, an epoxy lining was applied to the inside of the KW Basin (but not to the KE Basin), thus reducing the potential for seepage through the concrete walls. Each basin is underlain by an asphalt membrane designed to capture moisture that might potentially leak from the basin. Any moisture captured is routed to a sump, where a pump is activated to return the moisture to the basin. The membrane extends in excess of 6 meters (20 feet) past the outer (west) edge the South Loadout Pit at each basin, a location with higher-than-average potential for damage to the basin floor in the event of a cask drop accident (Meichle 1996). Leakage collected by the membrane would be directed to a sump, where a pump can remove the water at a rate of 606 liters (160 gallons) per minute, directing it back into the basin. Water leakage in excess of 606 liters (160 gallons) per minute is expected to leak past the membrane under the basin, although the exact flow path is not known. The sub-basin asphalt membrane does not extend beneath the pickup chute area, which is located between the main bays of the storage basin and the reactor building. A construction joint between the two structures has leaked in the past, allowing shielding water to discharge into the vadose zone and underlying groundwater (see Section 4.2.2).

The water level in each basin is monitored continuously by a bubbler system and water level gauge. Based on water level data, calculations are performed periodically to determine water loss (Conn 1992). Any loss greater than that estimated to be from evaporation is interpreted as seepage to the ground. In the event of suspected water loss to the environment, notification is made to the Hanford Groundwater Monitoring Project. Clean makeup water is added periodically to maintain the water level within desired limits. Basin water levels and moisture collection system sumps are monitored as part of daily shift operations.

Makeup water for routine replacement of water lost via evaporation, and for emergency use in the event of major leakage, is stored in clearwells located adjacent to the KE reactor complex. One of the four clearwells originally used to store treated river water for use as reactor coolant is currently maintained for this purpose.[12] The clearwell at the southeast corner of the KE Reactor building holds approximately 34 million liters (9 million gallons) of clean water for use in the fire suppression utility lines and as makeup water for the basins.

4.1.3 Shielding Water Characteristics

Tritium is present at relatively high concentrations in each basin. Because of tritium's mobility, it is used as the primary indicator to track potential leakage that gets into the groundwater flow system. Antimony-125 is also a mobile radionuclide, but has a short half-life (9.5 months) so is less useful for tracking groundwater plumes. Technetium-99 is presumed to be present in relatively small concentrations and is useful as an indicator of shielding water, although because of the relatively small amounts, it is less useful than tritium for delineating plumes. Strontium-90 and cesium-137 are present in the K Basins, although they are less mobile in the environment because of adsorption onto sediment. The shielding water in KE Basin contains higher concentrations of radionuclides than does the KW Basin, because of the better condition and containment of fuel stored in the latter basin. The concentrations of tritium, strontium-90, and cesium-137 in each basin are shown in Figures 4.2 and 4.3.

The water temperature in each K Basin is maintained between 10 and 16 degrees C. (50 and 60 degrees F.). During 1977, unusually high water loss was observed from the KE Basin. The relatively lower temperatures during the winter months were a suspected contributor to the leakage rate (Poppe 1980). Cooler basin water temperatures were thought to cause concrete contraction and an expansion of minor cracks that are present in the basin. Since then, basin water temperatures have been kept fairly constant and at optimal levels to minimize seepage through minor cracks. During a subsequent investigation of water levels and water temperatures in the K Basins, it was suggested that higher temperatures (i.e., above an optimal range) could also lead to increased water loss associated with the expansion of the basin concrete bottoms and sides (although minor cracks would be expected to close under increased temperatures (Conn 1992, pp. 3 and 10). The preferred explanation, however, is that increased water temperatures lead to increased evaporation loss, not necessarily leakage loss.

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[12] Personal communication from G. S. Hunacek (Fluor Hanford, Inc.) to R. E. Peterson (Pacific Northwest National Laboratory), Richland, Washington, dated July 2001.

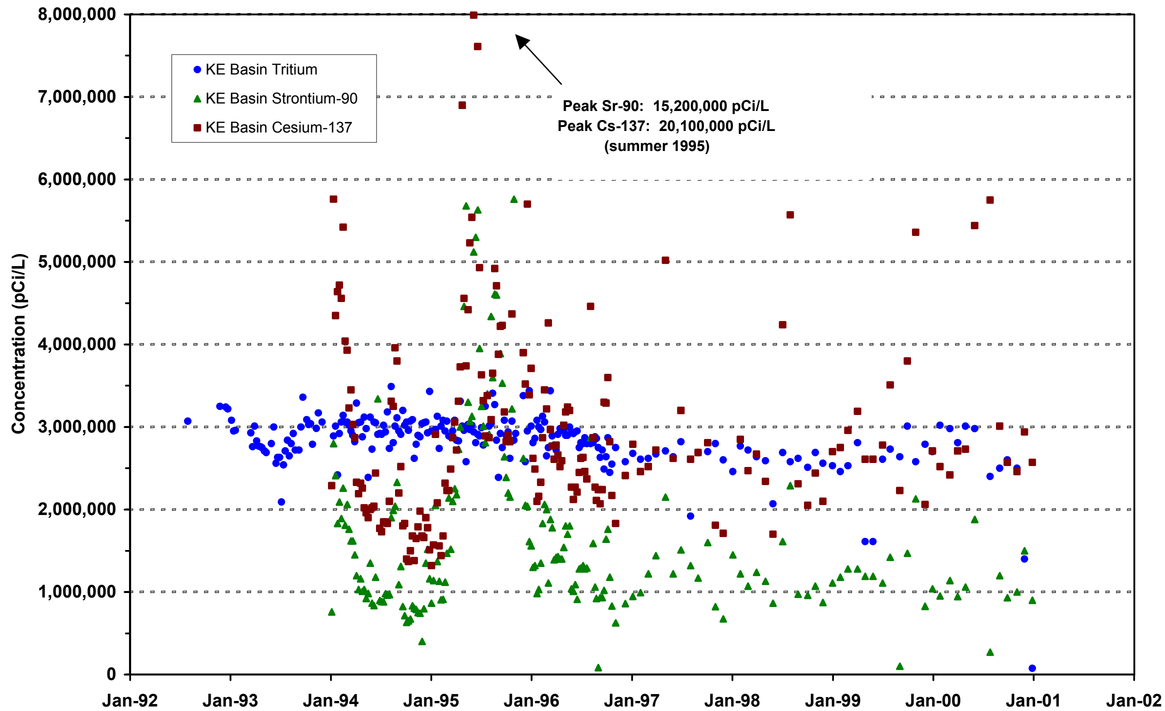

Figure 4.2. Concentration of Selected Radionuclides in KE Basin Shielding Water

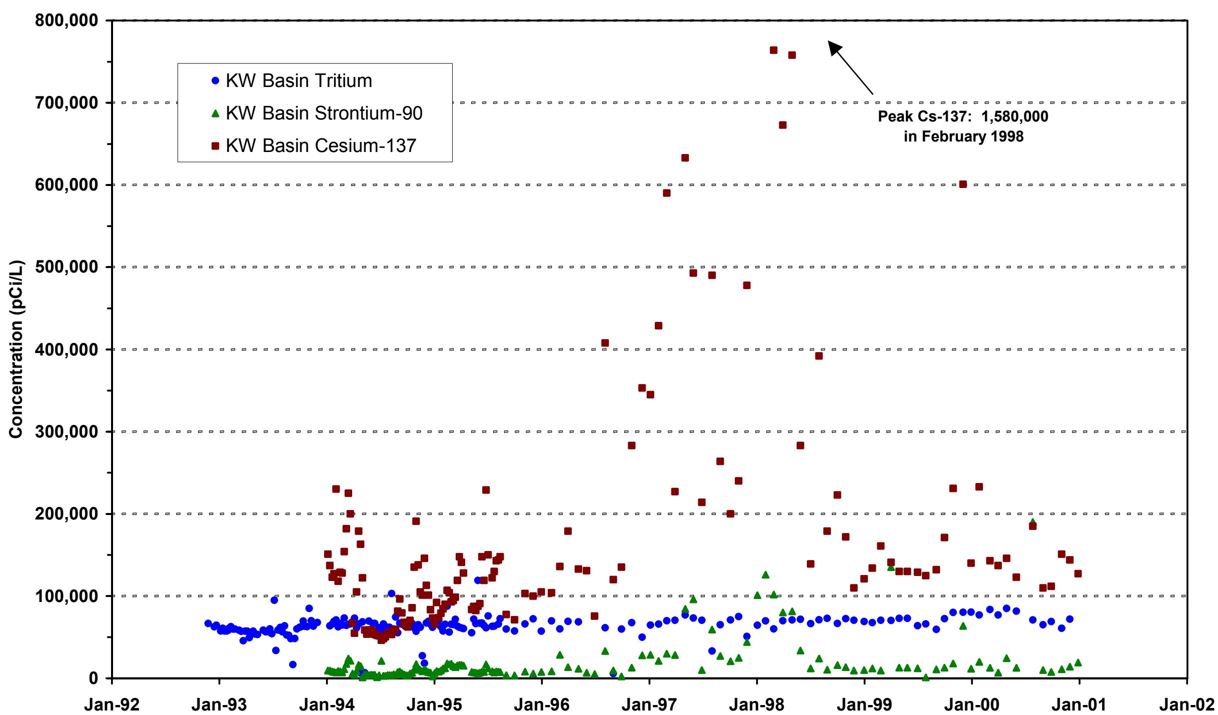

Figure 4.3. Concentration of Selected Radionuclides in KW Basin Shielding Water

4.2 Historical Leakage Events

There have been two periods of extensive leakage from KE Basin. The first occurred during the early phase of converting the basin from its original purpose during reactor operations to that of storage of fuel from the N Reactor. The second period occurred approximately 13 years later. There are no documented occurrences of leakage from the KW Basin.

4.2.1 KE Basin – 1976 to 1979

Approximately 56.8 million liters (15 million gallons) of shielding water are estimated to have been lost to the underlying soil column during the period 1976 to 1979 (DOE/RL 1999a, p. 2-2). The state of Oregon requested DOE perform an in-depth analysis of this leakage period. Highlights from that analysis follow:[13]

- Water loss during this period had been monitored using drawdown tests in the basin, and the leakage rate was determined to be dependent on water temperature, i.e., higher leak rates were associated with cooler temperatures. Peak water loss rate was 1,819 liters (480 gallons) per hour, which occurred during 1977 to 1978.

- The refurbishing of KW Basin revealed the reason KE Basin was leaking, i.e., the construction joint between the storage basin and reactor building was identified as the potential leakage site.

- Sealing the construction joint was competed in May 1980.

- Four new monitoring wells were installed along the downgradient side of the KE Basin in 1981.

Radionuclide concentrations in the KE Basin were relatively low during leakage in the late 1970s. However, approximately 2,500 curies of radionuclides, exclusive of tritium, were estimated to have been released (Table 4.1), with peak water loss rates occurring during 1977. This inventory, except for tritium

Table 4.1. Estimate of Radionuclides Released During 1970s Leakage

Radionuclide	Estimated 1980 Inventory in Soil Column (Ci)	Half-Life (yrs)	Mobility in Soil and Water
Cobalt-60	3.6	5.271	Low
Strontium-90	1,470.0	29.1	Medium
Cesium-137	1,050.0	30.17	Low
Plutonium-238	0.21	87.7	Medium
Plutonium-239/240	1.3	24,100	Medium
Source: Letter, J. R. Hunter (U.S. Department of Energy) to Mary Lou Blazek (Oregon Department of Energy) *105-KE Storage Basin Leak*, December 11, 1989.			

[13] Letter from J. R. Hunter (U.S. Department of Energy) to Mary Lou Blazek (Oregon Department of Energy) *105-KE Storage Basin Leak*, dated December 11, 1989.

(and possibly minor amounts of antimony-125 and technetium-99), was largely retained within the vadose zone because of adsorption onto soil particles. Following passage of the most mobile radionuclides (i.e., tritium and technetium-99), strontium-90 is probably the next radionuclide most likely to appear in groundwater monitoring wells downgradient of the basin. An earlier estimate suggested 1.4 years for strontium-90 to reach the water table and a travel time via groundwater flow to the nearest downgradient well of 26 years (Johnson et al. 1995, pg. 3-7). Assuming strontium-90 did reach groundwater by 1979, it should appear at downgradient monitoring well 199-K-27 in approximately 2005. Slow downward migration of radionuclides from past leakage, such as strontium-90, is expected to continue for many years.

There were no monitoring wells within reasonable proximity downgradient of the basin in the late 1970s, so no record of the plume created by this leakage is available. Earlier speculation suggested that a tritium pulse seen in well 199-K-19 in the early-to-mid 1980s represented leakage from the 1976 to 1979 period (Johnson et al. 1995, p. 1-7). In light of more current information on groundwater flow velocity and flow direction, it seems an unlikely connection, unless a preferential pathway, such as underground piping, was involved.

Monitoring at the new wells installed in 1981 did not reveal evidence of a groundwater plume, as illustrated by the trend plots shown in Figure 4.4. The explanation is that the plume created by the 1976 to 1979 leakage had already passed downgradient of these well locations.

An increase in tritium concentrations at downgradient well 199-K-27 started in approximately 1989 and peaked in 1990, as shown in Figure 4.4. At the time, a detailed evaluation of water loss rates from

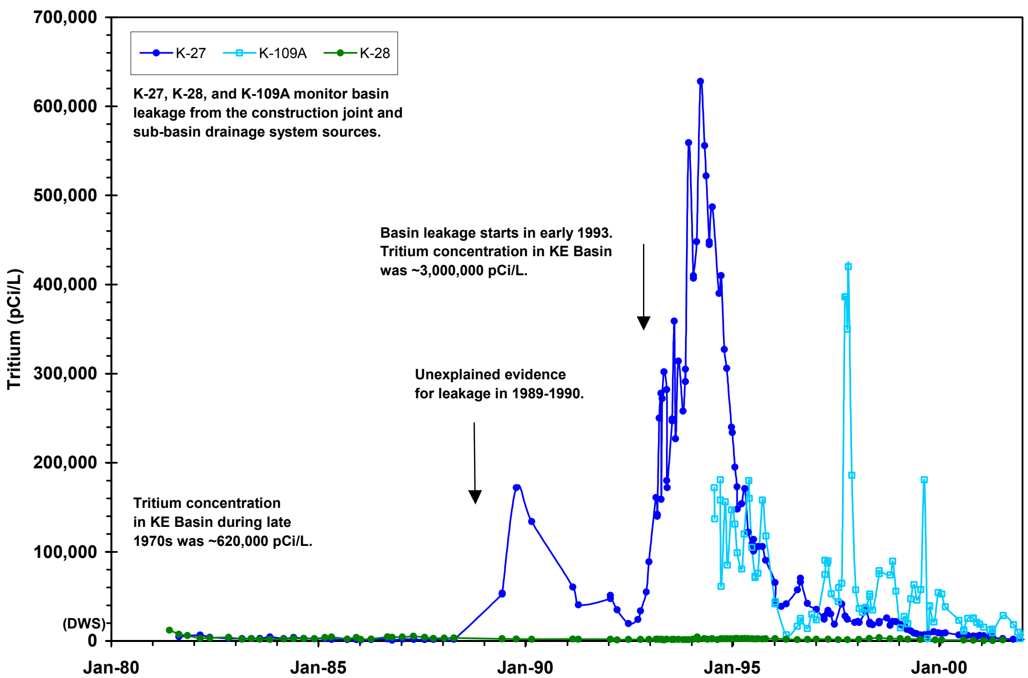

Figure 4.4. Tritium Concentrations at New Wells Installed Following 1976-1979 Leakage from KE Basin

the K Basins was being undertaken (Conn 1992). Some uncertainty existed in the interpretation of basin water level and water temperature data because it was difficult to distinguish between loss because of evaporation and loss via leakage. The evidence from well 199-K-27 indicates that at least some leakage occurred during the latter part of the 1980s.

4.2.2 KE Basin – 1993

Leakage was first noticed in February 1993 when water balance calculations showed an increased loss rate that could not be explained by evaporation alone.[14] Leakage was suspected to have occurred during the period January through August 1993, with an average water loss rate estimated at 95 liters (25 gallons) per hour. The construction joint in the pickup chute structure was the suspected leakage location and additional measures to seal it were undertaken. The moisture collection system beneath each basin does not extend to the area beneath the pickup chute, so shielding water was discharged into the vadose zone and underlying groundwater. By March 1995, the loading chute structure was physically isolated from the main storage basin and contamination removed.

A tritium plume was created by this period of leakage and recorded as it passed by downgradient monitoring well 199-K-27 (Figure 4.5). Since that time, a primary monitoring objective has been to track

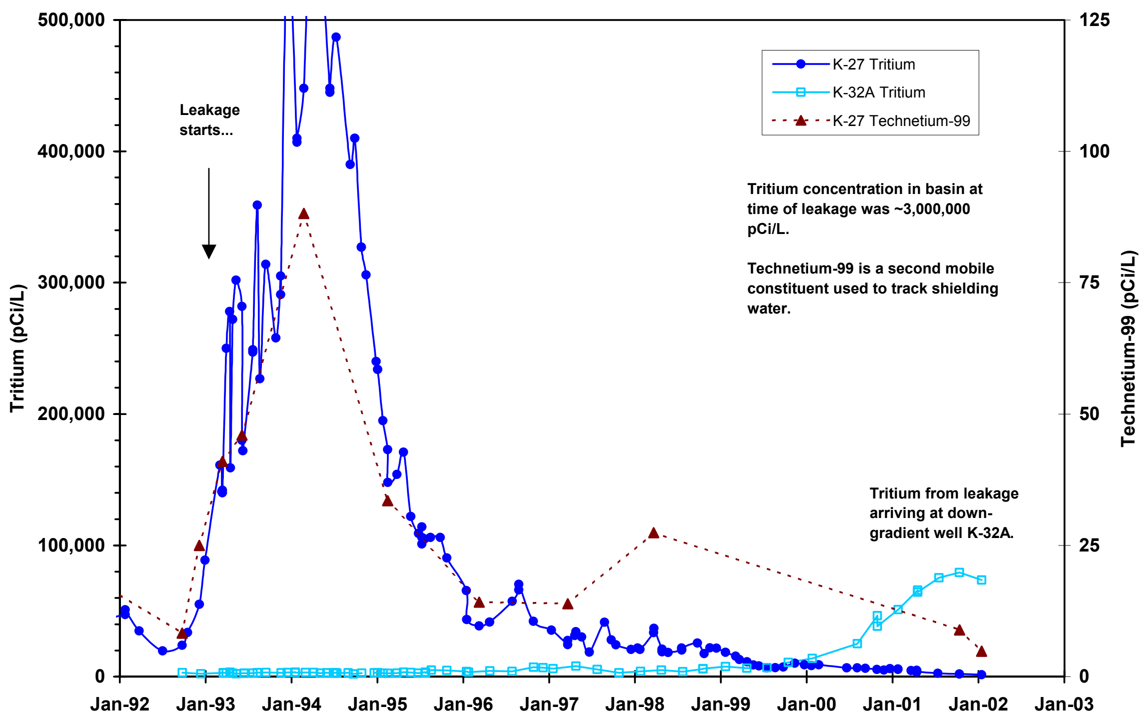

Figure 4.5. Tritium Plume Created by 1993 Leakage from KE Basin

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[14] Presentation by Westinghouse Hanford Co. to Washington State Department of Ecology and the U.S. Department of Energy, *105-K East Fuel Storage Basin Technical Briefing*, on June 21, 1993.

the plume, which has remained elusive because of limited coverage by wells. It appears that the plume front arrived at downgradient well 199-K-32A in fall 2000 (see Section 5.2 for further discussion of rate).

4.3 Sources of Groundwater Contamination Adjacent to K Basins

Additional past-practices waste sites that are potential sources for contaminants common to the fuel storage basins are present near each of the K Reactor complexes (see Figure 1.3). None are currently operating; disposal to these sites ended with the shutdown of the reactors in 1971. However, because the vadose zone beneath these sites contains residual amounts of contamination, continual downward movement into groundwater occurs. The following brief descriptions are summarized from the technical baseline report for the 100-KR-4 Operable Unit (Carpenter and Coté 1994) unless otherwise cited.

4.3.1 Reactor Atmosphere Gas Condensate Cribs

These cribs are located approximately 30 meters (100 feet) to the east of each reactor building, beneath gravel-covered areas currently used as parking space. The crib at KE Reactor is designated the 115-KE Condensate Crib (waste site 116-KE-1) and at KW Reactor the 115-KW Condensate Crib (waste site 116-KW-1). Each received an estimated 800,000 liters (21,120 gallons) of condensate effluent from the reactor gas purification systems during the reactor operating years of 1955 to 1971. The most abundant and mobile contaminants were carbon-14 and tritium, with each crib receiving approximately 100 curies of each radionuclide. During the operating years, no groundwater monitoring wells were installed downgradient of the cribs, so their effect on groundwater conditions was unknown.

Groundwater monitoring wells constructed in 1992 are located approximately 40 meters (130 feet) downgradient from each crib. Elevated tritium and carbon-14 concentrations are detected at each of these wells, indicating a continual downward migration of contamination from past disposal which maintains the current plumes. At the KE Condensate Crib, evidence suggests that the rate of downward migration is enhanced by infiltration of moisture from the surface (i.e., rainfall and snow melt). Remediation of these cribs is scheduled to follow completion of spent fuel transfer from the fuel storage basins.

4.3.2 Fuel Storage Basins Drain Fields

Each fuel storage basin had a sub-basin moisture collection system that routed effluent to a drain field, which included a vertical steel casing extending downward to approximately 3 meters (10 feet) below the water table. At KE Reactor the drain field is designated the KE Basin French drain or reverse well (waste site 116-KE-3) and at the KW Reactor it is referred to as the KW Basin French drain/reverse well (waste site 116-KW-2). The drain fields were used during the operating years (1955 to 1971) and were physically disconnected from the sub-basin moisture collection systems during 1977 to 1978. No groundwater monitoring wells were in existence downgradient of these drain fields during the years that they were in operation, so the magnitude of their effect on groundwater is unknown.

Residual amounts of radionuclides (e.g., strontium-90 and cesium-137) are likely to remain in the vadose zone beneath these waste sites. Monitoring wells constructed in 1992 are located close to each of the drain fields. At the KE drain field, vadose zone contamination has apparently been remobilized in recent years by above-normal infiltration of water from the surface, which was caused by fire hydrant utility line breaks (Johnson et al. 1998, p. 2.20).

4.3.3 Miscellaneous Disposal and Unplanned Release Sites

The 1706-KER waste crib (waste site 116-KE-2) is located near the southwest corner of the KE Reactor building. The crib received effluent from the test and experimental facilities housed in the 1706-KE building laboratories. A primary contributor to the effluent was depleted ion exchange resins that were flushed to the crib. It is estimated 3 million liters (79,200 gallons) of liquid waste was disposed to the crib during the operating years (1955 to 1971). Cobalt-60, cesium-137, tritium, and strontium-90 are typical radiological constituents of the waste. An estimated 100,000 kilograms (220,500 pounds) each of sodium hydroxide and sulfuric acid also may have been disposed to the crib.

Numerous septic systems were in use around the reactor buildings during the operating years, and some remain in use today to support operations at the fuel storage basins. Table 4.2 presents a summary of known septic systems. Their operation is probably responsible for some or all of the nitrate contamination detected in 100-K Area groundwater.

Along the south side of the water treatment basins for each reactor were large storage tanks that contained sodium dichromate stock solution, which was transported to the area via railcars. The sodium dichromate was added to the reactor coolant water as a corrosion inhibitor. It was added to form a concentration of 2.0 ± 0.2 ppm as $Na_2Cr_2O_7 \bullet 2H_2O$ (HAPO 1953, pp. 6-1 to 6-2). This equates to a dissolved chromium concentration of 700 µg/L. Spillage and leakage of the stock solution occurred, and the chromium currently detected upgradient of the KE Reactor and around the KW Reactor is likely to have come from these storage tank and chemical transfer sites.

Table 4.2. Septic Systems in the 100-K Area During Reactor Operating Years

Septic Tank Designation	Location and Facilities Supported	Disposal Rate L (gal) per day
1607-K1	Near south entrance to 100-K Area; supported 1701-K badgehouse, 1720-K Patrol change room, and 1721-K trailer	1,987 (525)
1607-K2	South side of water treatment basins, just west of the 183.1-KE building; supported 183-KE water treatment plant	1,324 (350)
1607-K3	South side of water treatment basins, just west of the 183.1-KW building; supported 183-KW water treatment plant	Unknown
1607-K4	Between 105-KW and 105-KE reactor buildings; (no other details available)	Unknown
1607-K5	East of 105-KE reactor building; supported 1706-KER laboratory, 1706-K water treatment laboratory, 165-KE powerhouse, 105-KE reactor building, and 115-KE gas recirculation system	2,649 (700)
1607-K6	East of 105-KW reactor building; (no other details available; probably similar functions as 1607-K5)	Unknown
Source: Modified after Carpenter and Coté (1994, Table 6-2).		

The 100-K Burial Ground (waste site 118-K-1), located to the east of the KE Reactor complex, is not normally considered a source for contaminants that show up in groundwater because liquid effluents were discharged to other facilities specifically designed for soil column disposal. However, recent evidence suggests that certain irradiated solid materials have the capacity to generate tritiated moisture in sufficient amounts to affect the underlying groundwater. This is suspected to have occurred at the 618-11 Burial Ground in the southern part of the Hanford Site (Dresel et al. 2000). Similar underground features and historical use of the 100-K Burial Ground, and an increase in tritium concentrations in nearby groundwater, create the suspicion that a similar situation may exist at the 100-K Area.

5.0 Geohydrologic Setting

The geohydrologic characteristics and groundwater contaminant conditions beneath the 100-K Area are described in detail in several readily-available documents. The reader is referred to the following documents for that information:

Geologic Characteristics

Hydrogeology of the 100-K Area, Hanford Site, South-Central Washington (Lindberg 1995)

Hydrology and Groundwater Contaminant Characteristics

Conceptual Site Models for Groundwater Contamination at 100-BC-5, 100-KR-4, 100-HR-3, and 100-FR-3 Operable Units, Hanford Site (Peterson et al. 1996)

Current Conditions

100-K Area (Peterson and McMahon 2002)

Groundwater Remediation Activities

Annual Summary Report: Calendar Year 2001 for the 100-HR-3, 100-KR-4, and 100-NR-2 Operable Units and Pump-and-Treat Operations (DOE/RL 2002)

A brief overview of the geologic, hydrologic, and contaminant conditions is presented in the following sections for the reader's convenience.

5.1 Geology

Figures 5.1, 5.2, and 5.3 are cross sections oriented perpendicular and parallel to the Columbia River, respectively. The vadose zone beneath the 100-K Area consists of approximately equal thicknesses of Hanford formation sediment ("Pasco Gravels") and Ringold Formation Unit E. Both sedimentary sequences are of fluvial origin and are typically comprised of coarse-grained materials. The Pasco Gravels are generally more transmissive than Ringold Unit E sediment. The uppermost saturated unit is within Ringold Unit E sediment. Columbia River Basalt underlies the Ringold Formation.

Earthquake activity near the 100-K Area is restricted to minor earthquakes associated with the Coyote Rapids swarm, which lies beneath the Columbia River in the vicinity of the 100-B/C, 100-K, 100-N, and 100-D Areas. Seismic events within this swarm area are all less than magnitude 3 and are not typically noticed in the 100-K Area. No events from this swarm area have triggered the strong motion accelerometer that is located just south of the 100-K Area, which has been in operation since 1998. However, the accelerometer was triggered by the magnitude 6.8 Nisqually earthquake, which occurred on February 28,

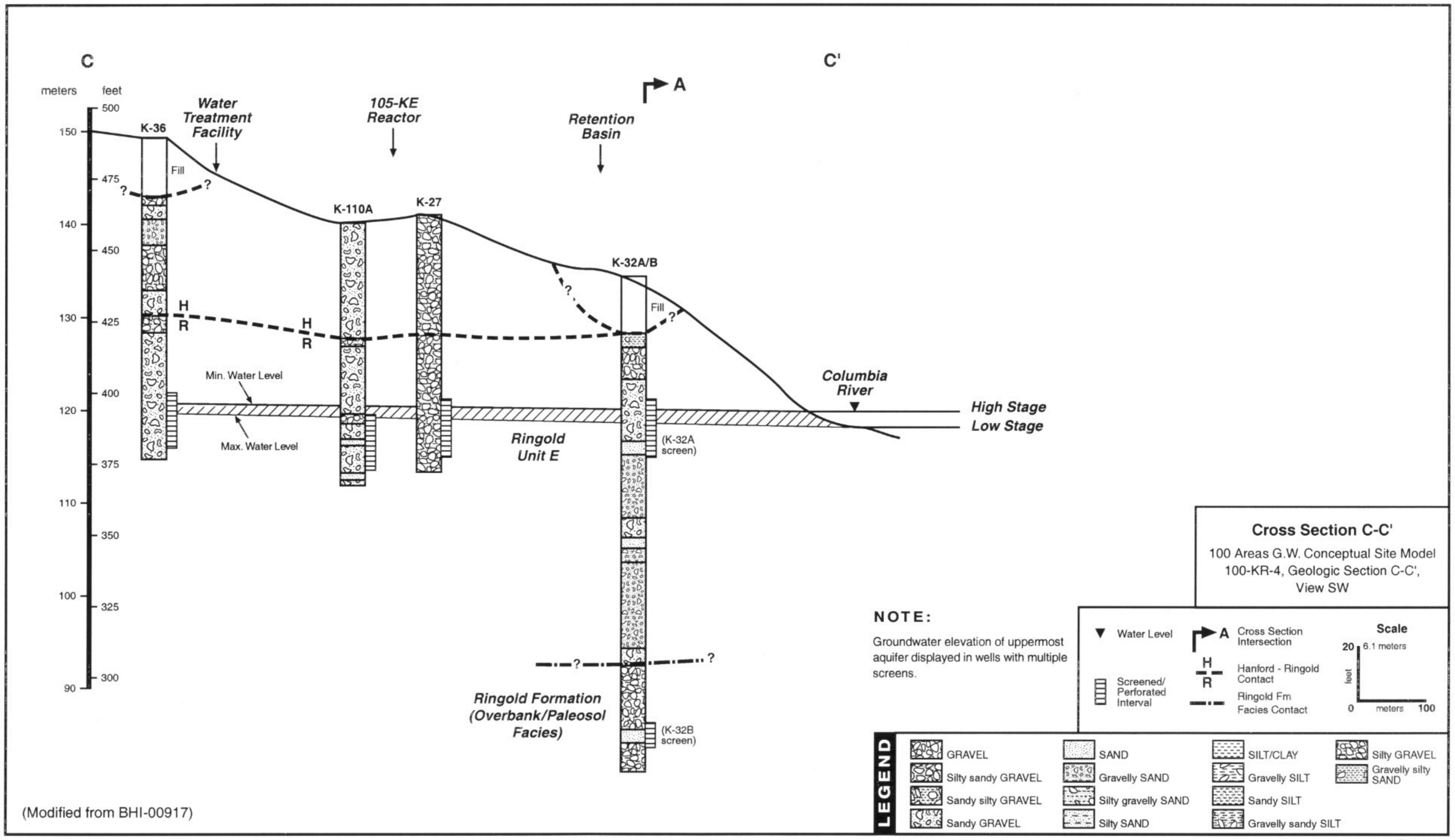

Figure 5.1. Hydrogeologic Cross Section Perpendicular to the Columbia River

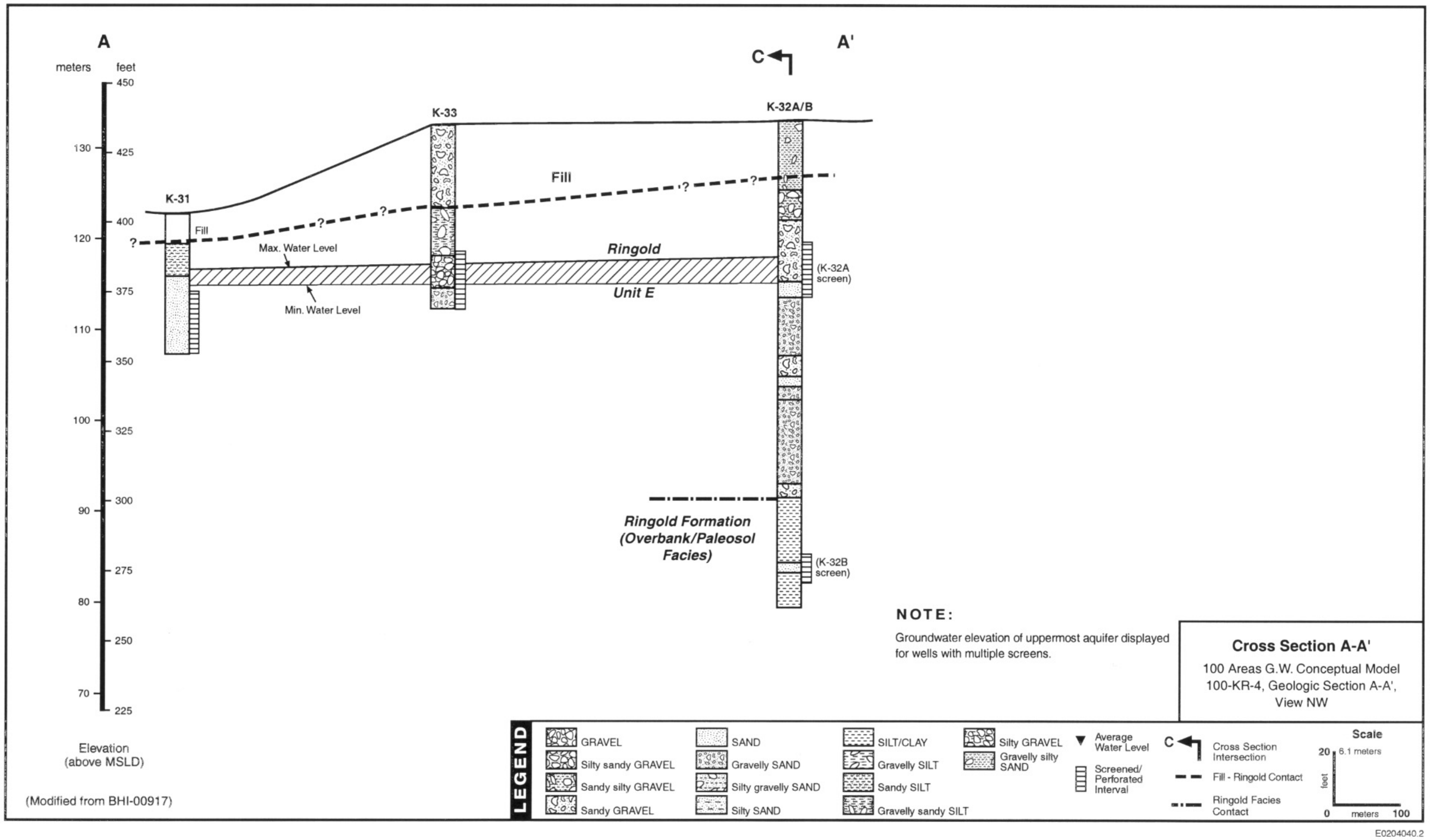

Figure 5.2. Hydrostratigraphic Cross Section Parallel to the Columbia River Downgradient of Reactors

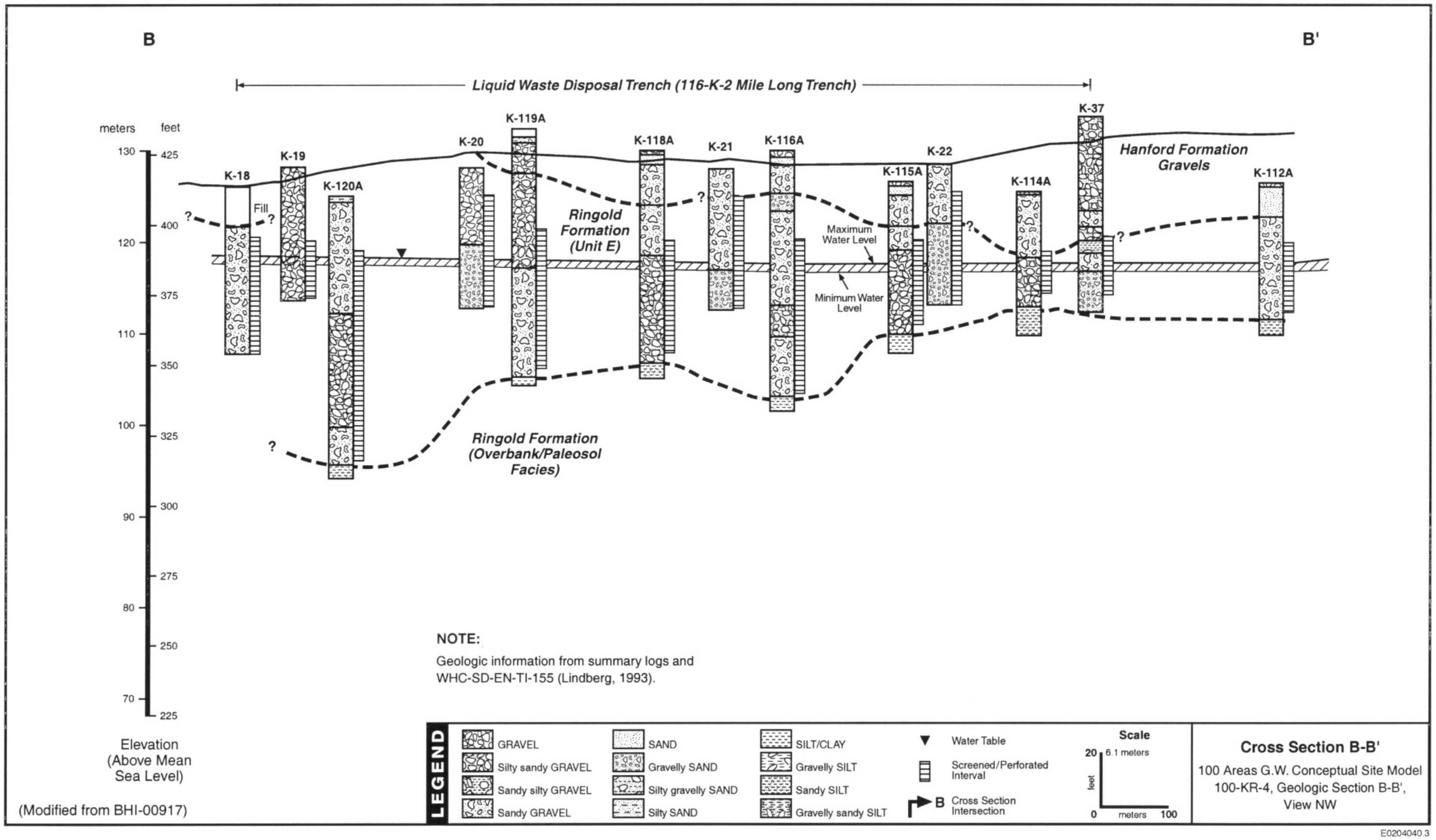

Figure 5.3. Hydrostratigraphic Cross Section Parallel to the Columbia River Downgradient of 100-K Trench

2001 (Hartshorn et al. 2001). This earthquake was clearly felt by those present in the 100-K Area facilities at the time. Of the five strong motion accelerometers on the Hanford Site, those at 100-K and 200 East Areas recorded the highest accelerations, which were approximately 0.002 to 0.003 g (gravity) for vertical motion, and 0.002 to 0.005 g for horizontal motion.

5.2 Aquifer Characteristics

The uppermost hydrologic unit (i.e., water-table aquifer) is the saturated portion of Ringold Formation Unit E. This unit consists of poorly sorted fluvial gravel and fluvial sand facies. In general, the unit is considered moderately transmissive to groundwater movement. Unit E is underlain by less transmissive fine-grained sediment of predominantly mud and sand mud facies that is associated with paleosols and fluvial overbank depositional environments. The contact between the two units is considered the bottom of the uppermost aquifer.

The water-table elevation beneath the 100-K Area is shown in Figure 5.4. The average elevation detected in 100-K Area monitoring wells during the period August 1992 to August 1995 is listed in Table 5.1. This period was chosen to illustrate the variability in elevations observed at each well in response to changes in river stage elevation. These years represent moderately low Columbia River discharge conditions, so average elevations may be higher during periods of greater discharge (e.g., during 1996 and 1997). However, abundant measurements were available for this period, thus providing a statistically more significant record of how responsive each well is to river stage changes. Note that the observed range in elevations generally decreases with increasing distance inland from the river, although this is not always true. Water levels in wells situated in more transmissive sediment (i.e., greater vertical hydraulic conductivity) will show a greater response to river stage fluctuations than those in less transmissive sediment.

The depth from the surface to the water table (depth-to-water) in 100-K Area wells generally falls in the range of approximately 6 to 30 meters (20 to 100 feet). A summary of all depth-to-water measurements made between January 1990 and January 2002 is presented in Table 5.2. This broad period of measurements illustrates the total range through which the water table may vary at a particular well and covers several multi-year drought and flood cycles of the Columbia River. (Note: Values in Table 5.2 are presented in feet, to be consistent with the units normally used in the field and on well construction and geologic logs.)

The hydraulic conductivity for the uppermost hydrologic unit has been measured using slug tests in the range 6 to 44 meters (19 to 145 feet) per day in a variety of 100-K Area wells (DOE/RL 1994). Porosities measured for sediment samples collected during well drilling have ranged from 10 to 40% for the uppermost aquifer (Williams 1994). Based on these discreet measurements and other more recent information, it is believed that representative values for hydraulic conductivity fall in the range 5 to 25 meters (16.4 to 82 feet) per day, and for effective porosity in the range 15 to 20%.

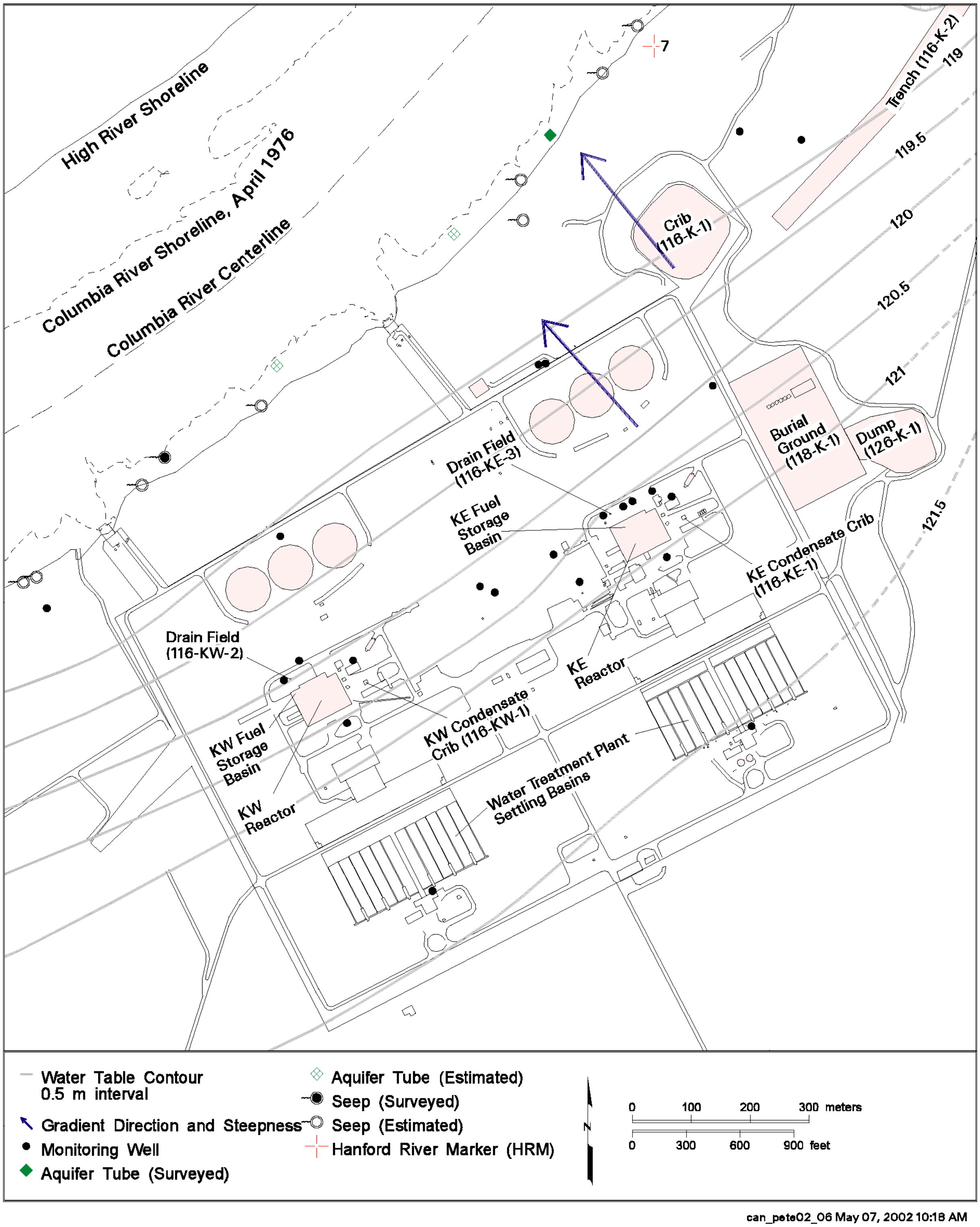

Figure 5.4. Water-Table Map for the 100-K Area (March 2001 Conditions)

Table 5.1. Average Water-Table Elevations in 100-K Area Wells

Well Name	Distance Inland[a] (m)	Average Elevation[b] (m)NAVD88)	Minimum Elevation (m)NAVD88)	Maximum Elevation (m)NAVD88)	Elevation Range (m)	Number of Results	Primary Use[c] (FY 2002)
Wells Near the 100-K Trench (interim remedial action for chromium contamination)							
199-K-20	380	118.71	117.2	119.5	2.3	36	Compliance-IRM
199-K-21	405	118.52	118.0	119.3	1.3	34	Performance-IRM
199-K-18	445	118.91	118.4	119.7	1.4	48	Compliance-IRM
199-K-22	475	118.63	118.2	119.3	1.1	35	Performance-IRM
199-K-37	520	118.89	118.6	119.3	0.7	34	Performance-IRM
199-K-19	535	119.07	118.6	119.7	1.2	38	Performance-IRM
Wells Near the K-East Reactor Complex							
199-K-32A	460	119.49	118.8	121.2	2.3	52	Fuel storage basin
199-K-11	680	120.27	119.9	120.8	0.9	39	Long-term monitoring
199-K-13	700	120.30	119.9	120.9	0.9	42	Long-term monitoring
199-K-111A	700	120.38	119.9	121.4	1.5	13	Long-term monitoring
199-K-109A	710	120.77	120.3	122.2	2.0	17	Fuel storage basin
199-K-27	720	120.68	120.3	121.3	1.0	63	Fuel storage basin
199-K-28	725	120.57	119.6	121.0	1.4	49	Fuel storage basin
199-K-29	740	120.67	119.8	121.5	1.7	35	Fuel storage basin
199-K-23	765	120.81	120.5	121.2	0.7	36	Long-term monitoring
199-K-30	770	120.79	120.4	121.4	1.0	53	Fuel storage basin
199-K-110A	840	120.95	120.7	121.4	0.7	15	Fuel storage basin
199-K-36	1140	121.71	121.4	121.9	0.5	36	Long-term monitoring
Wells Near the K-West Reactor Complex							
199-K-31	290	118.72	117.8	119.8	2.1	31	Long-term monitoring
199-K-33	400	118.91	118.1	120.1	2.0	32	Fuel storage basin
199-K-34	590	120.02	119.6	120.7	1.1	50	Fuel storage basin
199-K-107A	600	120.09	119.6	120.7	1.0	14	Fuel storage basin
199-K-106A	645	120.25	119.0	121.1	2.1	23	Fuel storage basin
199-K-108A	720	120.56	120.0	121.4	1.4	14	Fuel storage basin
199-K-35	1035	121.55	121.3	121.8	0.5	31	Long-term monitoring
Wells That Monitor Hydrologic Units Below the Water Table Aquifer							
199-K-32B	460	121.98	121.6	122.5	1.0	27	Long-term monitoring
Wells Located Inland (Upgradient) from the 100-K Area							
699-72-73	880	121.71	121.5	122.0	0.5	38	Long-term monitoring
699-78-62	1740	121.09	120.2	121.4	1.2	34	Long-term monitoring
699-70-68	2015	122.33	122.1	122.6	0.4	42	Long-term monitoring
699-73-61	3000	122.34	122.1	122.6	0.5	40	Long-term monitoring

(a) Distance inland is measured from the Columbia River mid-channel centerline.
(b) Average elevation for the period August 1992 through August 1995; outliers removed.
(c) Primary use refers to monitoring project most dependent on groundwater samples from the well.
IRM = Interim remedial measure.

Table 5.2. Average Depth-to-Water in 100-K Area Wells

Well Name	Distance Inland[a]	Average DTW[b] (ft)	Minimum DTW (ft)	Maximum DTW (ft)	DTW Range (ft)	Number of Results	Primary Use[c] (FY 2002)
Wells Near the 100-K Trench (interim remedial action for chromium contamination)							
199-K-117A	325	30.06	21.3	34.3	13.0	54	Compliance-IRM
199-K-114A	350	25.38	20.3	28.9	8.7	57	Compliance-IRM
199-K-112A	370	26.59	23.3	29.0	5.6	37	Extraction-IRM
199-K-20	380	34.78	26.5	40.8	14.3	104	Compliance-IRM
199-K-113A	385	24.78	23.6	26.0	2.4	2	Extraction-IRM
199-K-115A	390	24.62	24.6	24.6	0.0	1	Extraction-IRM
199-K-118A	400	34.10	33.2	35.0	1.8	2	Performance-IRM
199-K-120A	400	19.71	18.1	21.3	3.2	2	Extraction-IRM
199-K-21	405	36.29	31.8	39.2	7.4	50	Performance-IRM
199-K-18	445	22.32	14.1	25.8	11.7	107	Compliance-IRM
199-K-116A	460	36.28	35.4	37.2	1.8	2	Extraction-IRM
199-K-22	475	38.59	34.7	43.3	8.6	50	Performance-IRM
199-K-119A	510	42.80	41.9	43.7	1.8	2	Extraction-IRM
199-K-37	520	54.50	47.4	56.9	9.5	54	Performance-IRM
199-K-19	535	34.19	27.1	37.6	10.5	63	Performance-IRM
199-K-126	565	70.17	68.0	72.1	4.1	26	Compliance-IRM
Wells Near the K-East Reactor Complex							
199-K-32A	460	55.08	48.9	58.1	9.2	78	Fuel storage basin
199-K-11	680	74.73	70.0	77.6	7.6	59	Long-term monitoring
199-K-13	700	74.25	71.8	76.3	4.6	45	Long-term monitoring
199-K-111A	700	70.34	66.3	72.8	6.5	33	Long-term monitoring
199-K-109A	710	74.25	69.8	78.0	8.2	88	Fuel storage basin
199-K-27	720	73.11	68.2	76.5	8.3	144	Fuel storage basin
199-K-28	725	73.00	67.6	77.0	9.4	81	Fuel storage basin
199-K-29	740	73.96	68.8	77.7	8.9	69	Fuel storage basin
199-K-23	765	75.09	69.8	77.8	8.0	45	Long-term monitoring
199-K-30	770	72.17	67.6	75.6	8.0	144	Fuel storage basin
199-K-110A	840	73.37	68.5	76.5	8.0	42	Fuel storage basin
199-K-36	1140	97.93	94.6	102.6	8.0	66	Long-term monitoring
Wells Near the K-West Reactor Complex							
199-K-31	290	26.45	22.1	29.7	7.6	41	Long-term monitoring
199-K-33	400	56.89	50.5	59.7	9.1	42	Fuel storage basin
199-K-34	590	76.98	70.1	80.1	10.0	85	Fuel storage basin
199-K-107A	600	75.99	71.1	79.6	8.5	45	Fuel storage basin
199-K-106A	645	74.76	68.2	80.4	12.2	91	Fuel storage basin

Table 5.2. (contd)

Well Name	Distance Inland[(a)]	Average DTW[(b)] (ft)	Minimum DTW (ft)	Maximum DTW (ft)	DTW Range (ft)	Number of Results	Primary Use[(c)] (FY 2002)
199-K-108A	720	75.18	69.1	79.0	9.9	45	Fuel storage basin
199-K-35	1035	99.27	97.9	101.6	3.7	38	Long-term monitoring
Wells That Monitor Hydrologic Units Below the Water Table Aquifer							
199-K-32B	460	48.49	45.7	50.0	4.3	34	Long-term monitoring
Wells Located Inland (Upgradient) of the 100-K Area							
699-72-73	880	85.91	81.5	89.3	7.8	69	Long-term monitoring
199-K-121A	930	72.11	71.7	72.5	0.8	2	Injection-IRM
199-K-122A	1055	70.69	70.4	71.0	0.6	2	Injection-IRM
199-K-123A	1075	72.07	71.7	72.4	0.7	2	Injection-IRM
199-K-124A	1090	71.74	71.4	72.1	0.7	2	Injection-IRM
699-78-62	1740	75.41	73.7	78.7	5.0	55	Long-term monitoring
699-70-68	2015	127.86	125.5	130.4	4.9	63	Long-term monitoring
699-73-61	3000	133.24	131.5	134.9	3.5	63	Long-term monitoring

(a) Distance inland is measured from the Columbia River mid-channel centerline.
(b) Average depth-to-water (DTW) for measurements taken between January 1990 and January 2002; outliers removed.
(c) Primary use refers to monitoring project most dependent on measurements from this well.
IRM = Interim remedial measure.

5.3 Groundwater Movement

The long-term average hydraulic gradient for the water table (see Figure 5.4) is oriented toward the river and ranges between 0.003 and 0.005, based on historical data. The gradient arrows shown on Figure 5.4 are based on September 2001 water-table elevation data collected from wells surrounding the arrows (Table 5.3). Given the typical values for hydraulic parameters described above and the range in gradients, the average linear flow velocity can be calculated using the Darcy equation. Velocities calculated in this manner are provided in Table 5.4. Groundwater flow velocity is believed to most likely be in the range approximately 0.1 to 0.4 meters (1.3 feet) per day.

Previous determinations of groundwater flow direction and rate in 100-K Area wells include a test in February 1993 of the KV Associates ™ (KV Associates, Inc., Falmouth, MA) borehole flowmeter.[13] This instrument measures flow direction and velocity using a heat-pulse probe/thermistor arrangement (Kerfoot 1988). The results for well 199-K-30 indicated a flow direction of 325 degrees (azimuth clockwise from true north) and a velocity of 1.13 meters (3.7 feet) per day, which more recent evidence suggests is anomalously high for velocity. Near the KW Reactor complex, results from well 199-K-34 indicate a direction of 300 degrees and a velocity of 0.24 meter (0.8 feet) per day, which is in better

[13] Letter report from D. B. Barnett (Westinghouse Hanford Company, Richland, Washington) to J. W. Roberts (Westinghouse Hanford Company) *Brief Summary of K-Area Flowmeter Application*, dated May 4, 1993.

Table 5.3. Summary of Groundwater Flow Direction and Velocity Estimates

Method	Location	Velocity: (meters/day)	Direction (gradient)	Assumptions	Ref
Darcy Flow Equation	Vicinity of K Reactors	0.01 ~ 0.4	North/northwest	K = 0.95 ~ 16 m/d n = 20% grad = 0.003 ~ 0.005	(a)
KV Associates Flowmeter	Near KE Reactor (well 199-K-30)	1.13	325 degrees	Flow in borehole is representative of flow in aquifer	(b)
KV Associates Flowmeter	Near KW Reactor (well 199-K-34)	0.24	300 degrees	Flow in borehole is representative of flow in aquifer	(b)
KV Associates Flowmeter	Inland of KW Reactor (well 199-K-35)	0.15	335 degrees	Flow in borehole is representative of flow in aquifer	(b)
KV Associates Flowmeter	Near KW Reactor (well 199-K-106A)	0.63	342 degrees	Flow in borehole is representative of flow in aquifer	(a)
Tritium Plume Migration	KE Reactor to river	0.12	North/northwest	Same plume front at each well	(d)
Tritium Plume Migration	KW Reactor to river	0.89	North/northwest	Same plume front at each well	(d)
Trend-Surface Analysis (steel tape data)	KE Reactor to river (K-30, K-32A, and K-111A)	0.22	325 degrees (0.0043 grad)	K = 10 m/d n = 20% (1994 to present)	(e)
Trend-Surface Analysis (transducer data)	KE Reactor to river (K-30, K-32A, and K-111A)	0.24	318 degrees (0.0047 grad)	K = 10 m/d n = 20% (September 2001)	(e)
Trend-Surface Analysis (transducer data)	KE Reactor to river (K-18, K-32A, and K-111A)	0.25	321 degrees (0.0049 grad)	K = 10 m/d n = 20% (September 2001)	(e)

Abbreviations: K = hydraulic conductivity; n = effective porosity; and grad = hydraulic gradient (direction is measured clockwise from true north).
(a) Johnson et al. 1995.
(b) Letter report from D. B. Barnett (WHC) to J. W. Roberts (WHC), Richland, Washington, *Brief Summary of K-Area Flowmeter Application*, dated May 4, 1993.
(c) Williams 1994.
(d) Peterson and McMahon 2002.
(e) Peterson et al. 2002.

agreement with current estimates for velocity. Measurements also were made in well 199-K-35, which is located farther inland near the former KW water treatment settling basins. Direction at that well was 335 degrees and velocity was 0.15 meter (0.5 feet) per day. For all three measurements, the direction indicated is consistent with the long-term configuration of the water table. Two out of the three velocity values seem reasonable, as judged by comparison to other evidence.

The KV Associates™ flowmeter was also used in well 199-K-106A in March 1994 (Williams 1994, pp. 6 and D4). This well is located near the northeast corner of the KW Reactor complex; its location is

Table 5.4. Groundwater Flow Velocities (meters/day) Calculated for 100-K Area Range of Hydraulic Properties

Hydraulic Conductivity (K) (m/d):	Hydraulic Gradient (grad):			
	0.003	0.004	0.005	0.006
	Effective Porosity (n) = 10%			
2	0.06	0.08	0.10	0.12
5	0.15	0.20	0.25	0.30
10	0.30	0.40	0.50	0.60
20	0.60	0.80	1.00	1.20
25	0.75	1.00	1.25	1.50
30	0.90	1.20	1.50	1.80
	Effective Porosity (n) = 15%			
2	0.04	0.05	0.07	0.08
5	0.10	0.13	0.17	0.20
10	0.20	0.27	0.33	0.40
20	0.40	0.53	0.67	0.80
25	0.50	0.67	0.83	1.00
30	0.60	0.80	1.00	1.20
	Effective Porosity (n) = 20%			
2	0.03	0.04	0.05	0.06
5	0.08	0.10	0.13	0.15
10	0.15	0.20	0.25	0.30
20	0.30	0.40	0.50	0.60
25	0.38	0.50	0.63	0.75
30	0.45	0.60	0.75	0.90

Note: Average linear flow velocity in meters per day, calculated using the Darcy equation: vel = (K) x (1/n) x (grad). Ranges in hydraulic parameters are representative of the unconfined aquifer beneath the 100-K Area.

analogous to well 199-K-30 at the KE Reactor complex. The direction of flow was determined to be 342 degrees, with a velocity of 0.63 meters (2.07 feet) per day, assuming an effective porosity of 20 percent.

Estimates for contaminant transport flow velocities and travel times to the river were prepared in 1995 as background information for the K Basins groundwater monitoring plan (Johnson et al. 1995, pp. 2.12 to 2.16). That analysis suggested groundwater flow velocities in the range 0.01 to 0.4 meters (0.03 to 1.3 feet) per day, assuming hydraulic conductivities in the range 0.95 to 16 meters (3.1 to 52.5 feet) per day, an effective porosity of 20%, and gradients between 0.003 and 0.005. For movement between the KE Basin and the Columbia River when the gradient toward the river was steepest, the computed average linear flow velocity ranged between 0.014 and 0.24 meters (0.05 to 0.79 feet) per day, depending on the hydraulic conductivity value that was assumed for the computation.

The most recent direct evidence for the flow rate between the KE Reactor complex and the Columbia River suggests an average rate of approximately 0.12 meter (0.4 feet) per day. This estimate is based on the migration of a tritium plume associated with leakage from the KE Basin in 1993. Figure 5.5 shows tritium concentrations in well 199-K-27, located adjacent to the KE Basin on the downgradient side, and well 199-K-32A, located along the downgradient flowpath from the KE Basin to the Columbia River. The assumption is that the increase in tritium concentrations in each well represents the release of shielding water from the KE Basin in early 1993. Its arrival at well 199-K-32A approximately 6 years later is used to infer travel time and flow velocity. A similar analysis of a tritium pulse migration at the KW Reactor indicates a flow velocity of 0.89 meter (2.9 feet) per day between the KW Condensate Crib and well 199-K-33 (Figure 5.6). The higher apparent plume movement velocity near the KW Reactor is probably the result of more transmissive aquifer properties than those in the vicinity of the KE Reactor, although underground engineered structures could also influence the rate of plume migration.

In summary, groundwater flow direction and velocity in the 100-K Area have been estimated using a variety of methods, including the Darcy equation, direct measurement in wells, plume migration tracking, and analysis of hydraulic gradients (i.e., trend- surface analysis). A summary of those estimates is provided in Table 5.3. Groundwater appears to typically flow at a rate in the range of 0.1 to 1.0 meters (0.3 to 3.28 feet) per day, depending on location, with the most frequently determined rates in the range 0.2 to 0.3 meters (0.6 to 0.98 feet) per day.

An attempt has been made to illustrate the axis of flow downgradient from known sources for groundwater contamination near the KE Basin, which has leaked in the past. Based on water-table elevation data, “flow corridors” have been outlined along which a contaminant plume is expected to progress from a source. The analysis was initially completed in 1995 for the first fuel storage basins monitoring plan (Johnson et al. 1995). The illustration has been modified slightly for this revised monitoring plan and is shown in Figure 5.7. The shaded areas represent sectors through which the direction of groundwater flow may shift, depending on seasonal changes in the water-table configuration. Contaminant plumes that migrate through these sectors may spread laterally beyond the shaded areas because of dispersion and heterogeneity in aquifer properties.

5.4 Groundwater Contamination: Current Conditions

Contaminants of concern in 100-K Area groundwater include (in order of areal extent) the radionuclides tritium, carbon-14, and strontium-90, and the chemical constituents chromium, nitrate, and trichloroethene. Several additional constituents are at concentrations that occasionally exceed drinking water standards, but those occurrences are relatively isolated and do not represent widespread contaminant plumes. A listing of constituents that exceed drinking water standards for recent sampling results is provided in Appendix B.

The current (FY02) distribution of tritium and carbon-14 is shown in Figure 5.8 to illustrate the effect on groundwater caused by past leakage from the K Basins and past disposal to the nearby condensate cribs. The distribution of other radionuclides fall within the lateral limits of the tritium plume. Chromium is of concern in several wells near the KW Reactor, and nitrate exceeds the drinking water standard over a broad area. Trichloroethene slightly exceeds the standard in two wells downgradient of the KW Reactor complex. The distribution and trends of all these constituents are described more fully in the annual Groundwater Monitoring Project report (Peterson and McMahon 2002).

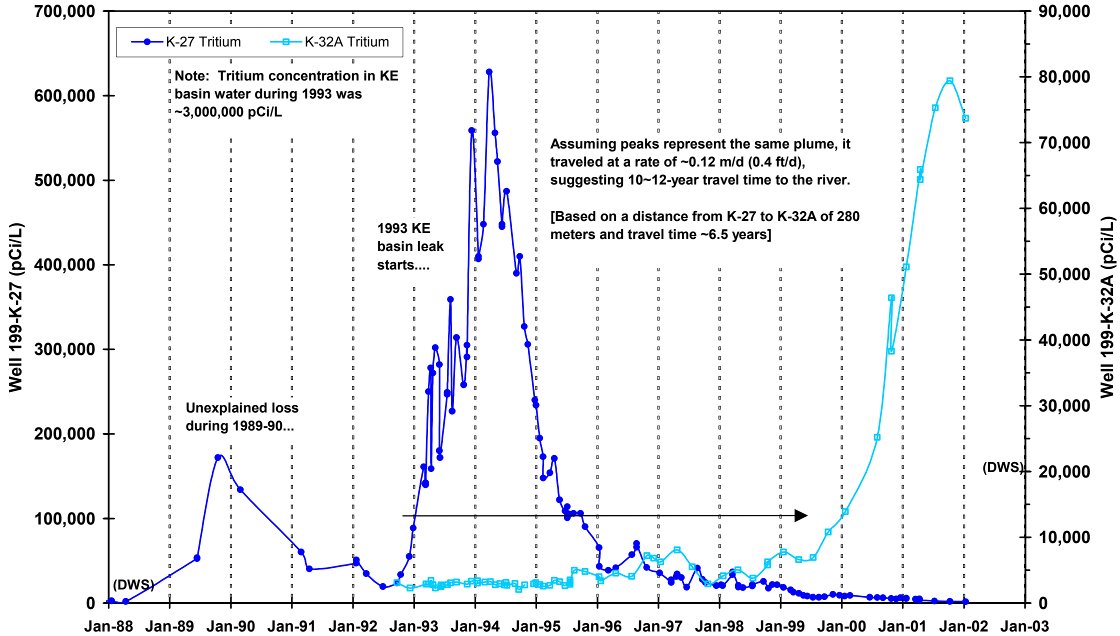

Figure 5.5. Plume Travel Velocity Downgradient from KE Basin

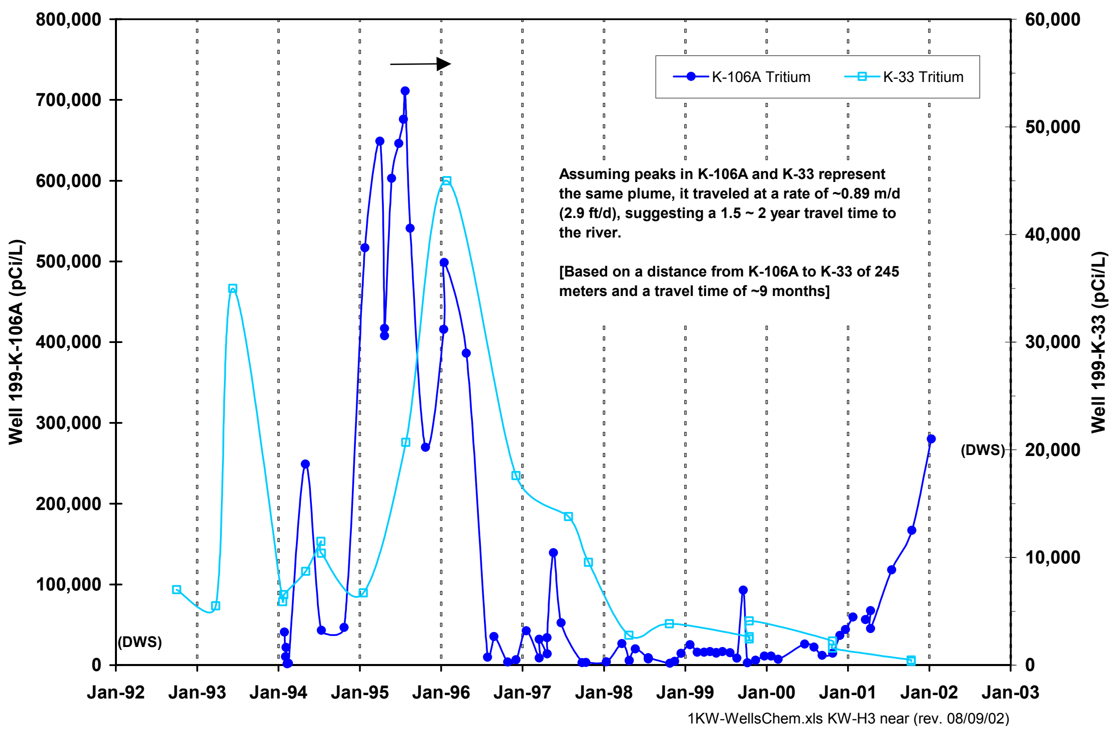

Figure 5.6. Plume Travel Velocity Downgradient from KW Condensate Crib

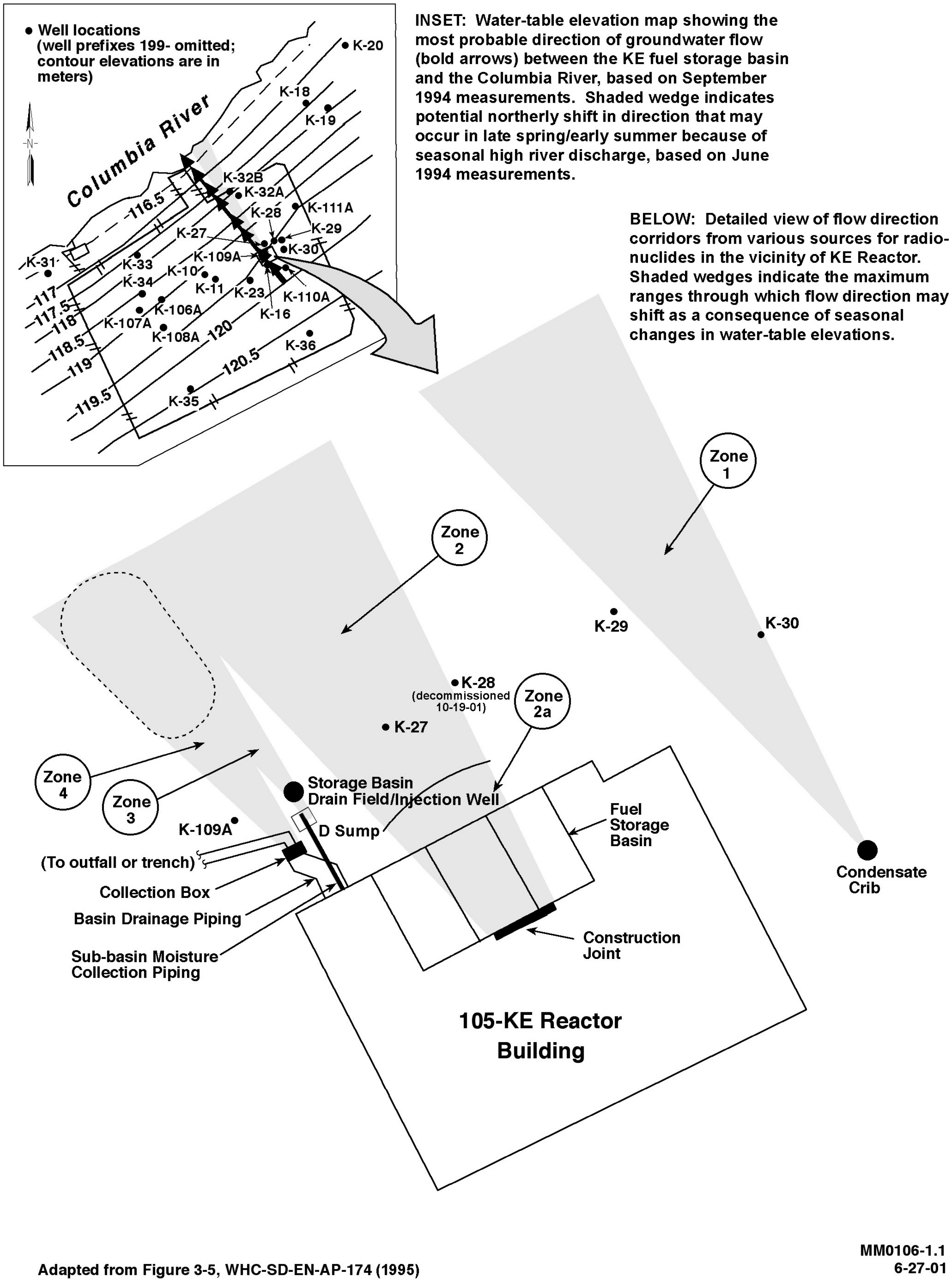

Figure 5.7. Flow Pathway Corridors Downgradient of KE Basin

FIGURE 5.7—EXPLANATION FOR SHADED ZONES 1 TO 5:

The areas downgradient of suspected sources where tritium, technetium-99, strontium-90, and other less mobile radionuclides may potentially migrate are illustrated by the shaded wedges labeled Zones 1 through 5. The wedges represent the range through which groundwater flow direction may vary because of seasonal changes in the water table. The initial width of each wedge reflects assumed dimensions at the point of entry to groundwater for contaminants from KE Basin leakage and past effluent disposal. (Sources are shown as bold circles and rectangles.) The left edge of each shaded zone reflects the flow direction indicated by September 1994 water table elevations, which are fairly representative of long-term low river stage conditions (see Inset). The right edge reflects flow direction indicated by June 1994 data, which represent short-term high river stage conditions. Contaminant plumes that move along these flow path corridors will have boundaries wider than the shaded areas, because of dispersion. Also, preferential flow channels in the unconfined aquifer, which may be created by natural stratigraphy or engineered structures, would alter the patterns suggested by the wedges. The actual locations downgradient of the various sources where radionuclides may have migrated depend on the release history, groundwater flow rate, and attenuation factors for each radionuclide (e.g., decay rate and soil adsorption coefficient).

<u>Zone 1</u> The source is a soil column disposal facility (crib) that received liquid effluent containing tritium and carbon-14. The effluent consisted of moisture removed from the inert gas that was circulated through the graphite pile of the KE Reactor between 1955 and 1971. The crib received an estimated 100 curies each of tritium and carbon-14. Infiltration of natural moisture through the crib and underlying soil column is the suspected process for continued downward transport of tritium and carbon-14 to groundwater. Plumes extending downgradient of this source suggest would likely be observed at wells K-30 and K-29, and possibly at K-32A.

<u>Zones 2 and 2a</u> These zones represent the downgradient directions expected for plumes created by leakage of KE Basin water via the construction joint between the basin and discharge chute (e.g., 1993 leakage). The pattern suggests that well K-27, possibly K-28, and K-32A are the wells likely to detect a tritium plume from the construction joint source. Strontium-90 moves more slowly than tritium, because of adsorption to sediment, but should follow the same direction corridor as tritium. Zone 2a illustrates the postulated extent of the 1993 leakage in the late 1990s. An increase in gross beta and strontium-90 in well K-27 has not yet been observed as of FY02.

<u>Zone 3</u> The source for this zone is the KE Basin drain field/injection well that received effluent from the sub-basin drainage collection system, which operated between 1955 and 1971. Installation of the "D Sump" in 1976 intercepted the line to the drain field and returned any sub-basin drainage back to the basin. A water volume recorder for this sump was installed in the early 1990's but has never indicated the presence of water in the sump. The shaded zone, which is shown as originating from the drain field (bold circle), D Sump, and the sub-basin drainage system piping, represents the direction taken by plumes created by potential leakage from these structures. The direction corridor does not include any existing monitoring wells, although dispersion of a plume with increasing distance from the source may result in K-32A intercepting a plume.

<u>Zone 4</u> The source for this zone is a piping collection box that received contaminated drain wastewater from the KE Reactor building and fuel storage basin, and may also have received basin overflow during normal reactor operations. Reactor building effluent sources ended in 1971 and the basin overflow was re-routed back to the basin by modifications made in 1975 to accommodate storage of irradiated fuel from N Reactor. Mobile basin water constituents (e.g., tritium) have had sufficient time to migrate to the river along this direction corridor; only less-mobile radionuclides (e.g., strontium-90) should be present currently (FY02). Considering the migration rate and travel time for strontium-90 from this source area, the current location for a plume, as suggested by the elliptical dashed line, would be considerably downgradient of well K-109A. Thus, it is unlikely that this potential past-practice source explains the elevated tritium and strontium-90 periodically observed at K-109A, unless contaminated basin water is inadvertently still being discharged to the collection box.

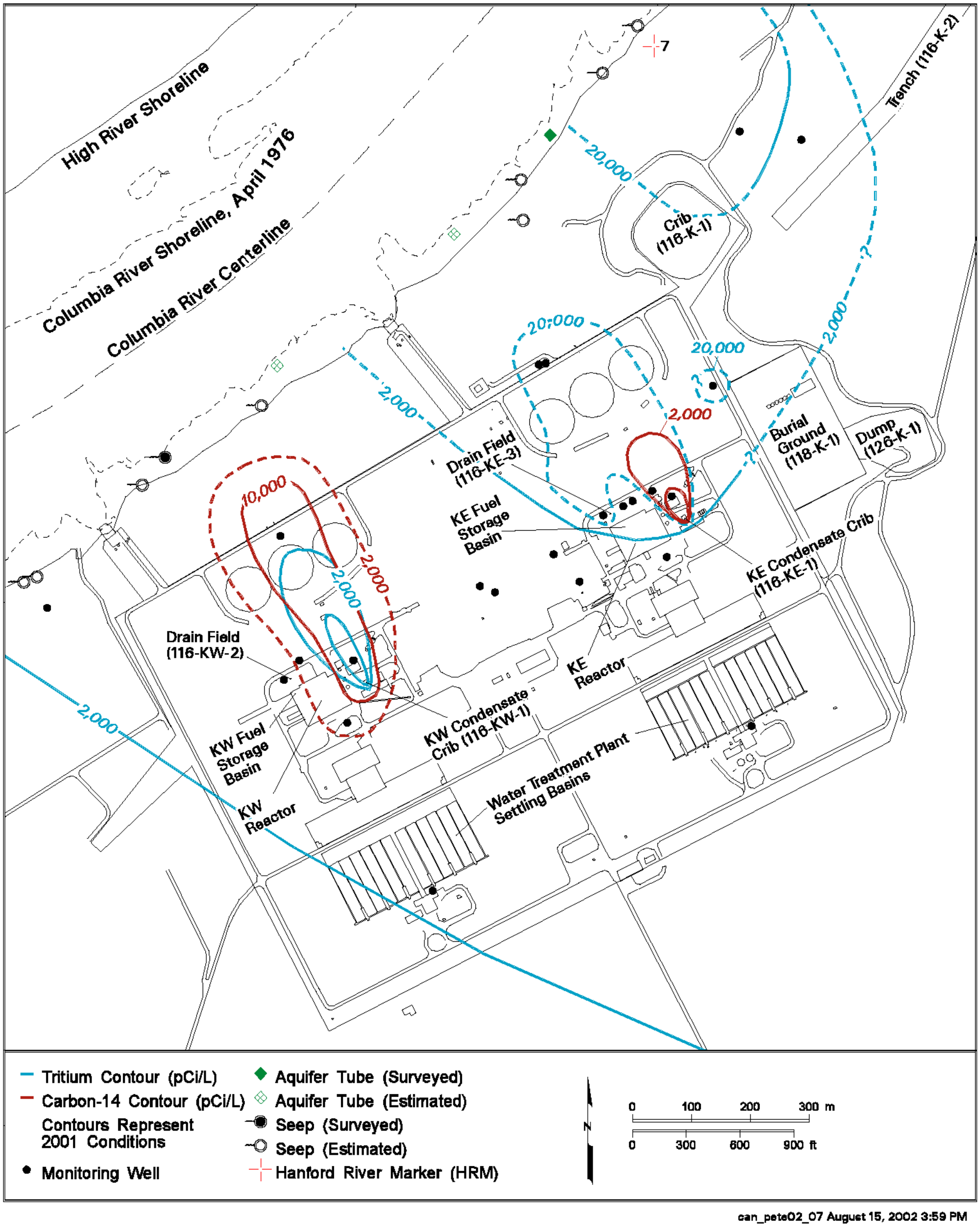

Figure 5.8. Tritium and Carbon-14 Plumes Downgradient of K Basins

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Appendix A

Integrated Sampling and Analysis Schedules for 100-K Area

Table A.1. Integrated Schedule for Groundwater Monitoring Wells and Riverbank Seepage Sites (FY02)

WELL	PROG	PROJ	Alkalinity	Alpha	Anions	Arsenic	Beta	Cr6+	Cyanide	DO	Gamma	Hg & Pb	I-129	ICP	Phenols	Sr-90	Tc-99	TDS	TOC	TOX	Tritium	Uranium	VOA	Other/Comments
199-K-11	CERC	100KR4		B	B		B				B			Bf/u							B			FY03
199-K-11	SURV	100K			A		A			A				Af							A			A:C14
199-K-18	CERC	100KR4		A	A		A	Mf			A			Af/u		A					A			
199-K-18	SURV	100K			A					A				Af							A			
199-K-19	CERC	100KR4		A	A		A	Sf			A			Af/u							A			
199-K-19	SURV	100K			A		A			A				Af							A			
199-K-20	CERC	100KR4		A	A		A	Mf			A			Af/u		A					A			
199-K-21	CERC	100KR4		A	A		A	Sf			A			Af/u							A			
199-K-21	SURV	100K								A						A								
199-K-22	CERC	100KR4		A	A		A	Sf			A			Af/u							A			
199-K-22	SURV	100K			A					A				Af		A					A			
199-K-23	CERC	100KR4		B	B		B				B			Bf/u							B			FY03
199-K-23	SURV	100K			A		A			A				Af										
199-K-27	CERC	100KR4		B	B		B				B			Bf/u		Q					B			
199-K-27	DOH	100K DOH		S	S		S				S										S			
199-K-27	SURV	100K BASIN		Q	Q		Q			Q						Q	Q				Q			
199-K-28	SURV	100K												Af										A:C14
199-K-28	SURV	100K BASIN		Q	Q		Q			Q											Q			
199-K-29	SURV	100K												Af										A:C14
199-K-29	SURV	100K BASIN		Q	Q		Q			Q											Q			
199-K-30	CERC	100KR4		B	B		B				B			Bf/u		Q					B			FY03. B:C14
199-K-30	SURV	100K	A											Af										A:C14
199-K-30	SURV	100K BASIN		Q	Q		Q			Q											Q			
199-K-31	CERC	100KR4		A	A		A				A			Af/u							A			
199-K-31	SURV	100K			A		A			A				Af			A				A			
199-K-32A	CERC	100KR4		A	A		A				A			Af/u							A			A:C14
199-K-32A	SURV	100K		Q	Q		Q			Q				Af			A				Q			A:C14
199-K-32B	CERC	100KR4		A	A		A				A			Af/u							A			Deep unconfined.
199-K-32B	SURV	100K	T		T					T				Tf							T			FY02. Deep unconfined.
199-K-33	CERC	100KR4		A	A		A				A			Af/u							A			A:C14
199-K-33	SURV	100K			A		A			A				Af							A		A	A:C14

Table A.1. (contd)

WELL	PROG	PROJ	Alkalinity	Alpha	Anions	Arsenic	Beta	Cr6+	Cyanide	DO	Gamma	Hg & Pb	I-129	ICP	Phenols	Sr-90	Tc-99	TDS	TOC	TOX	Tritium	Uranium	VOA	Other/Comments
199-K-34	CERC	100KR4		B	B		B				B			Bf/u							B			FY03. B:C14
199-K-34	SURV	100K												Af										A:C14
199-K-34	SURV	100K BASIN		Q	Q		Q			Q											Q			
199-K-35	CERC	100KR4		B	B		B				B			Bf/u							B			FY03.
199-K-36	CERC	100KR4		A	A		A	Qf			A			Af/u							A			A: Hg f/u
199-K-36	SURV	100K			A					A				Af							A			
199-K-37	CERC	100KR4		A	A		A	Sf			A			Af/u							A			
199-K-106A	CERC	100KR4		B	B		B				B			Bf/u							B			FY02. B:C14
199-K-106A	SURV	100K	A											Af									A	A:C14
199-K-106A	SURV	100K BASIN		Q	Q		Q			Q											Q			
199-K-107A	CERC	100KR4		A	A		A	Qf			A			Af/u							A			
199-K-107A	SURV	100K												Af										A:C14
199-K-107A	SURV	100K BASIN		Q	Q		Q			Q											Q			
199-K-108A	CERC	100KR4		A	A		A	Qf			A			Af/u							A			A:C14
199-K-108A	SURV	100K												Af										A:C14
199-K-108A	SURV	100K BASIN		Q	Q		Q			Q											Q			
199-K-109A	CERC	100KR4		A	A		A				A			Af/u		Q					A			
199-K-109A	DOH	100K DOH		S	S		S				S					S					S			S:C14, Pu-iso
199-K-109A	SURV	100K												Af										A:C14
199-K-109A	SURV	100K BASIN		Q	Q		M			M						Q	Q				M			
199-K-110A	CERC	100KR4		B	B		B				B			Bf/u							B			FY02
199-K-110A	SURV	100K												Af										A:C14
199-K-110A	SURV	100K BASIN		Q	Q		Q			Q											Q			
199-K-111A	CERC	100KR4		A	A		A				A			Af/u							A			A:C14
199-K-111A	SURV	100K		Q	A		Q			Q				Af			A				Q			A:C14
199-K-112A	ERC	100KR4 PT						Q								S					S			Extraction well.
199-K-113A	ERC	100KR4 PT						Q								S					S			Extraction well.
199-K-114A	CERC	100KR4						Mf								A					A			
199-K-114A	SURV	100K								A						A								
199-K-115A	ERC	100KR4 PT						Q								S					S			Extraction well.
199-K-116A	ERC	100KR4 PT						Q								S					S			Extraction well.

Table A.1. (contd)

WELL	PROG	PROJ	Alkalinity	Alpha	Anions	Arsenic	Beta	Cr6+	Cyanide	DO	Gamma	Hg & Pb	I-129	ICP	Phenols	Sr-90	Tc-99	TDS	TOC	TOX	Tritium	Uranium	VOA	Other/Comments
199-K-117A	CERC	100KR4						M4f								A					A			4 depth intervals for Cr.
199-K-117A	SURV	100K			A					A				Af		A								
199-K-119A	ERC	100KR4 PT						Q								S					S			Extraction well.
199-K-120A	ERC	100KR4 PT						Q								S					S			Extraction well.
199-K-125A	ERC	100KR4 PT						Q								S					S			Extraction well.
199-K-126A	CERC	100KR4						Mf								A					A			
699-70-68	CERC	100KR4		B	B		B				B			Bf/u							B			FY02
699-70-68	SURV	100K			A		A			A							A				A			
699-72-73	LTMC	100BC5		A	A		A							Af		A					A			
699-72-73	SURV	100K			A		A			A							A				A			
699-73-61	CERC	100KR4		B	B		B				B			Bf/u							B			FY02
699-78-62	CERC	100KR4		B	B		B				B			Bf/u							B			FY02
SK-057-3	CERC	100KR4		A	A		A				A			Af/u							A			
SK-063-1	SESP	Spring Seep			A																		A	
SK-077-1	CERC	100KR4		A	A		A				A			Af/u							A			
SK-077-1	SESP	Spring Seep			A																		A	
SK-082-2	CERC	100KR4		A	A		A				A			Af/u							A			

Abbreviations: A = annual; B = biennial (2 yrs); DO = dissolved oxygen; f = filtered; ICP = inductively coupled plasma; M = monthly; SA = semiannual; T = triennial (3 yrs); u = unfiltered; and VOA = volatile organic analysis.
Programs: CERC = CERCLA; LTMC = Long-term Monitoring (CERCLA); SURV = AEA Environmental Surveillance; SESP = Surface Environmental Surveillance Project
Source for table: FY 2002 Integrated Monitoring Plan for the Hanford Groundwater Monitoring Project (Hartman et al. 2001).

Table A.2. Aquifer Sampling Tube Sampling and Analysis Schedule (FY02)

Sample Location Name	HEIS Well ID No.	Area	Program	Project	*Offsite*				*Onsite*		
					Beta	Carbon-14	Sr-90	Tritium	Field parameters	Chromium	Nitrate
14-S	B8154	100-K	CERCLA	AQST					A		
14-M	B8153	100-K	CERCLA	AQST					A		
14-D	B8152	100-K	CERCLA	AQST	A		A	A	A	A	A
17-M	B8162	100-K	CERCLA	AQST					A		
17-D	B8161	100-K	CERCLA	AQST				A	A	A	A
18-S	B8204	100-K	CERCLA	AQST		A			A	A	
22-M	B8215	100-K	CERCLA	AQST					A		
22-D	B8214	100-K	CERCLA	AQST	A		A	A	A	A	
23-M	B8218	100-K	CERCLA	AQST					A		
23-D	B8217	100-K	CERCLA	AQST					A	A	
DK-04-2	B8526	100-K	CERCLA	AQST					A	A	
DK-04-3	B8527	100-K	CERCLA	AQST					A		

Abbreviations: A = annual sampling; AQST = aquifer sampling tube (see Peterson et al. 1998 [BHI-01153); HEIS = Hanford Environmental Information System.
Source for table: FY 2002 Integrated Monitoring Plan for the Hanford Groundwater Monitoring Project (Hartman et al. 2001).

References

CERCLA - *Comprehensive Environmental Response, Compensation, and Liability Act.* 1980. Public Law 96-510, as amended, 94 Statute 2767, 42 USC 9601 et seq.

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Peterson, R. E., J. V. Borghese, and D. B. Erb. 1998. *Aquifer Sampling Tube Installation Completion Report: 100 Area and Hanford Townsite Shorelines.* BHI-01153, Rev. 0, prepared by CH2M HILL Hanford, Inc. for Bechtel Hanford, Inc., Richland, Washington.

Appendix B

Recent Analytical Results in 100-K Area Wells

Table B.1. Summary of Recent Analytical Results Where Maximum Contaminant Levels are Exceeded in100-K Area Wells (January 1, 1999 to August 1, 2002)

Constituent	Filtered	Well Name	Number of Results	Number of Detects	Number of Outliers	Units	Minimum	Maximum	Average	Standard Value	Standard Reference	Number of Samples that Exceed
Aluminum	Yes	199-K-11	3	1	0	ug/L	93	93	93	50	SMCL	1
Aluminum	Yes	199-K-18	8	3	0	ug/L	20	60	44	50	SMCL	2
Aluminum	Yes	199-K-20	5	1	0	ug/L	73	73	73	50	SMCL	1
Aluminum	Yes	199-K-21	4	2	0	ug/L	28	57	43	50	SMCL	1
Aluminum	Yes	199-K-30	5	1	0	ug/L	98	98	98	50	SMCL	1
Aluminum	Yes	199-K-37	4	3	0	ug/L	25	62	43	50	SMCL	1
Aluminum	Yes	199-K-108A	5	4	0	ug/L	19	63	39	50	SMCL	1
Aluminum	No	199-K-18	5	4	0	ug/L	71	219	146	50	SMCL	4
Aluminum	No	199-K-20	5	2	0	ug/L	41	71	56	50	SMCL	1
Aluminum	No	199-K-21	4	4	0	ug/L	26	93	47	50	SMCL	1
Aluminum	No	199-K-32B	3	2	0	ug/L	26	64	45	50	SMCL	1
Aluminum	No	199-K-35	2	2	0	ug/L	116	248	182	50	SMCL	2
Aluminum	No	199-K-36	3	3	0	ug/L	44	208	147	50	SMCL	2
Aluminum	No	199-K-37	4	3	0	ug/L	25	75	48	50	SMCL	1
Aluminum	No	199-K-106A	2	2	0	ug/L	43	405	224	50	SMCL	1
Aluminum	No	199-K-107A	4	4	0	ug/L	59	639	418	50	SMCL	4
Aluminum	No	199-K-108A	3	2	1	ug/L	46	260	153	50	SMCL	1
Aluminum	No	199-K-109A	3	2	1	ug/L	95	284	189	50	SMCL	2
Aluminum	No	199-K-110A	2	2	0	ug/L	27	102	65	50	SMCL	1
Aluminum	No	199-K-111A	3	3	0	ug/L	30	691	274	50	SMCL	2
Carbon-14	No	199-K-29	3	3	0	pCi/L	2,380	4,400	3,133	2,000	MCL	3
Carbon-14	No	199-K-30	5	5	0	pCi/L	4,930	16,300	11,288	2,000	MCL	5
Carbon-14	No	199-K-33	6	6	0	pCi/L	6,590	13,400	10,480	2,000	MCL	6
Carbon-14	No	199-K-34	4	4	0	pCi/L	2,280	5,150	3,708	2,000	MCL	4
Carbon-14	No	199-K-106A	4	3	1	pCi/L	6,690	35,600	16,653	2,000	MCL	3
Carbon-14	No	199-K-108A	5	5	0	pCi/L	312	4,150	1,838	2,000	MCL	2
Chromium	Yes	199-K-18	8	8	0	ug/L	58	108	83	50	MCL	8
Chromium	Yes	199-K-19	4	4	0	ug/L	87	98	90	50	MCL	4
Chromium	Yes	199-K-20	5	5	0	ug/L	99	108	103	50	MCL	5
Chromium	Yes	199-K-21	4	3	0	ug/L	7	62	41	50	MCL	2
Chromium	Yes	199-K-22	3	3	0	ug/L	139	166	151	50	MCL	3
Chromium	Yes	199-K-23	3	3	0	ug/L	11	51	28	50	MCL	1
Chromium	Yes	199-K-34	4	3	0	ug/L	44	76	62	50	MCL	2
Chromium	Yes	199-K-36	4	4	0	ug/L	102	1,200	501	50	MCL	4

Table B.1. (contd)

Constituent	Filtered	Well Name	Number of Results	Number of Detects	Number of Outliers	Units	Minimum	Maximum	Average	Standard Value	Standard Reference	Number of Samples that Exceed
Chromium	Yes	199-K-37	4	4	0	ug/L	55	74	65	50	MCL	4
Chromium	Yes	199-K-107A	6	6	0	ug/L	412	586	520	50	MCL	6
Chromium	Yes	199-K-108A	5	4	0	ug/L	1	272	81	50	MCL	1
Chromium	Yes	199-K-112A	1	1	0	ug/L	57	57	57	50	MCL	1
Chromium	No	199-K-18	5	5	0	ug/L	60	119	90	50	MCL	5
Chromium	No	199-K-19	4	4	0	ug/L	87	95	91	50	MCL	4
Chromium	No	199-K-20	5	5	0	ug/L	97	128	119	50	MCL	5
Chromium	No	199-K-21	4	4	0	ug/L	20	58	43	50	MCL	2
Chromium	No	199-K-22	3	3	0	ug/L	149	188	165	50	MCL	3
Chromium	No	199-K-32A	3	3	0	ug/L	13	57	31	50	MCL	1
Chromium	No	199-K-32B	3	3	0	ug/L	15	66	44	50	MCL	1
Chromium	No	199-K-36	3	3	0	ug/L	314	1,310	772	50	MCL	3
Chromium	No	199-K-37	4	4	0	ug/L	59	76	71	50	MCL	4
Chromium	No	199-K-107A	4	4	0	ug/L	382	567	497	50	MCL	4
Chromium	No	199-K-108A	3	3	0	ug/L	17	54	41	50	MCL	2
Chromium	No	199-K-110A	2	2	0	ug/L	69	145	107	50	MCL	2
Gross beta	No	199-K-21	4	4	0	pCi/L	83	91	87	50	MCL	4
Gross beta	No	199-K-34	13	13	0	pCi/L	56	97	77	50	MCL	13
Gross beta	No	199-K-106A	12	7	0	pCi/L	6	50	21	50	MCL	1
Gross beta	No	199-K-107A	13	13	0	pCi/L	70	108	90	50	MCL	13
Gross beta	No	199-K-109A	33	32	1	pCi/L	475	23,800	7,713	50	MCL	32
Gross beta	No	699-70-68	3	3	0	pCi/L	54	89	72	50	MCL	3
Iron	Yes	199-K-20	5	3	0	ug/L	22	1,620	559	300	SMCL	1
Iron	Yes	199-K-21	4	3	0	ug/L	56	422	183	300	SMCL	1
Iron	No	199-K-18	5	5	0	ug/L	208	626	371	300	SMCL	2
Iron	No	199-K-20	5	5	0	ug/L	1,970	3,130	2,536	300	SMCL	5
Iron	No	199-K-21	4	4	0	ug/L	32	3,060	941	300	SMCL	2
Iron	No	199-K-23	1	1	0	ug/L	726	726	726	300	SMCL	1
Iron	No	199-K-31	3	3	0	ug/L	127	1,780	895	300	SMCL	2
Iron	No	199-K-35	2	2	0	ug/L	282	539	411	300	SMCL	1
Iron	No	199-K-36	3	3	0	ug/L	576	762	681	300	SMCL	3
Iron	No	199-K-106A	2	2	0	ug/L	61	774	417	300	SMCL	1
Iron	No	199-K-107A	4	4	0	ug/L	70	1,280	751	300	SMCL	3
Iron	No	199-K-108A	3	3	0	ug/L	59	1,900	868	300	SMCL	2
Iron	No	199-K-109A	3	3	0	ug/L	239	8,680	3,151	300	SMCL	2

Table B.1. (contd)

Constituent	Filtered	Well Name	Number of Results	Number of Detects	Number of Outliers	Units	Minimum	Maximum	Average	Standard Value	Standard Reference	Number of Samples that Exceed
Iron	No	199-K-110A	2	2	0	ug/L	894	1,390	1,142	300	SMCL	2
Iron	No	199-K-111A	3	3	0	ug/L	62	1,050	431	300	SMCL	1
Manganese	Yes	199-K-21	4	4	0	ug/L	2	104	48	50	SMCL	2
Manganese	Yes	199-K-109A	5	5	0	ug/L	1	82	19	50	SMCL	1
Manganese	No	199-K-20	5	5	0	ug/L	43	67	57	50	SMCL	3
Manganese	No	199-K-21	4	4	0	ug/L	5	194	68	50	SMCL	2
Manganese	No	199-K-109A	3	3	0	ug/L	6	248	88	50	SMCL	1
Manganese	No	699-73-61	2	2	0	ug/L	27	60	43	50	SMCL	1
Nickel	Yes	199-K-36	4	4	0	ug/L	31	121	76	100	MCL	1
Nickel	Yes	199-K-109A	5	5	0	ug/L	22	135	55	100	MCL	1
Nickel	Yes	199-K-110A	4	4	0	ug/L	29	104	76	100	MCL	1
Nickel	No	199-K-109A	3	3	0	ug/L	36	288	121	100	MCL	1
Strontium-90	No	199-K-20	4	4	0	pCi/L	9	17	13	8	MCL	4
Strontium-90	No	199-K-21	4	4	0	pCi/L	39	48	43	8	MCL	4
Strontium-90	No	199-K-22	3	3	0	pCi/L	6	9	7	8	MCL	1
Strontium-90	No	199-K-34	2	2	0	pCi/L	31	42	36	8	MCL	2
Strontium-90	No	199-K-107A	2	2	0	pCi/L	39	41	40	8	MCL	2
Strontium-90	No	199-K-109A	16	16	0	pCi/L	1,040	6,970	3,355	8	MCL	16
Strontium-90	No	199-K-113A	6	6	0	pCi/L	11	13	12	8	MCL	6
Strontium-90	No	199-K-114A	3	3	0	pCi/L	18	21	19	8	MCL	3
Strontium-90	No	199-K-115A	6	6	0	pCi/L	10	12	11	8	MCL	6
Trichloroethene	No	199-K-33	3	3	0	ug/L	8	11	9	5	MCL	3
Trichloroethene	No	199-K-106A	3	3	0	ug/L	11	23	18	5	MCL	3
Trichloroethene	No	199-K-107A	1	1	0	ug/L	5	5	5	5	MCL	1
Tritium	No	199-K-18	17	17	0	pCi/L	30,300	42,600	36,547	20,000	MCL	17
Tritium	No	199-K-29	13	13	0	pCi/L	8,490	98,300	33,145	20,000	MCL	7
Tritium	No	199-K-30	31	31	0	pCi/L	453,000	2,230,000	945,323	20,000	MCL	31
Tritium	No	199-K-32A	15	15	0	pCi/L	6,620	79,400	42,209	20,000	MCL	10
Tritium	No	199-K-106A	27	26	1	pCi/L	2,680	280,000	43,981	20,000	MCL	11
Tritium	No	199-K-109A	33	32	1	pCi/L	2,320	181,000	31,249	20,000	MCL	18
Tritium	No	199-K-111A	15	15	0	pCi/L	359	98,200	57,072	20,000	MCL	12

Table B.1. (contd)

Constituent	Filtered	Well Name	Number of Results	Number of Detects	Number of Outliers	Units	Minimum	Maximum	Average	Standard Value	Standard Reference	Number of Samples that Exceed
Tritium	No	199-K-120A	6	6	0	pCi/L	27,800	76,100	56,650	20,000	MCL	6
Tritium	No	699-72-73	3	3	0	pCi/L	14,300	21,300	17,633	20,000	MCL	1

Note: Values for chromium include an analyses for total chromium combined with those for hexavalent chromium.
Abbreviations: MCL = maximum contaminant level for drinking water supplies (EPA regulations); SMCL = secondary maximum contaminant level.
Source: Query of Groundwater Monitoring Project's Data Viewer and Evaluator (DaVE) for time period January 1, 1999 through August 1, 2002.

Appendix C

Groundwater Monitoring Locations in 100-K Area

Table C.1. Groundwater Monitoring Locations in the 100-K Area

Location Name	Well Identifier	Type	Facility (Waste Site ID) or Feature Monitored	Purpose or Capability (FY 2002)	100-KR-4 Long-Term Monitoring (CERCLA)	Interim Remedial Action (CERCLA)	Spent Nuclear Fuels (AEA)	Groundwater Surveillance (AEA)	GWMP Water Levels (AEA)
199-K-10	A5738	Well	KE/KW Reactor complexes	(Decommissioned)					
199-K-11	A4643	Well	KE/KW Reactor complexes	Adjacent	KR4-RI			100-K	
199-K-13	A4644	Well	KE reactor complex	Adjacent					
199-K-18	A4647	Well	100-K Crib (116-K-1); 100-K Trench (116-K-2)	Interim action compliance	KR4-RI	KR4-IA		100-K	
199-K-19	A4648	Well	100-K Crib (116-K-1); 100-K Trench (116-K-2)	Interim action performance	KR4-RI	KR4-IA			X
199-K-20	A4649	Well	100-K Trench (116-K-2)	Interim action compliance	KR4-RI	KR4-IA			X
199-K-21	A4650	Well	100-K Trench (116-K-2)	Interim action performance	KR4-RI	KR4-IA		100-K	X
199-K-22	A4651	Well	100-K Trench (116-K-2)	Interim action performance	KR4-RI	KR4-IA		100-K	
199-K-23	A4652	Well	1706-KE facility (116-KE-2,-6)	Adjacent	KR4-RI			100-K	
199-K-27	A4653	Well	105-KE Fuel Storage Basin; KE Reactor complex	Downgradient	KR4-RI		K Basins	100-K	X
199-K-28	A4654	Well	105-KE Fuel Storage Basin; KE Reactor complex	Downgradient (Decommissioned Oct. 2001)				100-K	
199-K-29	A5480	Well	105-KE Fuel Storage Basin; KE Reactor complex	Downgradient				100-K	
199-K-30	A4655	Well	115-KE Condensate Crib (116-KE-1)	Downgradient	KR4-RI		K Basins	100-K	
199-K-31	A4656	Well	KW Reactor complex	Near-river well	KR4-RI				
199-K-32A	A4657	Well	KE Reactor complex; 107-KE Retention Basins (116-KE-4)	Downgradient	KR4-RI			100-K	
199-K-32B	A4658	Well	KE Reactor complex; 107-KE Retention Basins (116-KE-4)	Downgradient; below unconfined aquifer	KR4-RI			100-K	
199-K-33	A4659	Well	KW Reactor complex; 107-KW Retention Basins (116-KW-3)	Downgradient	KR4-RI			100-K	
199-K-34	A4660	Well	105-KW Fuel Storage Basin; KW Reactor complex	Downgradient	KR4-RI			100-K	X
199-K-35	A4661	Well	183-KW sodium dichromate tank (120-KW-5); 183-KW sulfuric acid tanks (120-KW-3,-4)	Adjacent	KR4-RI				X
199-K-36	A4662	Well	183-KE sodium dichromate tank (120-KE-6); 183-KE sulfuric acid tanks (120-KE-4,-5)	Adjacent	KR4-RI			100-K	X
199-K-37	A4663	Well	100-K Trench (116-K-2)	Interim action performance	KR4-RI	KR4-IA			X
199-K-106A	A9842	Well	115-KW Condensate Crib (116-KW-1)	Downgradient	KR4-RI		K Basins	100-K	
199-K-107A	A9843	Well	105-KW Fuel Storage Basin (sub-basin drainage); 105-KW Fuel Storage Basin french drain (116-KW-2)	Downgradient	KR4-RI			100-K	

Table C.1. (contd)

Location Name	Well Identifier	Type	Facility (Waste Site ID) or Feature Monitored	Purpose or Capability (FY 2002)	100-KR-4 Long-Term Monitoring (CERCLA)	Interim Remedial Action (CERCLA)	Spent Nuclear Fuels (AEA)	Groundwater Surveillance (AEA)	GWMP Water Levels (AEA)
199-K-108A	A9844	Well	KW Reactor complex; 183-KW Clearwells	Adjacent	KR4-RI			100-K	
199-K-109A	A9828	Well	105-KE Fuel Storage Basin (sub-basin drainage); 105-KE Fuel Storage Basin french drain (116-KE-3)	Downgradient	KR4-RI		K-Basins	100-K	
199-K-110A	A9829	Well	KE Reactor complex; 183-KE Clearwells	Adjacent	KR4-RI			100-K	
199-K-111A	A9830	Well	KE Reactor complex	Downgradient	KR4-RI			100-K	
199-K-112A	B2799	Well	100-K Trench (116-K-2)	Interim action compliance		KR4-IA		100-K	
199-K-113A	B2800	Well	100-K Trench (116-K-2)	Interim action extraction		KR4-IA			
199-K-114A	B2801	Well	100-K Trench (116-K-2)	Interim action compliance		KR4-IA		100-K	
199-K-115A	B2802	Well	100-K Trench (116-K-2)	Interim action extraction		KR4-IA			
199-K-116A	B2803	Well	100-K Trench (116-K-2)	Interim action extraction		KR4-IA			
199-K-117A	B2804	Well	100-K Trench (116-K-2)	Interim action compliance		KR4-IA		100-K	
199-K-118A	B2805	Well	100-K Trench (116-K-2)	Interim action extraction (standby mode FY99)		KR4-IA			
199-K-119A	B2806	Well	100-K Trench (116-K-2)	Interim action extraction		KR4-IA			
199-K-120A	B2807	Well	100-K Crib (116-K-1); 100-K Trench (116-K-2)	Interim action extraction		KR4-IA			
199-K-121A	B2808	Well	100-K Trench (116-K-2)	Interim action injection					
199-K-122A	B2809	Well	100-K Trench (116-K-2)	Interim action injection					
199-K-123A	B2810	Well	100-K Trench (116-K-2)	Interim action injection					
199-K-124A	B2811	Well	100-K Trench (116-K-2)	Interim action injection					
199-K-125A	B8559	Well	100-K Trench (116-K-2)	Interim action extraction (replacement for K-118A)		KR4-IA			
199-K-126	B8760	Well	100-K Trench (116-K-2)			KR4-IA			
199-K-127	C3662	Well	100-K Trench (116-K-2)	Interim action extraction (new well January 2002)		KR4-IA			
199-K-128	C3663	Well	100-K Trench (116-K-2)	Interim action injection (new well January 2002)		KR4-IA			
699-70-68	A5319	Well	100-K Area background; plume moving NW from Gable Gap	Upgradient of 100-K Area; downgradient of Gable Gap	KR4-RI				
699-72-73	A5323	Well	100-K Area background; plume moving NW from Gable Gap	Upgradient of 100-K Area; downgradient of Gable Gap					
699-73-61	A5327	Well	100-K Area background	Upgradient of 100-K Area	KR4-RI				
699-78-62	A5332	Well	100-K Trench (116-K-2)	Upgradient of 100-K Trench; inland extend of mounding	KR4-RI				
699-81-62	A9000	Well	(None)	(Unknown)					
SK-057-3	none	Seep	100-K Area background	Shoreline exposure	KR4-RI				

Table C.1. (contd)

Location Name	Well Identifier	Type	Facility (Waste Site ID) or Feature Monitored	Purpose or Capability (FY 2002)	100-KR-4 Long-Term Monitoring (CERCLA)	Interim Remedial Action (CERCLA)	Spent Nuclear Fuels (AEA)	Groundwater Surveillance (AEA)	GWMP Water Levels (AEA)
SK-060-1	none	Seep	KW Reactor complex; 107-KW Retention Basins (116-KW-3)	Shoreline exposure					
SK-062-1	none	Seep	KW Reactor complex; 107-KW Retention Basins (116-KW-3)	Shoreline exposure					
SK-063-1	none	Seep	KW Reactor complex; 107-KW Retention Basins (116-KW-3)	Shoreline exposure					
SK-068-1	none	Seep	KE Reactor complex; 107-KE Retention Basins (116-KE-4)	Shoreline exposure					
SK-069-1	none	Seep	100-K Crib (116-K-1); 100-K Trench (116-K-2)	Interim action performance; shoreline exposure					
SK-070-1	none	Seep	100-K Trench (116-K-2)	Interim action performance; shoreline exposure					
SK-071-1	none	Seep	100-K Trench (116-K-2)	Interim action performance; shoreline exposure					
SK-072-1	none	Seep	100-K Trench (116-K-2)	Interim action performance; shoreline exposure					
SK-072-2	none	Seep	100-K Trench (116-K-2)	Interim action performance; shoreline exposure					
SK-077-1	none	Seep	100-K Trench (116-K-2)	Interim action performance; shoreline exposure	KR4-RI				
SK-079-1	none	Seep	100-K Trench (116-K-2)	Interim action performance; shoreline exposure					
SK-080-1	none	Seep	100-K Trench (116-K-2)	Interim action performance; shoreline exposure					
SK-082-1	none	Seep	100-K Trench (116-K-2)	Interim action performance; shoreline exposure					
SK-082-2	none	Seep	100-K Trench (116-K-2)	Interim action performance; shoreline exposure	KR4-RI				
13-S	B8151	AQST	100-K Area background	Aquifer near river channel					
13-D	B8149	AQST	100-K Area background	Aquifer near river channel					
14-S	B8154	AQST	100-K Area background	Aquifer near river channel					
14-M	B8153	AQST	100-K Area background	Aquifer near river channel					
14-D	B8152	AQST	100-K Area background	Aquifer near river channel					
15-M	B8156	AQST	100-K Area background	Aquifer near river channel					
17-M	B8162	AQST	KW Reactor complex; 107-KW Retention Basins (116-KW-3)	Aquifer near river channel					
17-D	B8161	AQST	KW Reactor complex; 107-KW Retention Basins (116-KW-3)	Aquifer near river channel					

Table C.1. (contd)

Location Name	Well Identifier	Type	Facility (Waste Site ID) or Feature Monitored	Purpose or Capability (FY 2002)	100-KR-4 Long-Term Monitoring (CERCLA)	Interim Remedial Action (CERCLA)	Spent Nuclear Fuels (AEA)	Groundwater Surveillance (AEA)	GWMP Water Levels (AEA)
18-S	B8204	AQST	KE Reactor complex; 107-KE Retention Basins (116-KE-4)	Aquifer near river channel					
19-M	B8206	AQST	100-K Crib (116-K-1); 100-K Trench (116-K-2)	Interim action performance; aquifer near river channel					
19-D	B8205	AQST	100-K Crib (116-K-1); 100-K Trench (116-K-2)	Interim action performance; aquifer near river channel					
21-S	B8213	AQST	100-K Trench (116-K-2)	Interim action performance; aquifer near river channel					
21-M	B8212	AQST	100-K Trench (116-K-2)	Interim action performance; aquifer near river channel					
22-M	B8215	AQST	100-K Trench (116-K-2)	Interim action performance; aquifer near river channel					
22-D	B8214	AQST	100-K Trench (116-K-2)	Interim action performance; aquifer near river channel					
23-M	B8218	AQST	100-K Trench (116-K-2)	Interim action performance; aquifer near river channel					
23-D	B8217	AQST	100-K Trench (116-K-2)	Interim action performance; aquifer near river channel					
DK-04-2	B8526	AQST	100-K Trench (116-K-2)	Interim action performance; aquifer near river channel					
DK-04-3	B8527	AQST	100-K Trench (116-K-2)	Interim action performance; aquifer near river channel					

Notes: "Seep' = natural riverbank seepage; "AQST" = aquifer sampling tubes near the low-river stage shoreline; AEA = Atomic Energy Act; CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.

References

Atomic Energy Act of 1954. as amended, 68 Stat. 919, 42 USC 2011 et seq.

CERCLA - *Comprehensive Environmental Response, Compensation, and Liability Act.* 1980. Public Law 96-510, as amended, 94 Statute 2767, 42 USC 9601 et seq.

Appendix D

Facility Names and Waste Site Identifiers in the 100-K Area

Table D.1. Facility Names and Waste Site Identifiers for the 100-K Area

Facility Name	Waste Site Designator
100-K Crib	116-K-1
100-K Mile Long Trench	116-K-2
1904-K Outfall	116-K-3
107-KE Retention Basins	116-KE-4
107-KW Retention Basins	116-KW-3
115-KE Condensate Crib	116-KE-1
1706-KER Waste Crib	116-KE-2
105-KE Storage Basin French Drain	116-KE-3
150-KE Heat Recovery Station	116-KE-5
1706-KE Condensate Collection Tank	116-KE-6A
1706-KE-Evaporation Tank	116-KE-6B
1706-KE Waste Accumulation Tank	116-KE-6C
1706-KE-Ion Exchange Column	116-KE-6D
115-KW Condensate Crib	116-KW-1
105-KW Storage Basin French Drain	116-KW-2
150-KW Heat Recovery Station	116-KW-4
100-K Burial Ground	118-K-1
Sludge Burial Ground	118-K-2
105-KE Reactor Building	118-KE-1
105-KE Horizontal Control ROD Storage Cave	118-KE-2
105-KW Reactor Building	118-KW-1
105-KW Horizontal Control ROD Storage Cave	118-KW-2
165-KE Brine Pit	120-KE-8
165-KW Brine Pit	120-KW-6
100-K Gravel Pit	126-K-1
1717-K Gasoline Storage Tank	130-K-1
1717-K Waste Oil Storage Tank	130-K-2
105-KE Emergency Diesel Oil Storage Tank	130-KE-1
166-KE Oil Storage Tank	130-KE-2
116-KE Reactor Exhaust Stack	132-KE-1
116-KW Reactor Exhaust Stack	132-KW-1
105-KW Emergency Diesel Fuel Tank	130-KW-1
166-KW Oil Storage Tanks	130-KW-2
105-KE Reactor Fuel Storage Basin Leak	UPR-100-K-1
Septic Tank Systems	1607-K4
Liquid Waste Site, Wet Fish Studies Laboratory	*
French Drain – East Side of 1706-KE	*
Liquid Waste Site (French Drain)	*
Liquid Waste Site (118-K-3 Filter Crib)	*
Heat Exchanger Pit	*
Solid Waste Site (Vacuum Pit)	*
French Drain – East Side of 1705-KE	*
French Drain – South Side of 119-KW	*
183-KE Filter Waste Facility Dry Well	120-KE-1
183-KE Filter Waste Facility French Drain	120-KE-2
183-KE Filter Water Facility Trench	120-KE-3
183-KE1 Sulfuric Acid Storage Tank	120-KE-4

Table D.1. (contd)

Facility Name	Waste Site Designator
183-KE2 Sulfuric Acid Storage Tank	120-KE-5
183-KE Sodium Dichromate Tank	120-KE-6
183-KE Brine Pit	120-KE-9
183-KW Filter Water Facility Dry Well	120-KW-1
183-KW Filter Water Facility French Drain	120-KW-2
183-KW Sulfuric Acid Storage Tank	120-KW-3
183-KW2 Sulfuric Acid Storage Tank	120-KW-4
183-KW Sodium Dichromate Storage Tank	120-KW-5
183-KW Brine Pit	120-KW-7
183-KE Liquid Alum Storage Tank No. 2	126-KE-2
183-KE Liquid Alum Storage Tank No. 1	126-KE-3
100-K Burning Pit	128-K-1
100-K Construction Dump	128-K-2
182-K Emergency Diesel Oil Storage Tank	130-K-3
Howitzer Site	600-4
100-K Construction Laydown Area	600-29
Septic Tank Systems	1607-K
Sodium Silicate Storage Tank Site	*
Caustic Soda Storage Tank Site	*
100-KW Liquid Alum Storage Tanks	*
Caustic Neutralization Pits	*
Acid Neutralization Pits	*
Acid Neutralization Pits	*
Acid Neutralization Pits & Dry Wells	*
Sulfuric Acid Tanks	*
Bauxite Tanks	*
Solid Waste Site (Paved Area & Collapsed Structure)	*
Solid Waste Site – West of 183-KE Water Treatment Facility	*

*Designator not assigned.
Source: Carpenter and Cote 1994.

Reference

Carpenter, R. W. and S. L. Coté. 1994. *100-K Area Technical Baseline Report.* WHC-SD-EN-TI-239, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Appendix E

National Priorities List Agreement

Appendix E

NPL Agreement and TPA Milestones

CCN # 040549

Control Number: 108	NPL Agreement/Change Control Form ___ Change _X_ Agreement ___ Information Operable Unit(s): 100-KR-4	Date Submitted: 11/20/96 Date Approved:
Document Number/Title: Modifications to the Groundwater Sampling and Analysis Schedules for the 100-KR-4 Operable Unit Groundwater Sampling Project		**Date Document Last Issued:**
Originator: A. J. Knepp		**Phone:** 372-9189

Summary Description:

Four modifications to the previous groundwater sampling and analysis schedule for the 100-KR-4 Operable Unit (100 NPL Agreement/Change Control Form #29, August 1992, and #59, November 1993) are being made:

1. The sampling frequency for most wells is reduced from semiannual to annual. Annual sampling will be conducted to coincide with seasonal low river conditions that typically occur during the period September through November.

2. Sampling locations are selected on the basis of proximity to the Columbia River, historical trends in each well, and contaminant plume locations.

3. More frequent sampling of wells with contaminant levels exceeding ARARs, or that show increasing trends is conducted using cost-effective methods (e.g., field instruments, Mobile Lab, or no purging of the well prior to sampling).

4. Data validation, as performed during the limited field investigation, is not performed for all new data. Modified data verification and validation steps are adopted that improve cost-effectiveness without compromising data quality. Data evaluation activities are expanded to enhance the quality of information derived from sampling and analysis activities.

The attached Tables 1, 2, and 3 summarize the changes to the sampling program for the 100-K Area. Minor modifications to the list of specific wells used and constituents analyzed may be necessary to account for changing field conditions, IRM operational requirements, and changes identified during data evaluation.

Affected documents include:

1) DOE-RL. 1992. *Remedial Investigation/Feasibility Study Work Plan for the 100-KR-4 Operable Unit, Hanford Site, Richland, Washington*. DOE/RL-90-21, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Appendix A includes a Quality Assurance Project Plan (QAPjP) as required by EPA guidance.

2) 100 NPL Agreement/ Change Control Forms #59 "100-KR-4 Reduced Analyte GW Sampling List," November 1993, and #29, "100-KR-4 Operable Unit Groundwater Monitoring Network," August 1992.

Justification and Impact of Change:

The changes in the sampling schedule will result in a more integrated and cost-effective program. The impact of this change includes increased efficiency in obtaining data that can be applied to data quality objectives for multiple programs (e.g., CERCLA remediation activities and DOE Order 5400 surveillance). Sample collection efforts are integrated to the fullest extent possible under a consolidated schedule. Where reductions in number of samples, analytes, and frequency of sampling occur, a minimal or negligible loss of relevant information is expected.

ERC Project Manager: G. C. Henckel	**Date:**
DOE Project Manager: A. C. Tortoso	**Date:**
Ecology Project Manager: W. W. Soper	**Date:**
EPA Project Manager: L. E. Gadbois	**Date:**

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Table 1. Sampling and Analysis Schedule for the 100-KR-4 Groundwater Project (Page 1 of 3)

Well Number	Facility Monitored/ Purpose[1]	Freq Basis[2]	Round 9 (completed 1/96)	Round 10 (FY97) & Round 11 (FY98)	IRM Monitor[4] (longterm)	RCRA/ Operations (FY96)[3]	Sitewide Surveil (1996)[3]
199-K-10 (analog K-11)	Reactor buildings						
199-K-11	Reactor buildings	2a	SA-1	BA(97)-2			
199-K-13 (analog K-109A)	Reactor buildings	2a	SA-1				
199-K-18	116-K-1 and 116-K-2 liquid waste disposal/ IRM compliance	1a	SA-1	A-2	Q-Cr		A
199-K-19	116-K-1 and 116-K-2 liquid waste disposal/ IRM performance	1a	SA-1	A-2	SA-Cr		
199-K-20	116-K-1 and 116-K-2 liquid waste disposal/ IRM compliance	1a	SA-1	A-2	Q-Cr		
199-K-21	116-K-1 and 116-K-2 liquid waste disposal/ IRM performance	1a	SA-1	A-2	SA-Cr		
199-K-22	116-K-1 and 116-K-2 liquid waste disposal/ IRM performance	1a	SA-1	A-2	SA-Cr		
199-K-23	Reactor building	2a	SA-1	BA(97)-2			
199-K-27	KE fuel storage basin	2a	SA-1	BA(98)-2 Q-H3		M	SA
199-K-28	KE fuel storage basin	2a				Q	A
199-K-29	KE fuel storage basin	2a				Q	A
199-K-30	116-KE-1 condensate crib	2a	SA-1	BA(97)-2 (+C14) Q-H3		M	A
199-K-31	Near river well	1a	SA-1	A-2			
199-K-32A	Retention basins/ near river	1a	SA-1	A-2 (+C14)		Q	
199-K-32B	Retention basins/ near river	1a	SA-1	A-2			
199-K-33	Retention basins/ near river	2a	SA-1	A-2 (+C14)			A

[1] Facility information comes from the 100-K Technical Baseline Report (Carpenter and Cote, 1994).
[2] Sampling frequency basis ("Freq Basis") codes are listed in Table 3.
[3] RCRA and Sitewide Surveillance schedules are presented for informational purposes.
[4] Frequencies and analytes as described in Draft A of the RDR/RAWP. They are subject to change as the performance/compliance monitoring DQO effort proceeds.

Sampling round codes:
- BA = biennial (year of next event)
- A = annual
- SA = semiannual
- Q = quarterly
- M = monthly
- -1 or -2 suffix identifies the analysis suite listed in Table 2
- (+C14) indicates constituent added to basic suite listed in Table 2
- Q-Cr indicates quarterly screening for chromium, Sr-90, etc.

Table 1. Sampling and Analysis Schedule for the 100-KR-4 Groundwater Project (Page 2 of 3)

Well Number	Facility Monitored/ Purpose[1]	Freq Basis[2]	Round 9 (completed 1/96)	Round 10 (FY97) & Round 11 (FY98)	IRM Monitor[4] (longterm)	RCRA/ Operations (FY96)[3]	Sitewide Surveil (1996)[3]
199-K-34	KW fuel storage basin	2	SA-1	BA(97)-2 (+C14)		Q	A
199-K-35	Sodium dichromate storage	2a	SA-1	BA(97)-2 (+Hg)			
199-K-36	Sodium dichromate storage	2d	SA-1	A-2 (+Hg) Q-Cr			A
199-K-37	116-K-1 and 116-K-2 liquid waste disposal/ IRM performance	1a	SA-1	A-2	SA-Cr		
199-K-106A	116-KW-1 condensate crib	2a	SA-1	BA(98)-2 (+C14) Q-H3		M	A
199-K-107A	Fuel storage basin tile field	2d	SA-1	A-2 Q-Cr		Q	
199-K-108A	Reactor building cribs, trenches	2c	SA-1	A-2 (+C14) Q-Cr		Q	
199-K-109A	Fuel storage basin tile field	1a	SA-1	A-2 Q-Sr90		M	A
199-K-110A	Reactor building cribs, trenches	2 e	SA-1	BA(98)-2		Q	
199-K-111A	Reactor area, downgradient	1a	SA-1	A-2 (+C14)			A
199-K-112A	IRM compliance				Q-Cr		
199-K-113A	IRM extraction				SA Q-Cr		
199-K-114A	IRM compliance				Q-Cr		
199-K-115A	IRM extraction				SA Q-Cr		
199-K-116A	IRM extraction				SA Q-Cr		
199-K-117A	IRM compliance				Q-Cr		
199-K-118A	IRM extraction				SA Q-Cr		

[1] Facility information comes from the 100-K Technical Baseline Report (Carpenter and Cote, 1994).
[2] Sampling frequency basis ("Freq Basis") codes are listed in Table 3.
[3] RCRA and Sitewide Surveillance schedules are presented for informational purposes.
[4] Frequencies and analytes as described in Draft A of the RDR/RAWP. They are subject to change as the performance/compliance monitoring DQO effort proceeds.

Sampling round codes:

BA = biennial (year of next event)
A = annual
SA = semiannual
Q = quarterly
M = monthly
-1 or -2 suffix identifies the analysis suite listed in Table 2
(+C14) indicates constituent added to basic suite listed in Table 2
Q-Cr indicates quarterly screening for chromium, Sr-90, etc.

Table 1. Sampling and Analysis Schedule for the 100-KR-4 Groundwater Project (Page 3 of 3)

Well Number	Facility Monitored/ Purpose[1]	Freq Basis[2]	Round 9 (completed 1/96)	Round 10 (FY97) & Round 11 (FY98)	IRM Monitor[4] (longterm)	RCRA/ Operations (FY96)[3]	Sitewide Surveil (1996)[3]
199-K-119A	IRM extraction				SA Q-Cr		
199-K-120A	IRM extraction				SA Q-Cr		
199-K-121A	IRM injection well						
199-K-122A	IRM injection well						
199-K-123A	IRM injection well						
199-K-124A	IRM injection well						
699-70-68	Background	2a	SA-1	BA(98)-2			
699-73-61	Background	2a	SA-1	BA(98)-2			
699-78-62	Background	2a	SA-1	BA(98)-2			
Seep 057-3	Area/ shoreline exposure			A-2			
Seep 077-1	Area/ shoreline exposure			A-2			A
Seep 082-2	Area/ shoreline exposure			A-2			

[1] Facility information comes from the 100-K Technical Baseline Report (Carpenter and Cote, 1994).
[2] Sampling frequency basis ("Freq Basis") codes are listed in Table 3.
[3] RCRA and Sitewide Surveillance schedules are presented for informational purposes.
[4] Frequencies and analytes as described in Draft A of the RDR/RAWP. They are subject to change as the performance/compliance monitoring DQO effort proceeds.

Sampling round codes:
- BA = biennial (year of next event)
- A = annual
- SA = semiannual
- Q = quarterly
- M = monthly
- -1 or -2 suffix identifies the analysis suite listed in Table 2
- (+C14) indicates constituent added to basic suite listed in Table 2
- Q-Cr indicates quarterly screening for chromium, Sr-90, etc.

Table 2. Analysis Suite Codes for the 100-KR-4 Groundwater Project

Analysis/ Parameter	Constituent Code #1 (Round 9--Completed 1/96)	Constituent Code #2 (Round 10--FY97/98)
Metals by inductively coupled plasma and atomic adsorption (filtered and unfiltered) Method: EPA 6010A (TAL)	Aluminum Antimony Arsenic Barium Beryllium Cadmium Calcium Chromium Cobalt Copper Iron Lead Magnesium Manganese Mercury Nickel Potassium Selenium Silver Sodium Thallium Vanadium Zinc	Aluminum Antimony Barium Beryllium Cadmium Calcium Chromium Cobalt Copper Iron Magnesium Manganese Mercury* Nickel Potassium Silver Sodium Vanadium Zinc
Anions by ion chromatography Method: EPA 300.0	Chloride Fluoride Nitrite Nitrate Sulfate Phosphate	Chloride Fluoride Nitrate Sulfate
Radionuclide screening:	Gamma spectrum Gross alpha Gross beta Activity scan	Gamma spectrum Gross alpha Gross beta Activity scan*
Specific radionuclides:	Carbon-14 Strontium-90 Tritium Uranium-234/235/238	Carbon-14* Strontium-89/90* Tritium
Miscellaneous parameters:	Turbidity	
Field parameters:	pH Specific conductance Temperature	pH Specific conductance Temperature Turbidity

Note: Constituent code #1 list is from the Sample Authorization Form for the sampling event. It is based on the constituent list presented in 100 NPL Agreement/ Change Control Form # 59. November 1993.

* Selected wells only.

sampanal\2cr4-con.tbl

Table 3. Criteria Used to Assign Sampling Frequency

1. Proximity to the Columbia River
    - 1a. Nearest well in reactor area -- ANNUAL
    - 1b. Strong influence by river fluctuations -- ANNUAL

2. Trend in historical data set (post-1990 results)
    - 2a. Coherent trend, low variability -- BIENNIAL
    - 2b. High variability (e.g., near-river wells) -- ANNUAL
    - 2c. Trend increasing, exceeds standards -- ANNUAL + field screening
    - 2d. Change in recent results -- ANNUAL + field screening
    - 2e. Trend decreasing, below standards -- BIENNIAL or none

3. No clearly defined trend in historical data set (post-1990 results)
    - 3a. Location outside known plume -- ANNUAL
    - 3b. Location inside known plume -- ANNUAL + field screening

4. New well constructed for remedial action or characterization
    - 4a. First year -- QUARTERLY or per IRM requirements
    - 4b. No contamination, near river -- ANNUAL or per IRM
    - 4c. Contamination, near river -- ANNUAL or per IRM
    - 4d. No contamination, inland -- BIENNIAL or per IRM

Appendix F

Tri-Party Agreement Milestones

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Tri-Party Agreement Milestones

March 31, 2002 M-034-29:
Complete K East Basin and K West Basin facility modifications for alternate fuel transfer strategy cask transportation system.

This interim milestone shall be complete when all modifications to support transfer of spent nuclear fuel from K East Basin to K West Basin are complete. All modifications shall be constructed and installed, and all construction acceptance tests (CATs) shall be completed. The construction completion document, Section IB, shall be signed with either no exceptions or with only minor exceptions, which do not affect the functionality of the system.

September 30, 2002 M-034-12-T01:
Complete construction of K East Basin sludge and water system to support spent nuclear fuel removal.

The K East Basin sludge and water system shall be constructed and installed and DOE shall concur that all acceptance tests have been completed for turnover to operations, by signing the construction completion document, Section 11A (or equivalent form), with either no exceptions or with only minor exceptions, which do not affect the functionality of the system.

November 30, 2002 M-034-17:
Initiate removal of K East Basin spent nuclear fuel.

Initiate removal of spent nuclear fuel from the K East Basin and transport to the K West Basin.

December 31, 2002 M-034-08:
Initiate full scale K East Basin sludge removal.

DOE shall complete and approve K East sludge removal definitive design documents; all associated construction, and readiness assessments; and initiate removal of sludge from the basin.

December 31, 2002 M-034-18A:
Complete removal of spent nuclear fuel equivalent to 957 metric tons heavy metal from the K West Basin.

This interim milestone will be complete when spent nuclear fuel equivalent to 957 metric tons heavy metal has been removed from K West Basin and transported to the Cold Vacuum Drying Facility.

May 31, 2003 M-034-27-T01:
Complete removal of spent nuclear fuel equivalent to 1,252 metric tons heavy metal from the K West Basin.

This interim milestone will be complete when spent nuclear fuel equivalent to 1,252 metric tons heavy metal has been removed from K West Basin and transported to the Cold Vacuum Drying Facility.

December 31, 2003 M-034-28:
Complete removal of spent nuclear fuel equivalent to 1,619 metric tons heavy metal from the K West Basin.

This interim milestone will be complete when spent nuclear fuel equivalent to 1,619 metric tons heavy metal has been removed from K West Basin and transported to the Cold Vacuum Drying Facility.

May 31, 2004 M-034-25-T01:
Complete transfer of K East Basin spent nuclear fuel to the K West Basin.

This target date will be complete when all spent nuclear fuel has been removed from the K East Basin and has been transported into the K West Basin. It is understood that additional fuel fragments may be discovered during the subsequent removal of the sludge.

July 31, 2004 M-034-18B:
Complete removal of all K Basins spent nuclear fuel.

This interim milestone will be complete when all spent nuclear fuel has been removed from both the K West Basin and the K East Basin and has been transported to the Cold Vacuum Drying Facility. It is understood that additional fuel fragments may be discovered during removal of the sludge.

August 31, 2004 M-034-10:
Complete sludge removal from K Basins.

Fuel processing in K Basins shall be complete, including the capture of fuel canister sludge in the integrated water treatment system and removal of visible floor and pit sludge.

September 30, 2004 M-034-23:
Initiate full-scale K East Basin water removal.

January 31, 2005 M-034-09-T01:
Complete K Basins rack and canister removal.

All fuel storage racks and empty fuel canisters shall be removed from the K Basins.

September 30, 2005 M-034-24:
Complete K East Basin water removal.

October 31, 2005 **M-034-21-T01:**
Initiate full-scale K West Basin water removal.

August 31, 2006 **M-034-22:**
Complete K West Basin water removal.

July 31, 2007 **M-034-00A:**
Complete removal of spent nuclear fuel, sludge, debris, and water at DOE's K Basins.

(Prepared August 2, 2002 from email sent by Owen S. Kramer, Tri-Party Agreement Integration, Fluor Hanford)

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