

6.1 Hanford Groundwater Monitoring Project

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The strategy for protecting groundwater at the Hanford Site is presented in the *Hanford Site Ground-Water Protection Management Plan* (DOE-RL-89-12, Rev. 2). Two key elements of this strategy are to 1) protect the unconfined aquifer from further contamination and 2) monitor the extent of groundwater contamination. The Groundwater Monitoring Program at the Hanford Site documents groundwater quality to meet the needs of these elements. The monitoring program is designed to detect new contaminant plumes and to document the distribution and movement of existing groundwater contamination. Monitoring provides the historical baseline for evaluating current and future risk from exposure to groundwater contamination and for deciding on remedial options. Because the geology and hydrology of the Hanford Site control the movement of contaminants in groundwater, hydrogeologic studies are an integral part of the monitoring program.

The effort to protect groundwater quality at the Hanford Site is being implemented through programs to minimize wastes being discharged to the soil column and through site remediation activities. The Hanford Federal Facility Agreement and Consent Order (also known as the Tri-Party Agreement; Ecology et al. 1989) provides a framework for remediation of the Hanford Site, including groundwater, over a 40-year period. A summary of accomplishments in waste minimization and site remediation is presented in Section 2.0, "Environmental and Regulatory Compliance Summary."

DOE prepared a *Plan and Schedule to Discontinue Disposal of Liquids Into the Soil Column at the Hanford Site* (DOE 1987), which includes an alternative for treatment and disposal of contaminated effluent discharged to the soil. Of the 33 major waste streams identified, the Phase I (higher priority) streams have either been eliminated or are being treated and diverted to the 200 Areas Treated Effluent Disposal Facility. In addition, process condensate from the 242-A Evaporator is treated at the 200 Areas Effluent Treatment Facility and then discharged to the State-Approved Land Disposal Site north of the 200-West

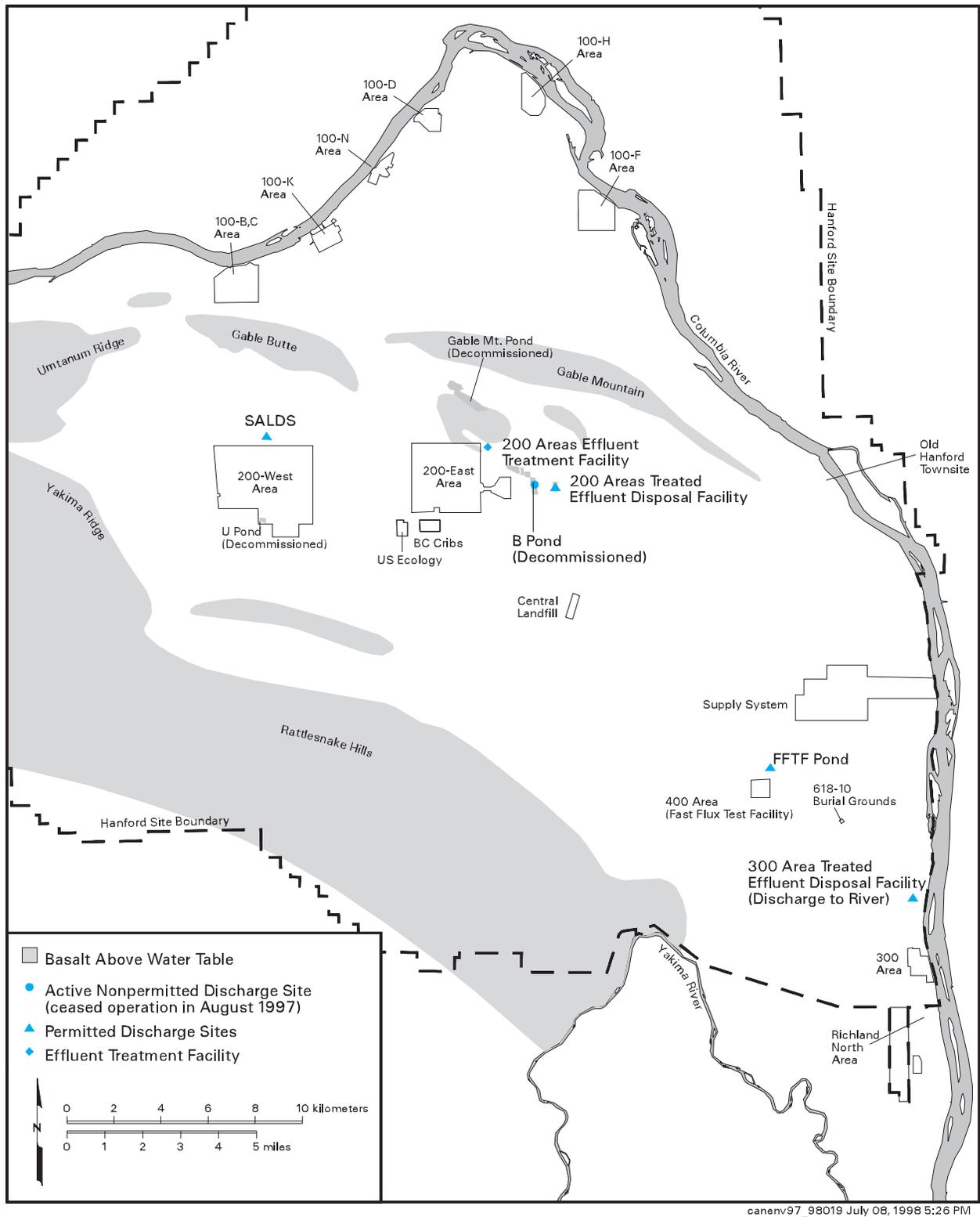
Area. The locations of these facilities are shown in Figures 1.0.2 and 6.1.1 and are discussed in detail in Section 2.3, "Activities, Accomplishments, and Issues." Disposal of liquids to soil has been significantly reduced during the last several years. For example, in 1987, over 23 billion L (6 billion gal) of liquid effluents were discharged to the soil. This was reduced to approximately 4.9 billion L (1.3 billion gal) in 1995 and <2.0 billion L (<530 million gal) in 1997. The locations of the effluent streams are shown in Figure 6.1.1. In 1997, approximately 51% of the liquid volume was discharged to B Pond, which ceased operating in August 1997, and approximately 45% was discharged to the 200 Areas Treated Effluent Disposal Facility.

Groundwater is used for drinking water and other purposes at a few locations on the Hanford Site. DE&S Hanford, Inc. and Pacific Northwest National Laboratory monitor drinking water supplies at the point of use. Results of the radiological monitoring conducted by Pacific Northwest National Laboratory and DE&S Hanford, Inc., are summarized in Section 4.3, "Hanford Site Drinking Water Surveillance." The locations of wells completed in the unconfined aquifer that provide water for drinking, fire suppression, and cooling are shown in Figure 6.1.2.

6.1.1 Geologic Setting

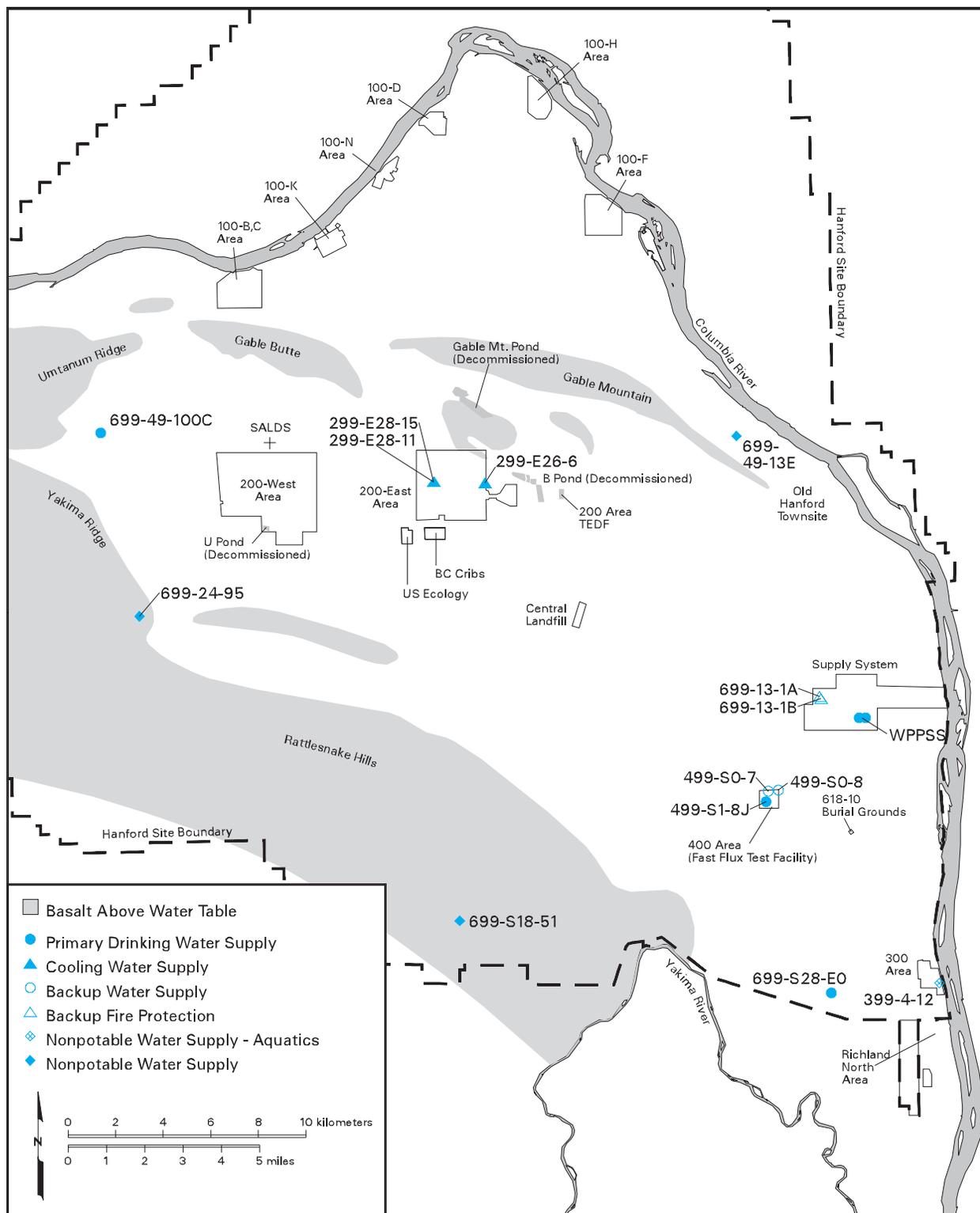
The Hanford Site lies within the Pasco Basin, one of several structural basins within the Columbia Plateau. Principal geologic units beneath the Hanford Site include, in ascending order, the Columbia River Basalt Group, the Ringold Formation, and the Hanford formation (informal name) (Figure 6.1.3).

The Columbia River basalts were formed from lava that periodically erupted from volcanic fissures. The regional river system eroded the basalt and deposited sediments across the basalt surfaces between eruptions. Zones between the basalt flows and the sediments deposited as



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Figure 6.1.1. Disposal Facilities for the Major Liquid Waste Streams on the Hanford Site



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Figure 6.1.2. Water Supply Wells in the Unconfined Aquifer

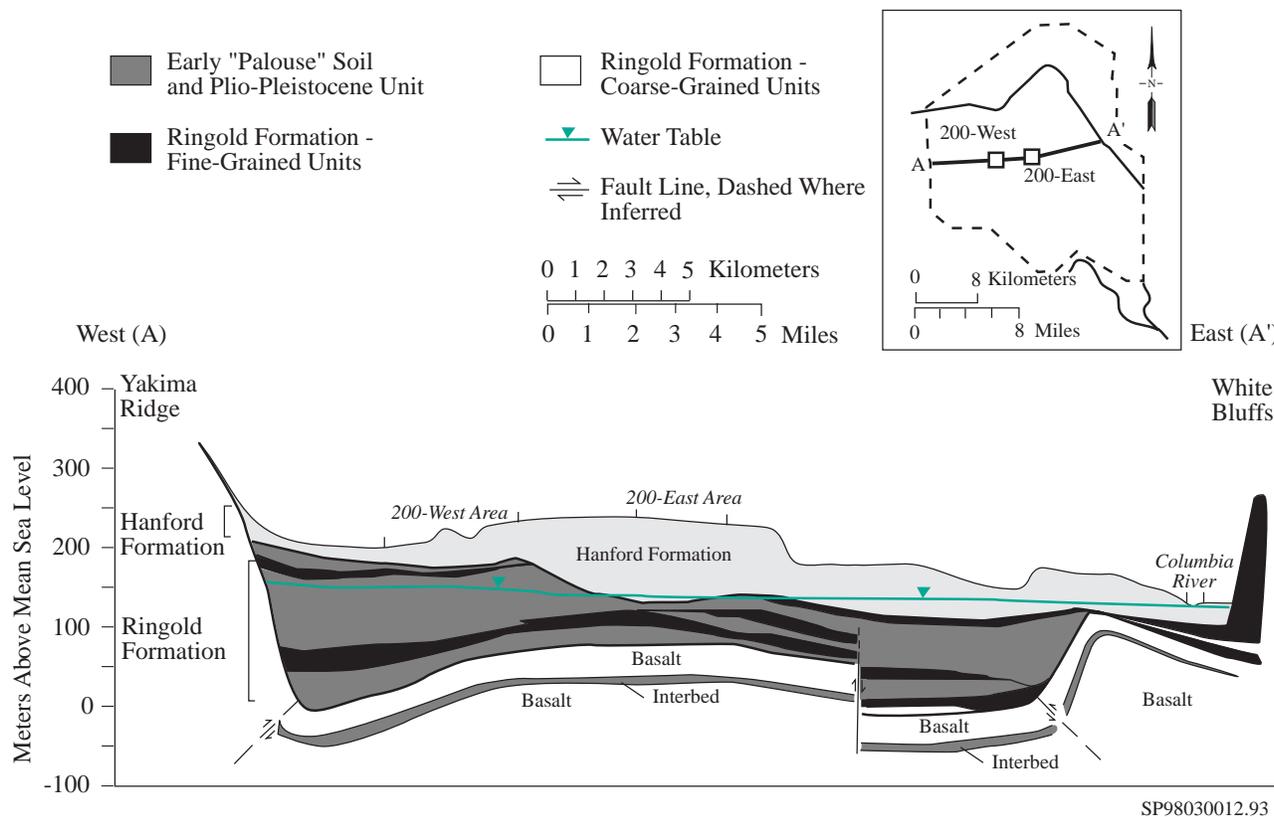


Figure 6.1.3. Geologic Cross Section of the Hanford Site

interbeds between basalt eruptions are frequently water bearing zones that are used as water sources in areas around the Hanford Site.

During the period of basalt deposition, tectonic pressure was very slowly deforming the basalt flows into the generally east-west trending ridges that border the Pasco Basin today. After the last major basalt eruption, sand and gravel of the Ringold Formation were deposited in the central portion of the Pasco Basin by the ancestral Columbia River as it meandered back and forth across the relatively flat basalt surface. Following uplift of the basalts and overlying sediments, the Columbia River began to erode, rather than deposit, sediments in the Pasco Basin. The uppermost mud layer was eroded from much of the Pasco Basin and a caliche layer, part of the Plio-Pleistocene unit, developed in places on the eroded surface of the Ringold Formation.

The Hanford formation sediments were deposited by catastrophic ice age floods during the recent geologic past. Fine sands and silts were deposited in slackwater areas at the margins of the basin. However, primarily sand and

gravel were deposited on the Hanford Site. In places, these sediments are covered by up to a few meters (feet) of recent stream or windblown deposits.

More detailed information on the geology of the Pasco Basin can be found in BHI-00184, DOE/RW-0164 (Vol. 1), PNNL-11793 (Section 3.1), WHC-MR-0391, WHC-SD-EN-TI-014, and WHC-SD-EN-TI-019.

6.1.2 Groundwater Hydrology

Both confined and unconfined aquifers are present beneath the Hanford Site. An aquifer is a water-saturated geologic interval or unit that has a high permeability, meaning it can transmit significant quantities of water. A confined aquifer is bounded above and below by low permeability materials that restrict the vertical movement of water. The confining layers may be dense rock such as the central parts of basalt flows, silt, clay, or well-cemented sediments. Areally extensive confined aquifers at the Hanford Site are found primarily within interflows and interbeds of the Columbia River basalts. These are

referred to as basalt-confined aquifers. Locally confined aquifers are also found below the clays and silts of the Ringold Formation.

An unconfined aquifer, or water-table aquifer, is overlain by unsaturated sediments. The upper surface of the saturated zone in an unconfined aquifer, which is called the water table, rises and falls in response to changes in the volume of water stored in the aquifer. In general, the unconfined aquifer at the Hanford Site is located in the Hanford and Ringold Formations. In some areas, the water table is below the bottom of the Hanford formation and the unconfined aquifer is entirely within the Ringold Formation. The Hanford formation sands and gravels are unconsolidated and are generally much more permeable than the compacted and silty Ringold Formation gravels. Clay and silt units and zones of natural cementation form low permeability zones within the Ringold Formation.

The unconfined aquifer forms the uppermost groundwater zone and has been directly impacted by wastewater disposal at the Hanford Site. The unconfined aquifer discharges primarily into the Columbia River and is the most thoroughly monitored aquifer beneath the site. The Rattlesnake Ridge interbed is the uppermost, basalt-confined aquifer within the Pasco Basin and the Hanford Site. This aquifer and other confined aquifers are generally isolated from the unconfined aquifer by dense rock that forms the interior of the basalt flows. However, interflow between the unconfined aquifer and the basalt-confined aquifer system is known to occur at faults that bring a water bearing interbed in contact with other sediments or where the overlying basalt has been eroded to reveal an interbed (Newcomb et al. 1972, RHO-RE-ST-12 P, WHC-MR-0391). Additional information on the basalt-confined aquifer system can be found in PNL-10158 and PNL-10817.

The thickness of saturated sediments above the basalt bedrock is greater than 200 m (656 ft) in some areas of the Hanford Site and thins out along the flanks of the uplifted basalt ridges (Figure 6.1.4). Depth from the ground surface to the water table ranges from <0.3 m (1 ft) near the Columbia River to >106 m (348 ft) in the center of the site. The unconfined aquifer is bounded below by either the basalt surface or, in places, by relatively impervious clays and silts within the Ringold Formation. The water table defines the upper boundary of the unconfined aquifer. Laterally, the unconfined aquifer is bounded by basalt ridges and by the Yakima and Columbia Rivers. The basalt ridges have a low permeability and act as a barrier to the lateral flow of groundwater where they rise above the water table (RHO-BWI-ST-5, p. II-116).

The water-table elevation contours shown in Figure 6.1.5 indicate the direction of groundwater flow and the magnitude of the hydraulic gradient in the unconfined aquifer. Groundwater flow is generally perpendicular to the water-table contours from areas of higher elevation, or head, to areas of lower head. Areas where the contours are closer together are high gradient areas, where the "driving force" for groundwater flow is greater. However, because sediments with low permeabilities inhibit groundwater flow and produce steeper gradients, a high gradient does not necessarily mean high groundwater velocity. Lower transmissivity and steeper gradients are often associated with areas where the water table is below the bottom of the Hanford formation and the aquifer is entirely within the less permeable Ringold sediments. Figure 6.1.6 shows the generalized distribution of transmissivity as determined from aquifer pumping tests and groundwater flow model calibration. Additional information on aquifer hydraulic properties at Hanford is presented in DOE/RW-0164 (Vol. 2) and PNL-8337.

Recharge of water within the unconfined aquifer (RHO-ST-42) comes from several sources. Natural recharge occurs from infiltration of precipitation along the mountain fronts, runoff from intermittent streams such as Cold and Dry Creeks on the western margin of the site, and limited infiltration of precipitation on the Hanford Site. The Yakima River, where it flows along the southern boundary of the Hanford Site, also recharges the unconfined aquifer. The Columbia River is the primary discharge area for the unconfined aquifer. However, the Columbia River also recharges the unconfined aquifer for short periods during high river stage, when river water is transferred into the aquifer along the riverbank. Recharge from infiltration of precipitation is highly variable on the Hanford Site both spatially and temporarily. The rate of natural recharge depends primarily on soil texture, vegetation, and climate (Gee et al. 1992, PNL-10285), and ranges from near zero, where fine-grained soils and deep-rooted vegetation are present, to >10 cm/yr (>4 in./yr) in areas where soils are coarse textured and bare of vegetation.

Large-scale artificial recharge to the unconfined aquifer occurs from liquid waste disposal in the operating areas and offsite agricultural irrigation to the west and south. Discharge of wastewater has caused the water table to rise over most of the Hanford Site. Local areas with elevated water tables are called groundwater mounds. Figure 6.1.7 shows the change in water-table elevations between 1944 and 1979, when the water table had stabilized over most of the site. Reduced wastewater discharge to the soil

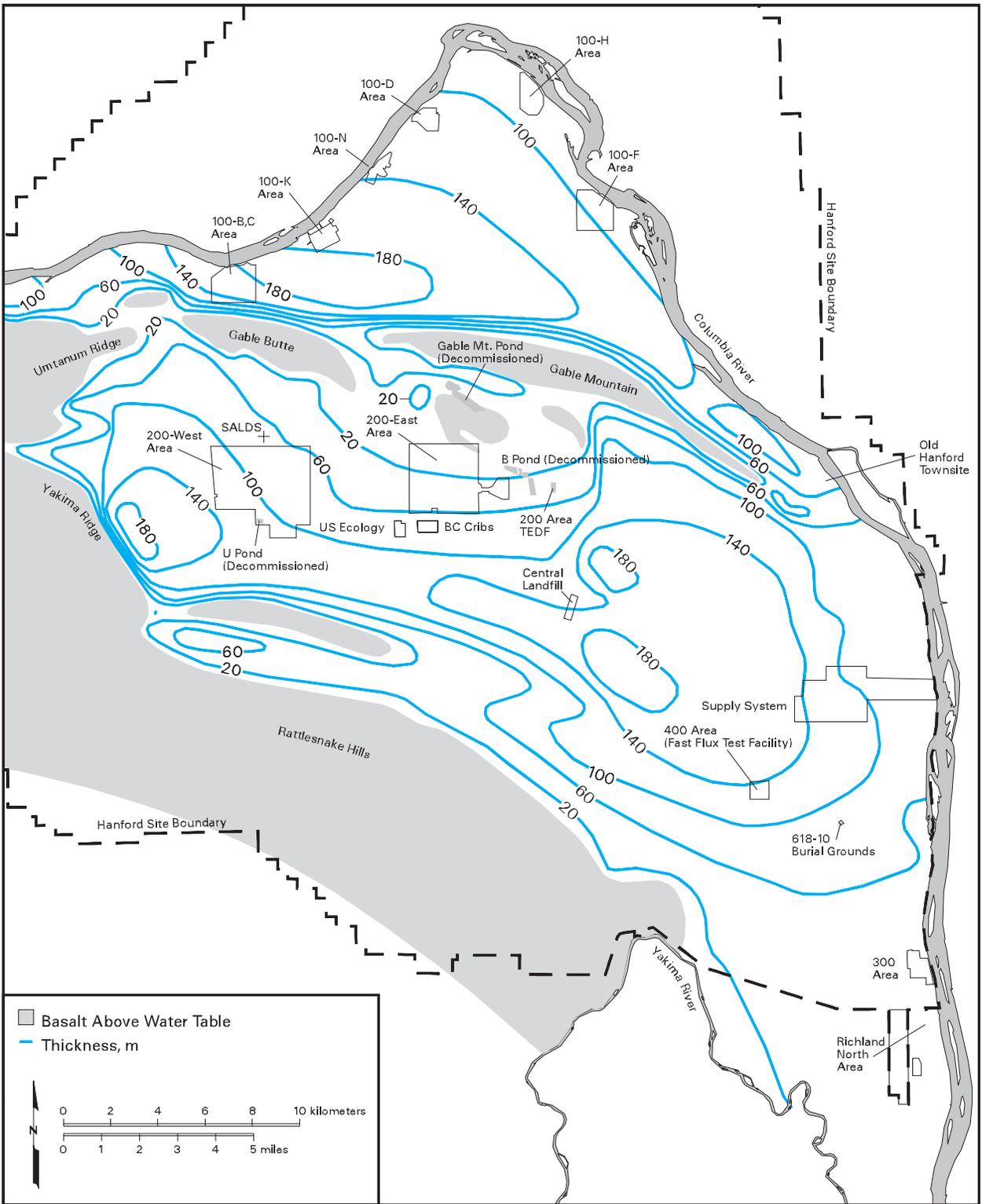


Figure 6.1.4. Saturated Thickness of the Unconfined Aquifer

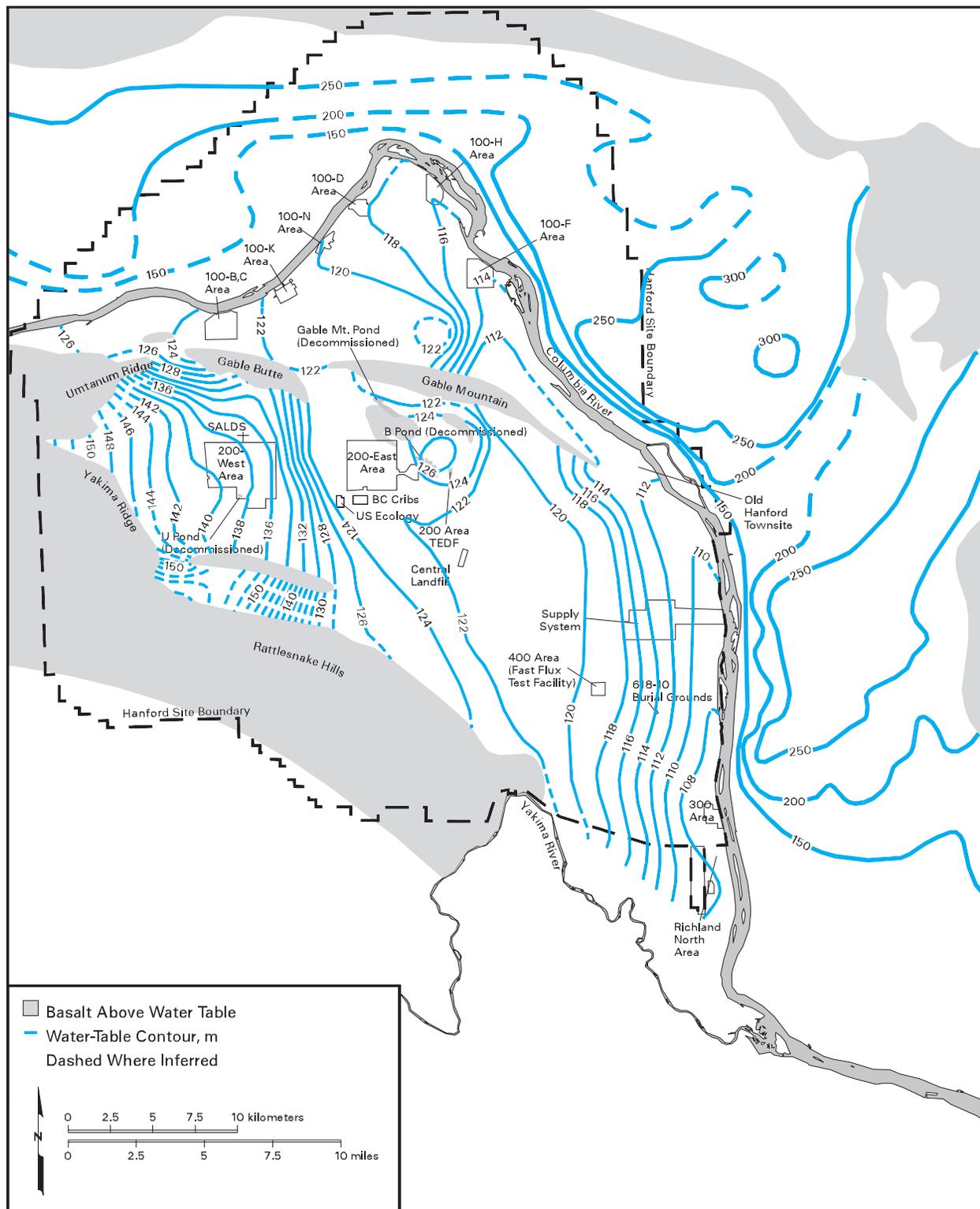


Figure 6.1.5. Water-Table Elevations for the Unconfined Aquifer at the Hanford Site and in Adjacent Areas East and North of the Columbia River, June 1997

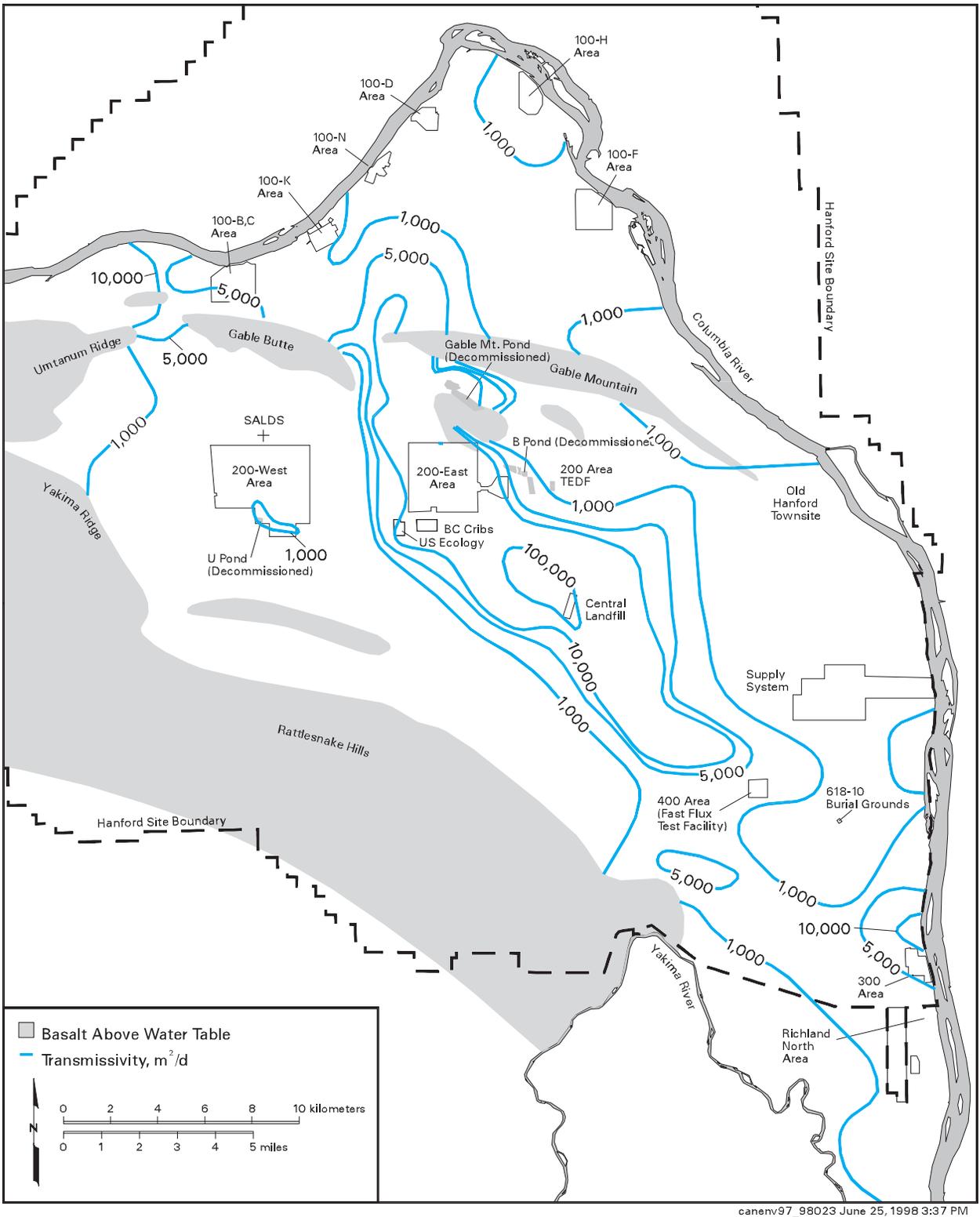


Figure 6.1.6. Transmissivity Distribution in the Unconfined Aquifer

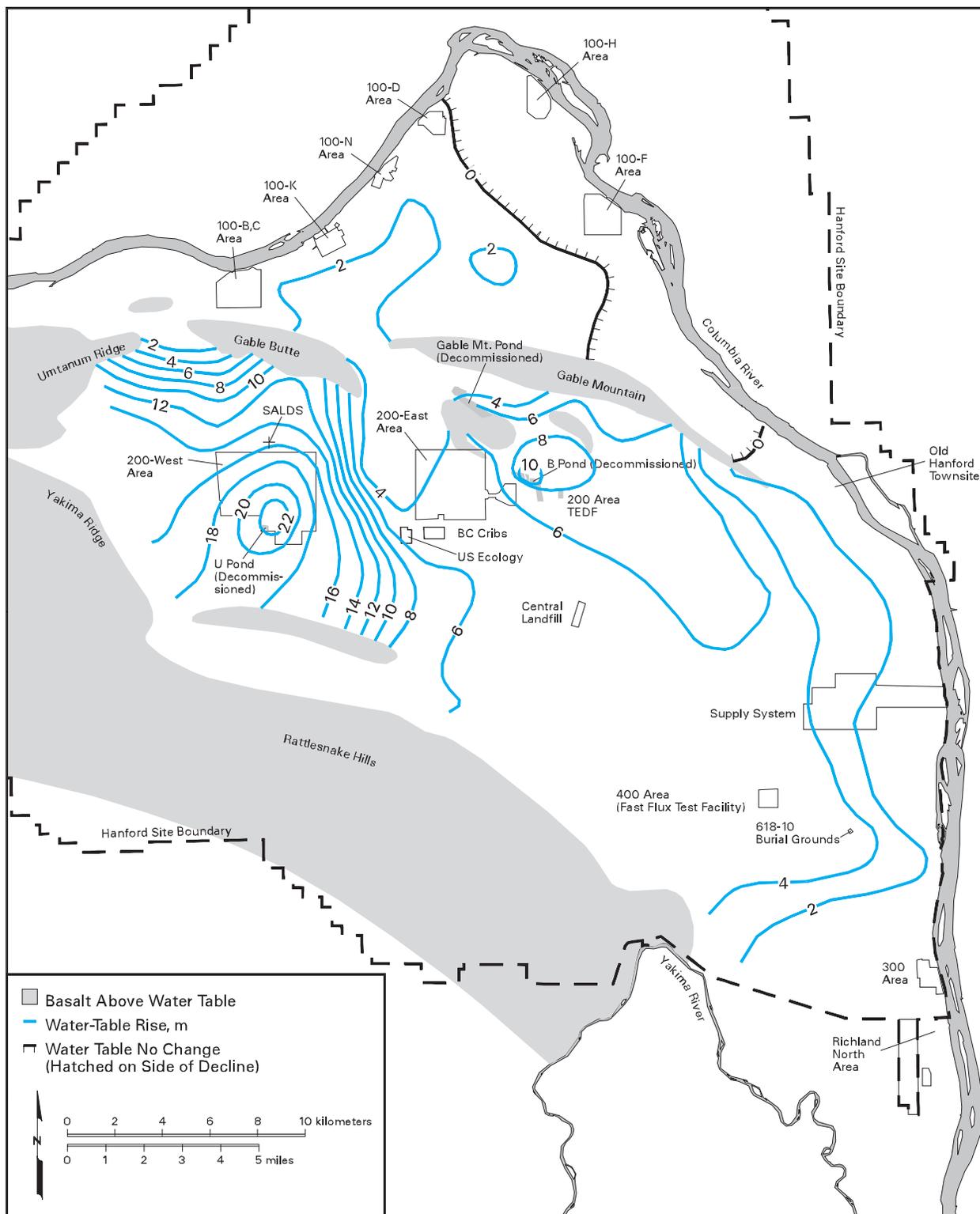


Figure 6.1.7. Change in Water-Table Elevations Between 1944 and 1979

column resulted in a decline in the water table over much of the Hanford Site. Figure 6.1.8 shows the decline between 1979 and 1995, when many waste streams were consolidated and wastewater discharge was reduced. The greatest decline in the water table occurred in the 200-West Area and is discussed below. The water table continues to decline over much of the Hanford Site, as illustrated by Figure 6.1.9, which shows the changes between 1996 and 1997.

Two major groundwater mounds formed in the vicinity of the 200-East and 200-West Areas in response to wastewater discharges. The first of these mounds was created by disposal at U Pond in the 200-West Area. After U Pond was decommissioned in 1984, the mound slowly dissipated and has become much less distinct over the last several years. However, the water table continues to decline in this area (see Figure 6.1.9). The second major mound was created by discharge to B Pond, east of the 200-East Area. The water-table elevation near B Pond increased to a maximum before 1990 and then decreased because of reduced discharge. After discharge to B Pond ceased in August 1997, the decline in the water-table elevation accelerated. The recent decline in the water-table elevation at B Pond is illustrated by the contours in Figure 6.1.9. These mounds have altered the unconfined aquifer's natural flow pattern, which is generally from the recharge areas in the west to the discharge areas (primarily the Columbia River) in the east and north. Water levels in the unconfined aquifer have continually changed as a result of variations in the volume and location of wastewater discharge. Consequently, the movement of groundwater and its associated constituents has also changed with time. Groundwater mounding related to wastewater discharges has also occurred in the 100 and 300 Areas; however, groundwater mounding in these areas is not as great as in the 200 Areas primarily because of lower discharge volumes.

In the 100 Areas, 300 Area, and other locations near the Columbia River, groundwater levels are influenced by river stage (PNL-9437). The Columbia River stage was unusually high throughout most of 1997, resulting in a rising water table near the river. This rise is illustrated in Figure 6.1.9 by the positive contours adjacent to the river. As a result of the rising water table near the river, water flowed from the river into the aquifer during much of the year.

6.1.3 Contaminant Transport

The history of contaminant releases and the physical and chemical principles of mass transport control the distribution of radionuclides and chemicals in groundwater. Processes that control movement of these contaminants at the Hanford Site are discussed below.

Most of the groundwater contamination at the Hanford Site resulted from discharge of wastewater from reactor operations, reactor fuel fabrication, and processing of spent reactor fuel. Table 6.1.1 lists the contaminants found in each area and the type of operation that generated them. In the 100 Areas, discharges included reactor cooling water, fuel storage basin water, filter backwash, and smaller amounts of waste from a variety of other processes. In the 200 Areas, large quantities of wastewater from fuel reprocessing were discharged. Other contamination sources in the 200 Areas include plutonium purification waste and decontamination waste. The plutonium purification process resulted in the discharge of large amounts of liquid organic chemicals in addition to aqueous solutions. In particular, carbon tetrachloride was discharged in the 200-West Area in a nonaqueous liquid form. This organic liquid, once in contact with groundwater, slowly dissolves and produces groundwater contaminant plumes. The presence of nonaqueous liquid has a major impact on the site's groundwater remediation strategy because the organic liquid in the subsurface represents a continuing source of groundwater contamination but is very difficult to clean up. Groundwater contamination in the 300 Area resulted mainly from discharge of fuel fabrication wastes.

Liquid effluents discharged to the ground at the Hanford Site facilities percolated downward through the unsaturated zone toward the water table. Radionuclide and chemical constituents move through the soil column and, in some cases, enter the groundwater. In some locations, sufficient water was discharged to saturate the soil column to the surface. Not all contaminants move at the same rate as the water in the subsurface. Chemical processes such as adsorption onto soil particles, chemical precipitation, and ion exchange slow the movement of some constituents such as strontium-90, cesium-137, and plutonium-239,240. However, these processes may be affected by the chemical characteristics of the waste such as high ionic strength, acidity, or presence of

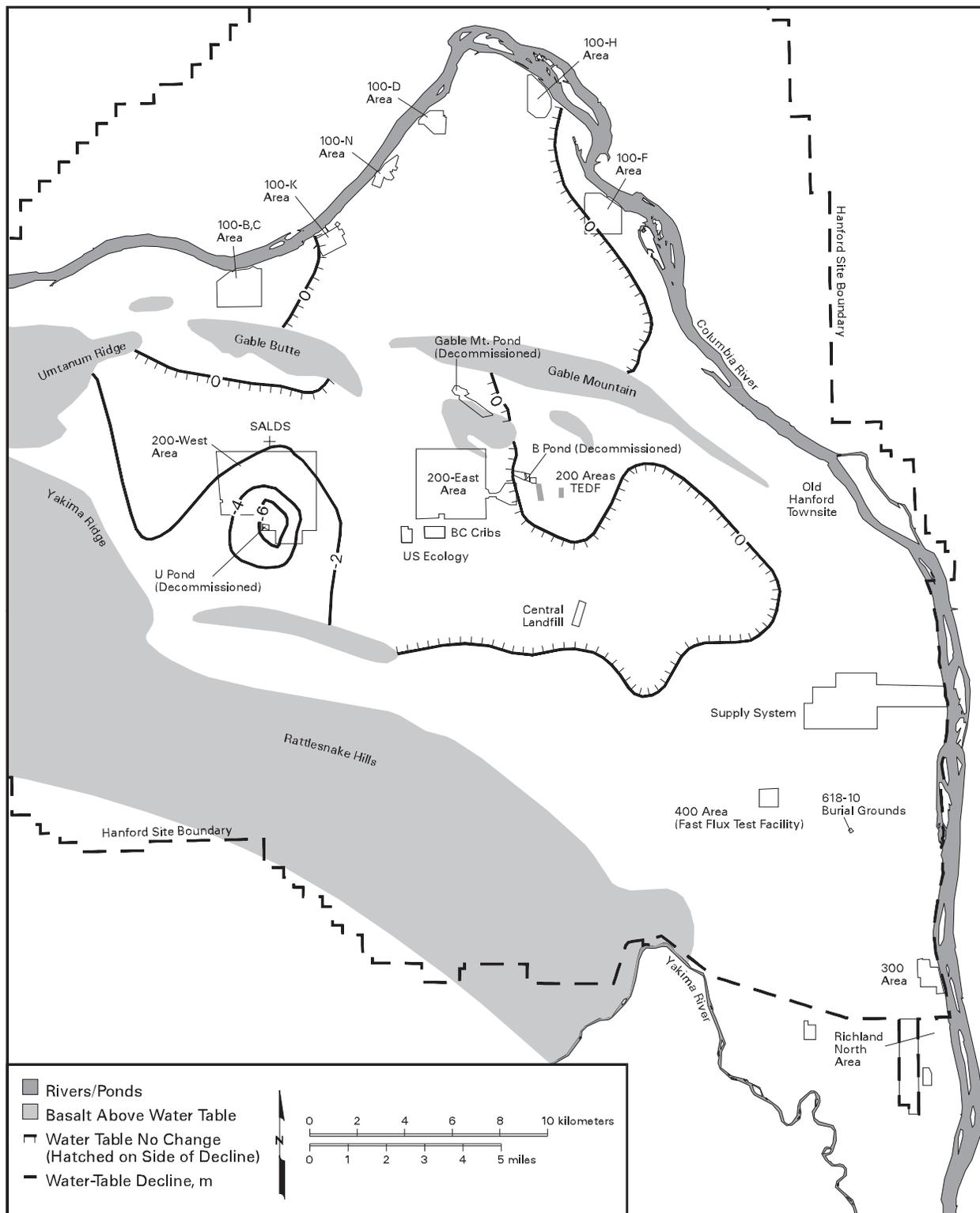
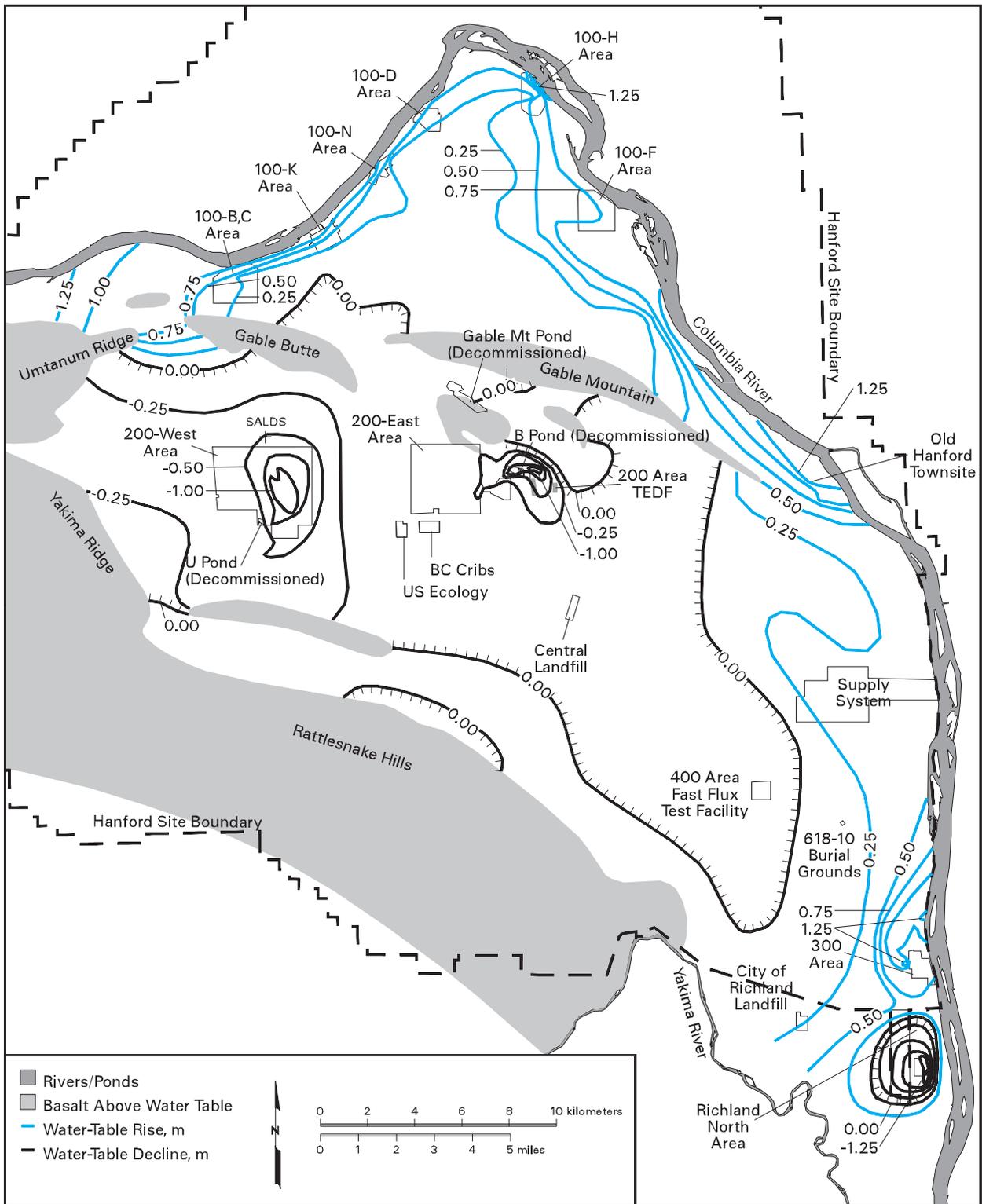


Figure 6.1.8. Change in Water-Table Elevations Between 1979 and 1995



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Figure 6.1.9. Change in Water-Table Elevations Between 1996 and 1997

Table 6.1.1. Chemical and Radiological Groundwater Contaminants and Their Link to Site Operations

Constituents Generated	Areas	Facilities Type
Tritium, ⁶⁰ Co, ⁹⁰ Sr, Cr ⁶ , SO ₄ ²⁻	100	Reactor operations
Tritium, ⁹⁰ Sr, ⁹⁹ Tc, ¹²⁹ I, ¹³⁷ Cs, Pu, U, CN ⁻ , Cr ⁶ , F ⁻ , NO ₃ ⁻	200	Irradiated fuel processing
Pu, carbon tetrachloride, chloroform, NO ₃ ⁻	200	Plutonium purification
⁹⁹ Tc, U, Cr ⁶ , trichloroethylene	300	Fuel fabrication

chemical complexants. Other radionuclides, such as technetium-99, iodine-129, and tritium, and chemicals, such as nitrate, are not as readily retained by the soil and move vertically through the soil column at a rate nearly equal to the infiltrating water. When the contaminants reach the water table, their concentrations are reduced by dilution with groundwater. As these dissolved constituents move with the groundwater, many radionuclides and chemicals adhere to sediment particle surfaces (adsorption) or diffuse into the particles (absorption). Dissolved constituents in groundwater tend to spread out by dispersion as the groundwater moves. Radionuclide concentrations are reduced by radioactive decay.

Outside the source areas (i.e., liquid disposal sites), there is typically little or no downward gradient (driving force or head), so contamination tends to remain in the upper part of the aquifer. Where large volumes of water are discharged, there may be a significant vertical hydraulic gradient that tends to move contaminants downward in the aquifer. Layers of low permeability silt and clay within the unconfined aquifer also limit the vertical movement of contaminants. Flow in the unconfined aquifer is generally toward the Columbia River, which acts as a drainage area for the groundwater flow system at Hanford. Contamination that reaches the river is further diluted by river water.

6.1.4 Groundwater Modeling

Numerical modeling of groundwater flow and contaminant transport is performed to simulate future groundwater flow conditions and predict the migration of contaminants through the groundwater pathway. During 1997, a model was used to simulate future movement of selected contaminant plumes in the unconfined aquifer system. A groundwater flow model was also applied to illustrate the interaction between the unconfined aquifer and the

Columbia River in the vicinity of the 100-N Area. The objective was to better understand the release of strontium-90 from the aquifer into the river. Other models were used in the design and evaluation of pump-and-treat activities aimed at remediation of contaminated groundwater in the 200-West Area. A brief description of these modeling efforts is provided here; additional details and results are presented in PNNL-11793 (Section 6.0) and PNNL-11801.

During the past several years, a three-dimensional flow and transport model has been under development. The objective of developing this model was to provide more accurate simulations of contaminant transport within the sitewide unconfined aquifer system. The model is based on the Coupled Fluid, Energy, and Solute Transport (CFEST) code (BMI/ONWI-660). During 1997, the model was updated to a new version of the CFEST code called CFEST-96. Information on the initial development of the three-dimensional CFEST model is available in PNL-10886. The model was used to simulate transient groundwater flow conditions through the year 2500 under assumed future recharge scenarios. The movements of existing tritium, strontium-90, technetium-99, iodine-129, and uranium plumes originating from the 200 Areas were predicted for this time period.

Future levels of tritium predicted by the sitewide model suggest that water supply wells in the 400 Area and emergency water supply wells in 200-East Area will continue to be impacted by the tritium plume originating from the 200-East Area for the next 10 to 20 years. Tritium levels in the upper part of the unconfined aquifer system in the 200-East and 400 Areas are expected to remain above 20,000 pCi/L until sometime between 2010 and 2020. Model results predicted that tritium now found in the 300 Area in excess of 2,000 pCi/L will not reach the North Richland well field, a municipal water supply south of the Hanford Site. The 200-East Area tritium plume was predicted to migrate primarily to discharge areas along

the Columbia River between the Old Hanford Townsite and the 300 Area over the next 90 to 100 years. A smaller plume will migrate northward to the Columbia River. The tritium plume from the 200-West Area was predicted to migrate beneath the 200-East Area as its concentration is reduced by dispersion and decay (half-life = 12.26 years).

Predictions of the iodine-129 plume indicated that it will migrate toward and discharge into the Columbia River over a period of about 570 years. During this period, iodine-129 concentrations predicted to discharge into the river will decline slightly by the process of dispersion. However, concentrations will not fall significantly below current levels because of the long half-life (16,000,000 years) of iodine-129. The technetium-99 and uranium plumes originating in the 200 Areas were predicted to continue migrating from source locations toward the Columbia River. Concentration levels of the simulated plumes will decline to below regulatory limits over a period of approximately 100 years because of plume dispersion. The strontium-90 plume in the 200-East Area will not migrate far from its current location because strontium-90 is sorbed by sediments. Concentrations will decline primarily because of radioactive decay (half-life = 28.8 years).

Modeling of groundwater interaction between the unconfined aquifer and the Columbia River in the vicinity of the 100-N Area was conducted as part of the evaluation of a proposed in situ treatment zone. The treatment zone would be placed in the aquifer close to the Columbia River and would contain a mineral, clinoptilolite, that reacts with strontium-90 and keeps it from migrating to the river. One of the uncertainties associated with this technology and other proposed remediation technologies at the 100-N Area is the effect of river stage fluctuations on groundwater movement near the river.

The Subsurface Transport Over Multiple Phases (STOMP) model (PNNL-11217) was used because of its ability to handle seepage face boundaries. The model simulated the interaction between the Columbia River and the unconfined aquifer in 1-h time steps for 4 weeks in October and early November. These 4 weeks were chosen because the Columbia River daily fluctuations are greatest during that time. Results of the simulation clearly demonstrate that variations in the level of the Columbia River have an impact on the near-river unconfined aquifer. Results also showed that bank storage is important in calculating total water movement from the aquifer into the river. In the model, the amount of water entering the river from bank

storage was an order of magnitude greater than the net flux of groundwater from the aquifer into the river. For contaminants that are not sorbed, such as tritium and hexavalent chromium, water entering the aquifer from the river dilutes the concentration of these contaminants before they enter the river. However, for contaminants that are sorbed onto sediments, the flux of river water in and out of the sediments may remove sorbed contaminants near the river faster than would be predicted assuming steady-state groundwater flow.

Groundwater models were also used to assess the performance of groundwater pump-and-treat systems in the 200-UP-1 and 200-ZP-1 Operable Units in the 200-West Area. In these systems, contaminated water is removed by means of extraction wells, treated, and either disposed of to the State-Approved Land Disposal Site (200-UP-1) or returned to the aquifer through injection wells (200-ZP-1) (BHI-01126). The models were used to predict system performance, assuming different extraction and injection well configurations, capture zones, and zones of hydraulic influence for the extraction and injection wells. Modeling was conducted using the Micro-FEM[®] finite-element code (Hemker-vanElburg, Amsterdam, The Netherlands). Groundwater modeling for the 200-UP-1 plume indicated that most of the targeted plume will be captured under the current well configuration. Modeling of the 200-ZP-1 pump-and-treat operation predicted that the high concentration area of the plume will be captured. During 1997, measurable progress was made toward hydraulic containment at each of these pump-and-treat operations (Section 5.9.4 in PNNL-11793).

6.1.5 Groundwater Monitoring

Groundwater monitoring at the Hanford Site is an integral part of the *Hanford Site Ground-Water Protection Management Plan* (DOE/RL-89-12, Rev. 2). This plan integrates monitoring at active waste disposal facilities to comply with monitoring requirements of the Resource Conservation and Recovery Act and Washington State regulations, as well as requirements for operational monitoring around reactor and chemical processing facilities, and environmental surveillance monitoring. Pacific Northwest National Laboratory manages these monitoring efforts to assess the distribution and movement of existing groundwater contamination, to identify potential and emerging groundwater contamination problems, and to integrate the various groundwater projects to minimize redundancy. Information on contaminant distribution and transport are integrated into a sitewide evaluation of

groundwater quality, which is documented in the annual groundwater monitoring report (e.g., PNNL-11793). Groundwater monitoring is also carried out during cleanup investigations under the Comprehensive Environmental Response, Compensation, and Liability Act as described in the 5-year plan (DOE/S-0078P). These investigations are managed by the environmental restoration contractor.

6.1.5.1 Groundwater Sampling and Analytes of Interest

Groundwater samples were collected from 726 wells for all monitoring programs during 1997. The locations of sampled wells are shown in Figures 6.1.10 and 6.1.11. Well names are indicated only for wells in the 600 and 400 Areas that are specifically discussed in the text. Because of the density of unconfined aquifer wells in the operational areas, well names in these areas are shown on detailed maps in the following sections. Figure 6.1.12 shows the locations of facilities where groundwater monitoring was conducted to comply with the Resource Conservation and Recovery Act (Appendix A in PNNL-11793). Wells at the Hanford Site generally follow a naming system in which the well name indicates the approximate location of the well. The prefix of the well name indicates the area of the site, as shown in Table 6.1.2. The well names for 600 Area wells follow a local coordinate system in which the numbers indicate the distance relative to an arbitrary datum location in the south-central part of the site.

The monitoring frequency for the wells is selected based on regulatory requirements, proximity to waste sources, and characteristics of the groundwater flow system at the sample location. Of the 726 wells sampled, 324 were sampled once, 184 twice, 54 three times, 81 four times, and 83 more than four times during the year.

Each monitoring program has access to groundwater data collected by other programs through a common database, the Hanford Environmental Information System. This database currently contains approximately 1.5 million groundwater monitoring result records. After the data are verified and/or validated, they are made available to state and federal regulators for retrieval.

Most groundwater monitoring wells on the site are 10 to 20 cm (4 to 8 in.) in diameter. Monitoring wells for the unconfined aquifer are constructed with well screens or perforated casing generally in the upper 3 to 6 m (10 to 20 ft) of the unconfined aquifer, with the open interval extending across the water table. This construction allows

sample collection at the top of the aquifer, where maximum concentrations of radionuclides tend to be found. Wells monitoring the shallowest of the basalt-confined aquifers have screens, perforated casing, or an open hole within the monitored aquifer. Wells drilled before 1985 were generally constructed with carbon steel casing. Wells recently constructed for Resource Conservation and Recovery Act monitoring projects and Comprehensive Environmental Response, Compensation, and Liability Act characterizations have been constructed with stainless steel casing and screens. Most monitoring wells onsite are sampled using either submersible or Hydrostar™ pumps (a registered trademark of Instrumentation Northwest, Inc., Redmond, Washington), though some wells are sampled with bailers or airlift systems.

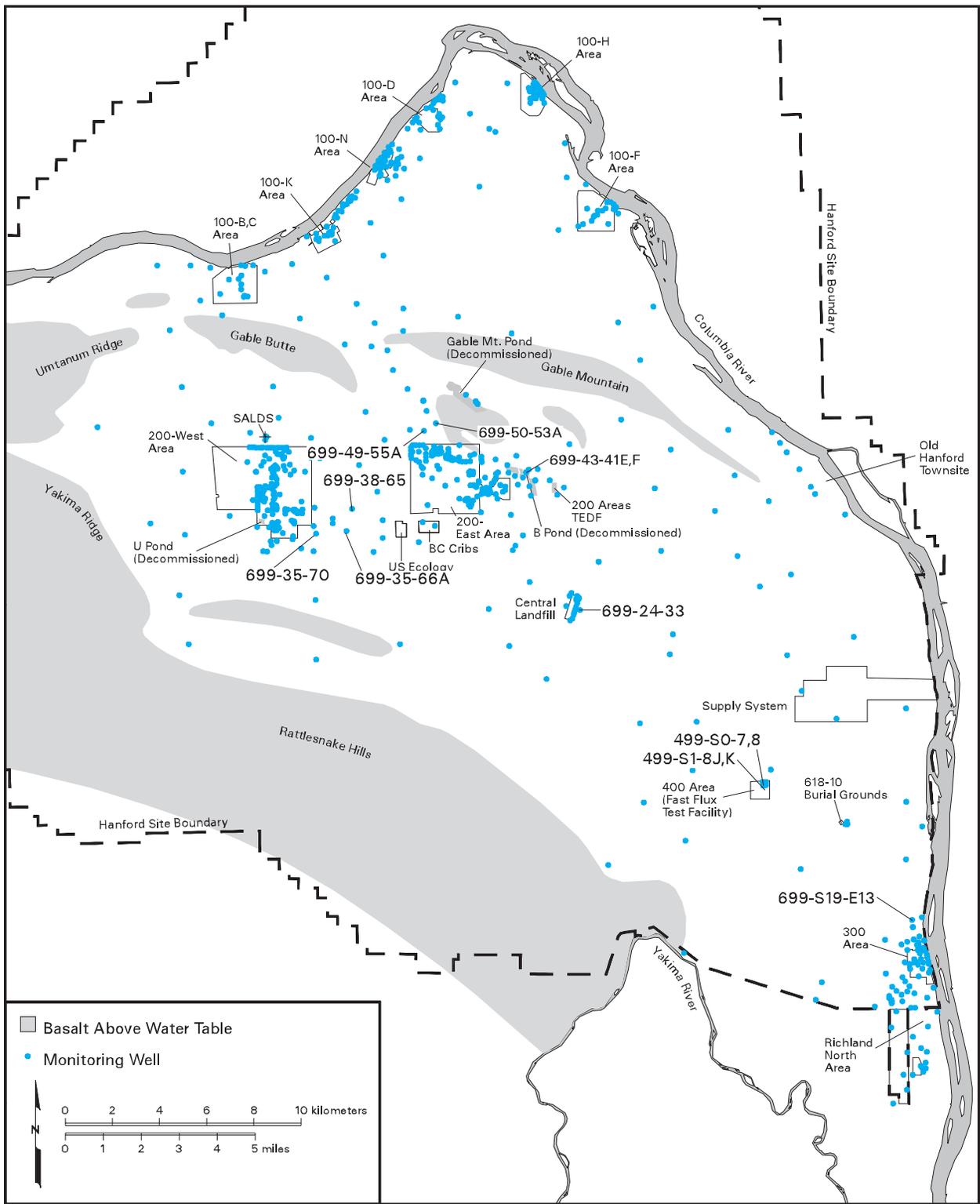
Samples were collected for all programs following documented sampling procedures (PNL-6894, Rev. 1; WHC-CM-7-4) based on U.S. Environmental Protection Agency (EPA) guidelines (OSWER 9950-1). Analytical techniques used are listed in DOE/RL-91-50, Rev. 2; PNL-10698 (Section 4.1.7); and Comprehensive Environmental Response, Compensation, and Liability Act work plans. The radionuclides and chemicals for which analyses were conducted are listed in Table 6.1.3.

Most groundwater samples collected onsite in 1997 were analyzed for tritium. Selected samples were analyzed for other radionuclides. Sample results for radionuclides are generally presented in picocuries per liter; however, the results for total uranium, which is usually measured by laser fluorescence, are given in micrograms per liter ($\mu\text{g/L}$).

Nitrate analyses were performed on many samples collected during 1997 because of the extensive areas with elevated nitrate concentrations originating from onsite and offsite sources. However, nitrate concentrations were below the EPA 45-mg/L drinking water standard (40 CFR 141) for most of the affected area. Selected monitoring wells were used for additional chemical surveillance. The results of previous chemical analyses and the proximity to known active and inactive chemical disposal sites were considered in choosing wells for sampling chemical contaminants.

6.1.5.2 Data Interpretation

Each analysis of a groundwater sample provides information on the composition of groundwater at one time at one location in the aquifer. Uncertainty in the analyses results from a number of sources. Some of the sources



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Figure 6.1.10. Unconfined Aquifer Monitoring Well Locations, 1997

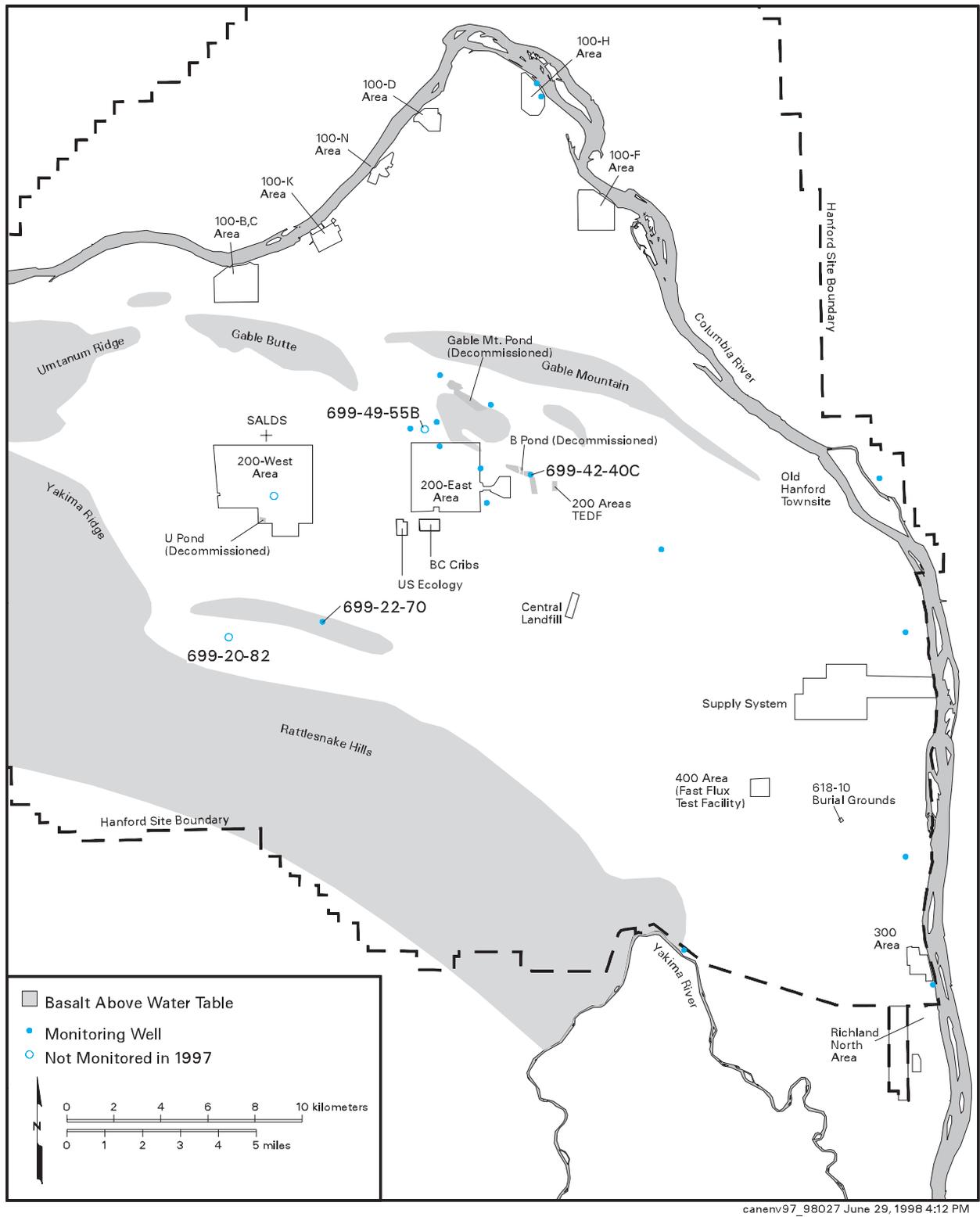


Figure 6.1.11. Confined Aquifer Monitoring Well Locations, 1997

Table 6.1.2. Explanation of the Hanford Site Well Naming System

Example Well Name	Area
199-	100 Areas
199-B3-47	100-B,C Area
199-D5-12	100-D Area
199-F8-3	100-F Area
199-H4-3	100-H Area
199-K-30	100-K Area
199-N-67	100-N Area
299-	200 Areas
299-W19-3	200-West Area
299-E28-4	200-East Area
399-	300 Area
399-1-17A	300 Area
499-	400 Area
499-S1-8J	400 Area
699-	600 Area
699-50-53A	600 Area north and west of datum
699-42-E9A	600 Area north and east of datum
699-S19-11	600 Area south and west of datum
699-S19-E13	600 Area south and east of datum

Note: Letters at end of well names distinguish either multiple wells located close together or multiple intervals within a single well bore.

of uncertainty are discussed below. Several techniques used to interpret the sample results are also discussed.

Groundwater sampling techniques are designed to collect a sample that is representative of the constituent concentration in the aquifer when the sample is taken. However, there are limitations in collecting representative samples or even defining precisely the volume of the aquifer represented by the sample. Proper well construction and maintenance, well purging, sample preservation, and, in some instances, filtering are used to help ensure consistent and representative samples. Careful sample labeling protocols, chain-of-custody documentation, and

bottle preparation avoid many gross errors in sample results. Duplicate samples and field blanks are used to assess the sampling procedure.

Uncertainties are inherent in laboratory analysis of samples. Gross errors can be introduced in the laboratory or during sampling. Gross errors include transcription errors, calculation errors, mislabeling results, field equipment problems, or other errors that result from not following established procedures. Often, these gross errors can be recognized because unreasonably high or unreasonably low values result. Data review protocols are used to investigate and correct gross errors.

Random errors are unavoidably introduced in the analytical procedures. Usually, there are insufficient replicate analyses to assess the overall random error at each sample location. Instruments for analysis of radioactive constituents count the number of radioactive decay products at a detector, and background counts are subtracted. The nature of radioactive decay and the instrument design result in a random counting error that is reported with the analytical result. Generally, a sample result less than the counting error indicates the constituent was not detected. The background subtraction may result in the reporting of results that are less than zero. Although less-than-zero results are physically impossible, the negative values are of use for some statistical analyses (see "Helpful Information" section for more details).

Systematic errors may result from instrument calibration, standard or sample preparation, chemical interferences in analytical techniques, as well as sampling methodology and sample handling. Sample and laboratory protocols have been designed to minimize systematic errors. The analytical laboratories participate in interlaboratory comparisons in which many laboratories analyze blind samples prepared by the EPA (Section 8.0, "Quality Assurance").

In 1997, double-blind samples for specific constituents were analyzed (Section 8.0, "Quality Assurance," discusses double-blind results). Several wells were also cosampled with the Washington State Department of Health for comparison, and the results are available from that agency.

The chemical composition of groundwater may fluctuate from differences in the contaminant source, recharge, or groundwater flow field. The range of this concentration fluctuation can be estimated by taking many samples, but there is a limit to the number that can be practicably taken. Comparison of results through time helps interpret this variability.

Table 6.1.3. Radionuclides and Chemicals Analyzed for in Groundwater, 1997

Radiological Parameters	Chemical Parameters
Tritium	pH (field and laboratory)
Carbon-14	Conductance (field)
Cobalt-60	Alkalinity
Strontium-90	Total carbon
Technetium-99	Total organic carbon
Ruthenium-106	Total organic halogens
Antimony-125	B, Be, Na, Mg, Al, K, Co, Si, As, Se
Iodine-129	Ca, V, Cr, Mn, Fe, Ni, Pb, Li, Mo, Hg
Cesium-137	Cu, Zn, Sr, Ag, Cd, Sb, Ba, Sn, Tl
Americium-241	F ⁻ , Cl ⁻ , NO ₃ ⁻ , PO ₄ ⁻³ , SO ₄ ⁻² , NO ₂ ⁻ , Br ⁻
Gross alpha	CN ⁻
Gross beta	NH ₄ ⁺
Plutonium isotopes	Volatile organic compounds
Radium isotopes	Semivolatile organic constituents
Uranium isotopes	Polychlorinated biphenyls
Uranium (total)	Dioxins/furans
	Pesticides/herbicides
	Biological oxygen demand/chemical oxygen demand
	Dissolved oxygen
	Total petroleum hydrocarbons
	Oil and grease

Overall sample uncertainty may be factored into data evaluation by considering the concentration trend in a given well over time. This often helps identify gross errors, and overall long-term trends can be distinguished from short-term variability. The interpretation of concentration trends depends on an understanding of chemical properties as well as site hydrogeology. The trend analysis, in turn, aids in refining the conceptual model of the chemical transport.

Plume maps presented in this section illustrate site groundwater chemistry. Although analytical data are available only at specific points where wells were sampled, contours are drawn to join the approximate locations of equal chemical concentration or radionuclide activity. The contour maps are simplified representations of plume geometry

because of map scale, the lack of detailed information, and the fact that plume depth and thickness cannot be fully represented on a two-dimensional map. Plume maps are a powerful tool because knowledge of concentrations in surrounding wells, groundwater flow, site geology, and other available information are factored into their preparation.

6.1.6 Groundwater Monitoring Results

The following sections summarize the distribution of radioactive and chemical contaminants detected in Hanford Site groundwater during 1997. These discussions are

followed by a summary of groundwater monitoring results for Resource Conservation and Recovery Act sites. More detailed information on groundwater monitoring, including listings of analysis results for each monitoring well in electronic format, is available in PNNL-11793. However, because PNNL-11793 (the annual groundwater report) covers the fiscal year, it does not include results from the last 3 months of 1997.

One way to assess the impact of radionuclides and chemicals in groundwater is to compare the concentrations to EPA's drinking water standards and DOE's derived concentration guides (40 CFR 141 and DOE Order 5400.5; see Appendix C, Tables C.2 and C.5). The drinking water standards are for protecting public drinking water supplies. The derived concentration guides are for protecting the public from radionuclides resulting from DOE activities. Specific drinking water standards have been proposed for only a few radiological constituents. Drinking water standards resulting in an annual dose of 4 mrem/yr have been calculated for other radionuclides by considering the half-life of the isotope, the energy and nature of the radioactive decay for that isotope, and the physiological factors such as the buildup of the isotope in particular organs. Drinking water standards are more restrictive than derived concentration guides. This is because the standards are based on an annual dose to the affected organ of 4 mrem/yr, while the guides are based on an effective dose equivalent of 100 mrem/yr (see Appendix C, Tables C.2 and C.5). In addition, the standards use older factors for calculating the concentrations that would produce a 4-mrem/yr dose than are used in calculating the guides. Thus, the values used below for standards are not always in agreement with the guides. The guides are available only for radionuclides. Primary and secondary drinking water standards are given for some chemical constituents; secondary standards are based on aesthetic rather than health considerations.

6.1.6.1 Radiological Monitoring Results for the Unconfined Aquifer

The radionuclides for which analyses were conducted on Hanford Site groundwater were listed in Table 6.1.3. The distribution of tritium, iodine-129, technetium-99, uranium, strontium-90, cesium-137, cobalt-60, and plutonium are discussed in the following sections. Gross alpha and gross beta are used as indicators of radionuclide distribution and are not discussed in detail because the specific radionuclides contributing to these measurements are discussed individually. Several other radionuclides, including ruthenium-103, antimony-125, and americium-241,

are associated with wastes from Hanford Site operations. Because of their very low concentrations in groundwater, they are not discussed in this section.

Tritium. Tritium is present in irradiated nuclear fuel and was released in process condensates associated with decladding and dissolution of the fuel. Tritium was also manufactured as part of the Hanford mission by irradiating targets containing lithium in several reactors from 1949 to 1952 (DOE/EIS-0119F, WHC-SD-EN-RPT-004). In the late 1960s, tritium production took place in N Reactor (WHC-MR-0388).

Tritium was present in many historical waste streams at the Hanford Site and is highly mobile, essentially moving at the same velocity as the groundwater. As a result, the extent of groundwater contamination from site operations is generally reflected by tritium distribution. Tritium is the radionuclide most frequently monitored at the Hanford Site for this reason. Figure 6.1.13 shows the 1997 distribution of tritium in the unconfined aquifer. Tritium is one of the most widespread contaminants in groundwater across the Hanford Site and exceeds the EPA 20,000-pCi/L drinking water standard in the 100-B,C, 100-D, 100-K, 100-N, 200, 400, and 600 Areas. It is assumed that the 20,000-pCi/L concentration yields an annual dose of 4 mrem/yr, as explained in the introduction to this section. Tritium exceeded the DOE 2,000,000-pCi/L derived concentration guide at one location in the 200-East Area.

In 1997, the only tritium bearing liquid effluent discharged to the soil column on the Hanford Site occurred at the State-Approved Land Disposal Site, which began operation in 1995 and located just north of the 200-West Area.

Tritium in the 100 Areas. Tritium concentrations greater than the 20,000-pCi/L drinking water standard were detected in the 100-B,C, 100-D, 100-K, and 100-N Areas. The highest tritium concentrations were detected in the 100-K Area. The largest tritium plume in the 100 Areas with concentrations above the drinking water standard occurs near the Columbia River from the 100-N Area to the 100-D Area.

Samples from two wells in the 100-B,C Area showed tritium concentrations that exceeded the 20,000-pCi/L drinking water standard in 1997. The concentrations downgradient of B Reactor waste disposal cribs showed an increasing trend between approximately 1994 and 1997, reaching a maximum of 420,000 pCi/L in 1997. The tritium concentration adjacent to the Columbia River slightly exceeded the drinking water standard in 1997.

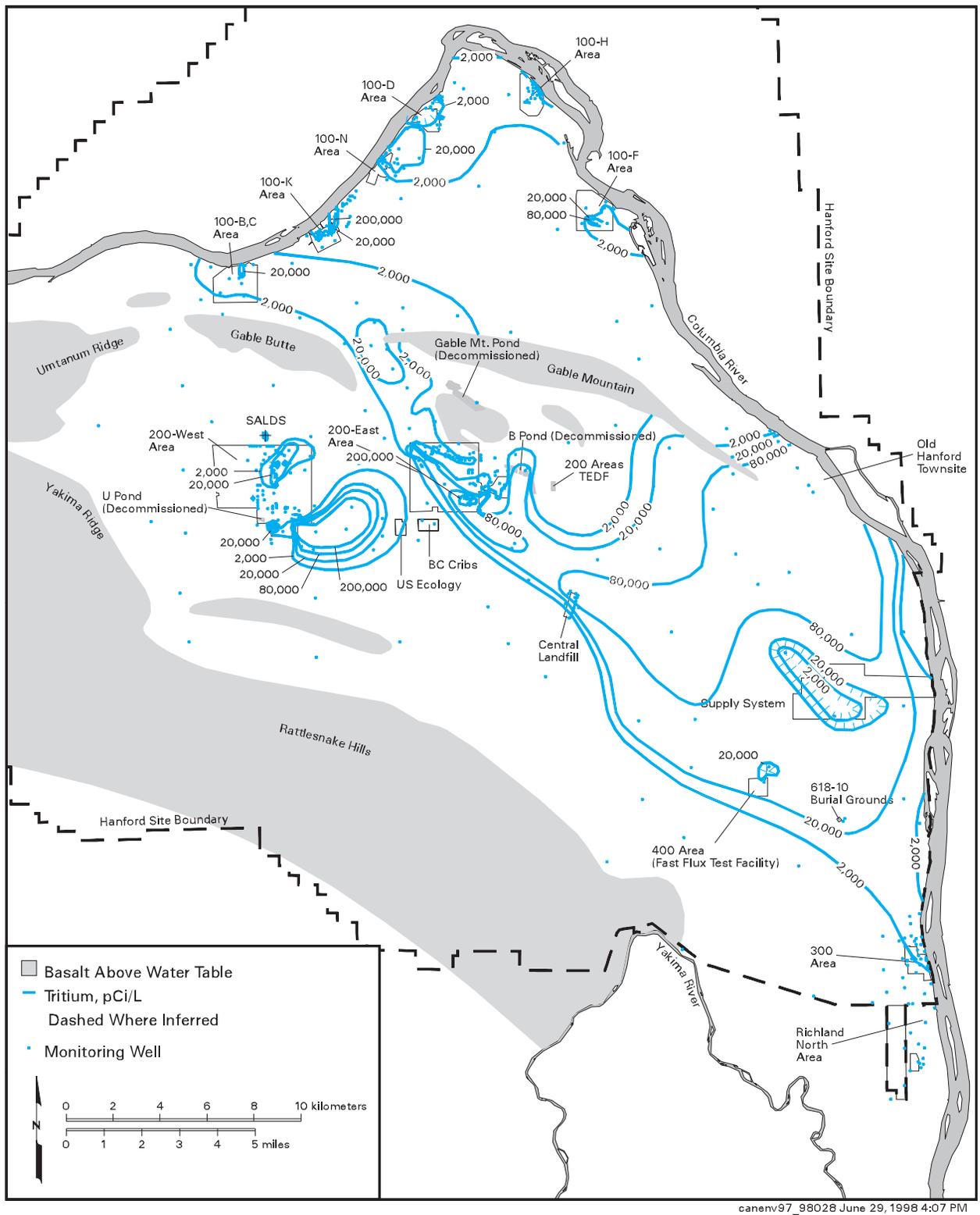


Figure 6.1.13. Tritium Distribution in the Unconfined Aquifer, 1997

In the 100-D Area, tritium concentrations were greater than the 20,000-pCi/L drinking water standard in two wells located in the southwestern corner of the area. The maximum tritium level reported during 1997 was 47,600 pCi/L. These concentrations are associated with the tritium plume that extends southwest to the 100-N Area.

In the 100-K Area, the highest tritium concentrations in groundwater occur in the vicinity of the KE and KW Reactors. Well 199-K-30, located near the KE Reactor, continued to contain the highest tritium level within the 100 Areas, with a maximum concentration of 536,000 pCi/L in 1997. The tritium trend for well 199-K-30 is shown in Figure 6.1.14. Previously, in April and May 1993, this well contained tritium in excess of the 2,000,000-pCi/L derived concentration guide. The tritium concentrations declined after reaching a lower peak in mid-1995 but began to increase in 1997. The probable source is past disposal to a french drain east of the reactor building (DOE/EIS-0119F). A well located at the northwestern corner of the KE Reactor showed the most abrupt increase in tritium concentrations in 1997, reaching a maximum of 420,000 pCi/L. Additional investigation is planned for 1998 to assess the cause of this increase. A well located adjacent to a french drain near the KW Reactor showed a maximum concentration of 52,300 pCi/L in 1997. This was almost an order of magnitude lower than the maximum (499,000 pCi/L) in 1996.

Tritium in the northern part of the 100-N Area is found in concentrations greater than the 20,000-pCi/L drinking water standard. The tritium plume in this area extends northeast to the 600 and 100-D Areas. This plume is associated with the 1301-N and 1325-N Liquid Waste Disposal Facilities. The most significant concentrations were reported in two wells near these facilities. The maximum tritium level reported in the 100-N Area in 1997 was 95,600 pCi/L near the 1325-N facility. A well located between the 1301-N facility and the Columbia River showed a maximum of 60,200 pCi/L in 1997.

Tritium in the 200-East and 600 Areas. The highest tritium concentrations in the 200-East Area continued to be measured in wells near cribs that received effluent from the Plutonium-Uranium Extraction Plant. However, tritium concentrations are generally decreasing slowly in this area. Concentrations greater than the 2,000,000-pCi/L derived concentration guide were detected in only one well (299-E17-9) in 1997 in the 200-East Area. The maximum tritium level detected in this well, which monitors the 216-A-36B Crib, was 3,070,000 pCi/L. This was the highest tritium concentration detected in any well onsite.

Tritium concentrations in the plume extending from the southeastern portion of the 200-East Area were generally lower in 1997 than in previous years as a result of dissipation and radioactive decay. Downgradient of the Plutonium-Uranium Extraction Plant, the area of contaminated groundwater with tritium concentrations above 200,000 pCi/L extended southeast of the 200-East Area boundary up until 1996. These high concentrations have extended at least as far southeast as the Central Landfill area in the recent past (PNL-8073). In 1997, the plume area above the 200,000-pCi/L concentration contour was considerably smaller and did not extend beyond the 200-East Area boundary.

The movement of the widespread tritium plume (see Figure 6.1.13), extending from the southeastern portion of the 200-East Area to the Columbia River, was consistent with patterns noted in recent monitoring reports (Section 4.8 in PNNL-11472, Section 5.10.3.2 in PNNL-11793). Separate tritium pulses associated with the two episodes of Plutonium-Uranium Extraction Plant operations can be distinguished in the plume. High tritium concentrations east of the 200-East Area near the Columbia River result from discharges to ground during the operation of the Plutonium-Uranium Extraction Plant from 1956 to 1972. Following an 11-year shutdown, plant operation began again in 1983 and ceased in December 1988. This resulted in elevated tritium concentrations measured in several wells downgradient from the 200-East Area. Movement of the leading edge of this second pulse is clearly observable near the Central Landfill (Figure 6.1.15), which shows arrival in early 1987. Tritium concentrations from the first pulse were much higher than from the second. The effects of the second operational period have not been detected near the Columbia River. A trend plot (Figure 6.1.16) of the tritium concentrations in well 699-40-1 near the shore of the Columbia River shows the arrival of the first pulse in the mid-1970s, but shows no indication that the second pulse has yet arrived.

The tritium plume has been monitored since the 1960s and provides information on the extent of groundwater contamination over time. Figure 6.1.17 shows the distribution of tritium in selected years from 1964 through 1988. This figure was created from maps in BNWL-90, BNWL-1970, PNL-5041, and PNL-6825 (Section 5.0). The contours in the original references were recalculated and interpreted to provide uniform contour intervals. Figure 6.1.17 shows that tritium at concentrations greater than the 20,000-pCi/L drinking water standard reached the Columbia River in approximately the mid-1970s.

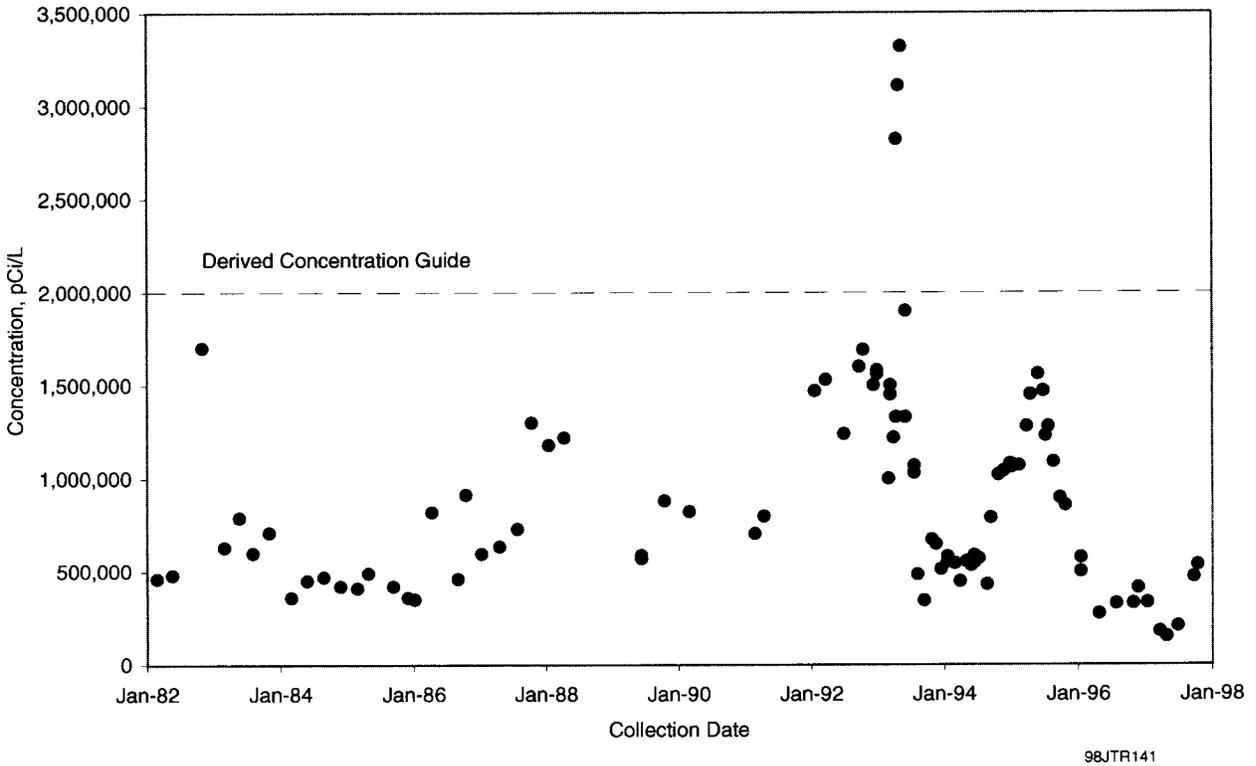


Figure 6.1.14. Tritium Concentrations in Well 199-K-30, 1982 Through 1997

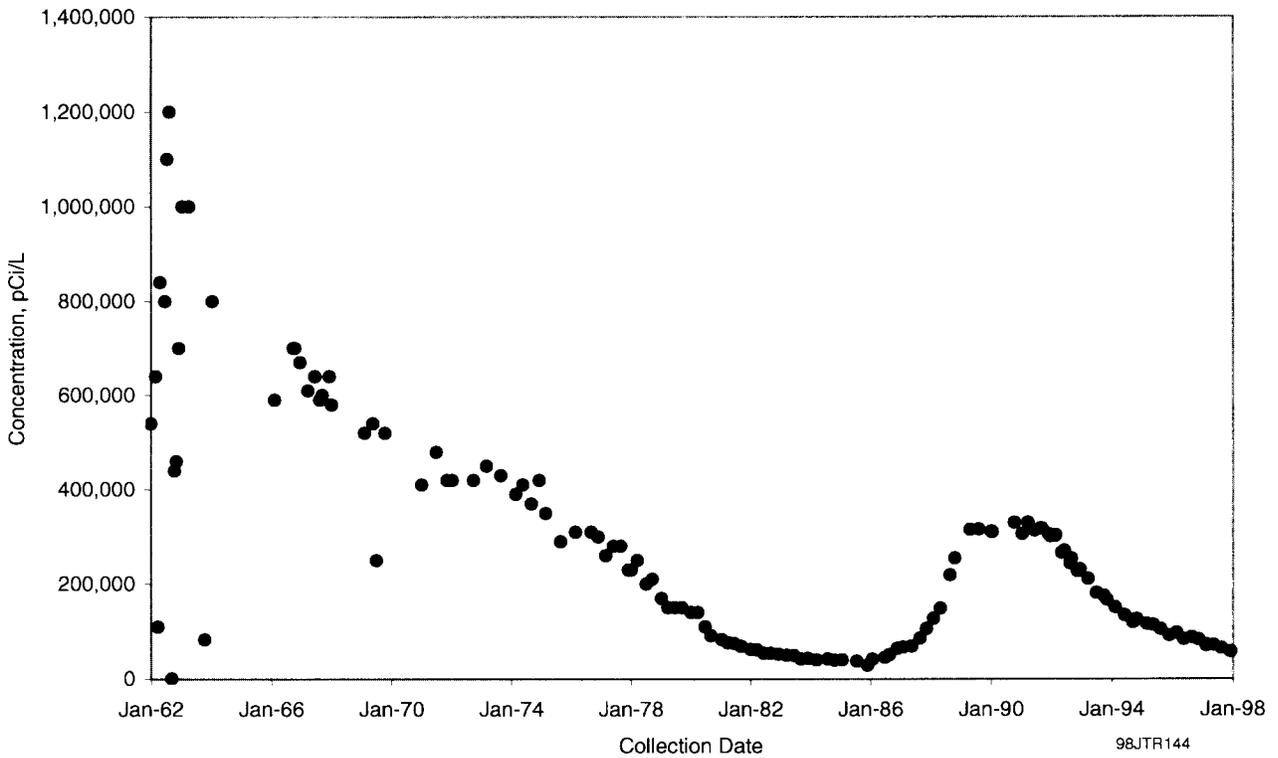


Figure 6.1.15. Tritium Concentrations in Well 699-24-33 Near the Central Landfill, 1962 Through 1997

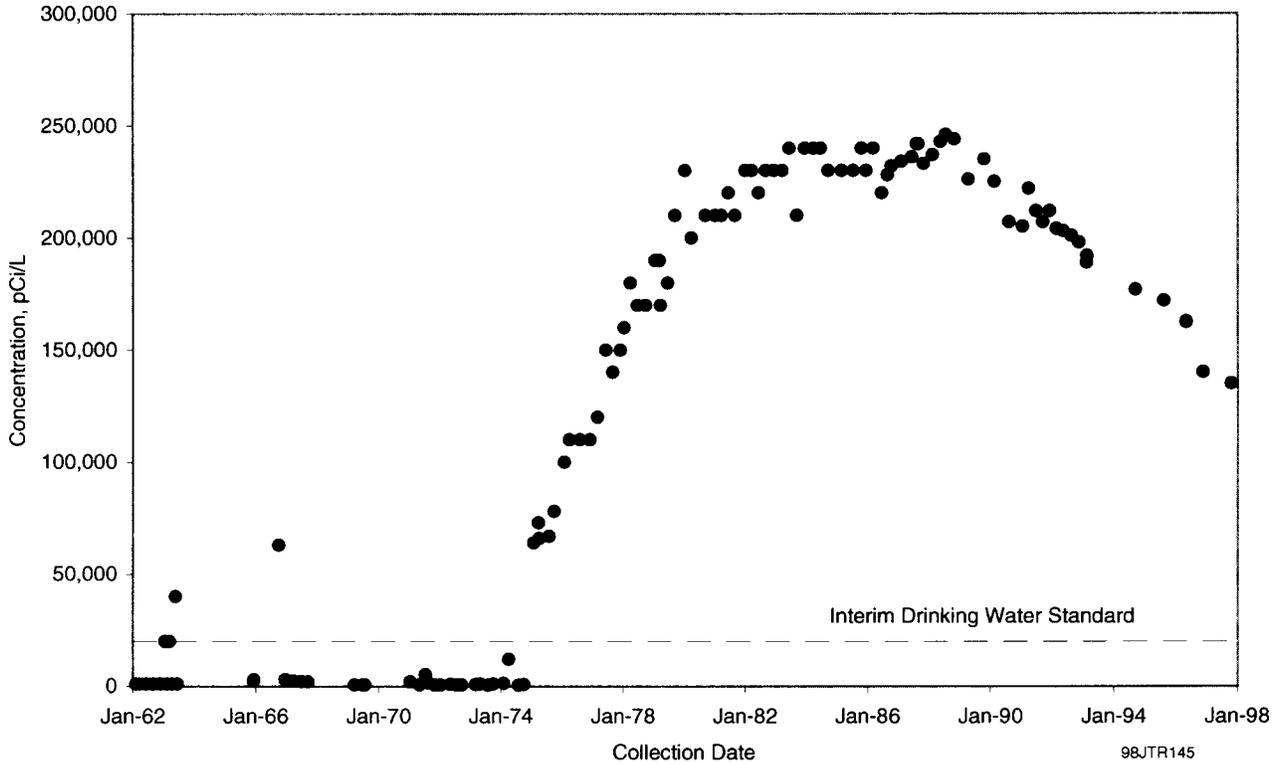


Figure 6.1.16. Tritium Concentrations in Well 699-40-1 Near the Columbia River, 1962 Through 1997

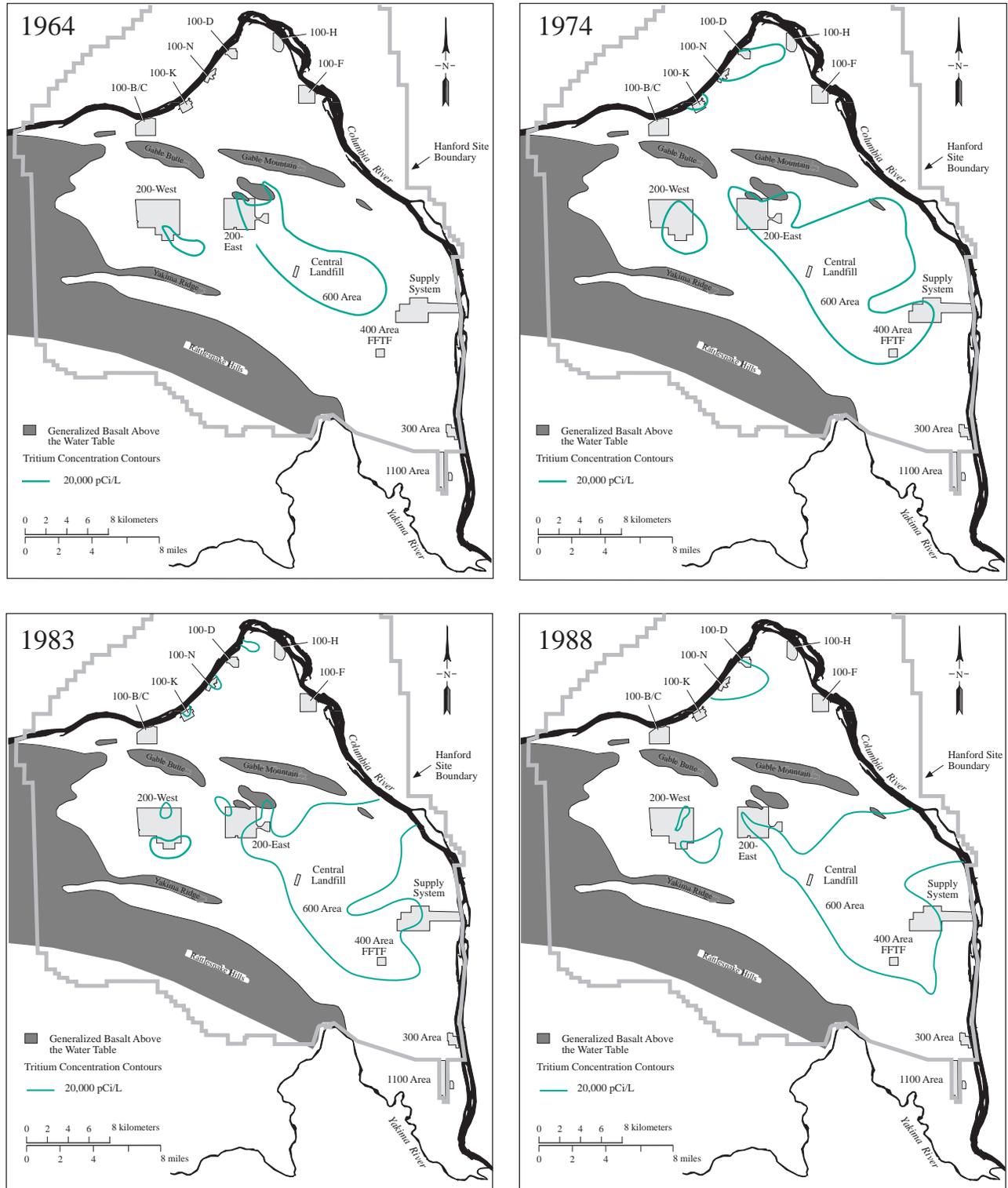
The configuration of the western portion of the tritium plume shown in Figure 6.1.13 closely matches previous predictions of the direction of contaminant movement from the 200-East Area (PNL-6328). Movement is forced to the south by the flow originating at the groundwater mound beneath the former B Pond. Flow to the southeast also appears to be controlled by a zone of highly permeable sediments, stretching from the 200-East Area toward the 400 Area (PNL-7144).

The tritium concentration distribution near the former B Pond shows an area of concentration above the drinking water standard that extends from the former B Pond south to the main tritium plume. B Pond produced a radial flow pattern of groundwater that mostly had low contaminant concentrations. The mound under the former B Pond has begun to dissipate since wastewater flow was diverted to the 200 Areas Treated Effluent Disposal Facility in August 1997. A new mound will presumably form under this facility, as long as it is used for disposal of site effluent.

Tritium is also found at levels above the drinking water standard in the northwestern part of the 200-East Area. This plume appears to extend to the northwest through

the gap between Gable Mountain and Gable Butte. The distribution of tritium concentrations to the northwest and southeast of the 200-East Area indicates a divide in groundwater flow direction across the 200-East Area. A pulse of tritium levels above the standard also occurred between Gable Mountain and Gable Butte.

Tritium in the 200-West Area. The extent of tritium plumes in and around the 200-West Area is also consistent with previous observations. Tritium from sources near the Reduction-Oxidation Plant forms the most extensive and highest concentration plume in the 200-West Area. This plume extends into the 600 Area east of the 200-West Area. The Reduction-Oxidation Plant is located in the southeastern part of the 200-West Area and operated from 1951 through 1967. No wells in the 200-West Area showed tritium levels in excess of the derived concentration guide during 1997. Samples from the well in the 200-West Area with the highest tritium concentrations (well 299-W22-9) contained a maximum of 1,290,000 pCi/L of tritium in 1996. However, this well was not sampled in 1997 because of declining water levels. The declining concentrations in this well are shown in Figure 4.8.21 of PNNL-11472. In the 600 Area east of the 200-West Area, tritium concentrations exceeded



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Figure 6.1.17. Historical Tritium Concentrations on the Hanford Site

200,000 pCi/L in three wells, with a maximum of 491,000 pCi/L in well 699-35-66A. Tritium levels have generally been declining, as illustrated by trend plots in Figure 6.1.18, however the highest levels in 1997 continue to be well above the 20,000-pCi/L drinking water standard by more than an order of magnitude. Only one well (299-W23-14) near the 216-S-25 Crib upgradient of the Reduction-Oxidation Plant in the 200-West Area showed concentrations that exceeded 200,000 pCi/L in 1997. The movement of groundwater in the 200-West Area is slow because Ringold Formation sediments have low permeability. Movement of the plumes in the 200-West Area is also slow as a result of declining hydraulic gradients since the closure of U Pond in 1984.

A smaller area of tritium contamination is found in the north-central part of the 200-West Area in the vicinity of the TX-TY single-shell high-level waste tank farms (see Figures 6.1.12 and 6.1.13) and T Plant disposal facilities, which received liquid waste from T Plant operations. The highest concentrations were detected near the TX-TY Tank Farms. The area where concentrations exceeded the drinking water standard extends northeast past the northern boundary of the 200-West Area.

Two wells monitoring the State-Approved Land Disposal Site just north of the 200-West Area showed tritium concentrations that exceeded the drinking water standard, with one of the wells showing a maximum value equal to that of the 2,000,000-pCi/L derived concentration guide in 1997. These concentrations are associated with the disposal site, which receives treated effluent containing tritium. This disposal site has been in operation since 1995.

Tritium in the 300 Area. The eastern portion of the tritium plume that emanates from the 200-East Area continues to move to the east-southeast and discharge into the Columbia River (see Figure 6.1.13). The southern edge of the tritium plume extends into the 300 Area, as shown in Figure 6.1.19. Figure 6.1.20 shows the trend of tritium concentrations in well 699-S19-E13 just north of the 300 Area. Tritium concentrations in this well, which have shown increased levels since 1985, reached a maximum of 14,500 pCi/L in 1997. Even though tritium concentrations in the 300 Area are below the 20,000-pCi/L drinking water standard, a concern has been the potential migration of the tritium plume to an offsite municipal water supply to the south. The municipal water supply consists of the city of Richland’s well field and recharge basins (see Figure 6.1.19).

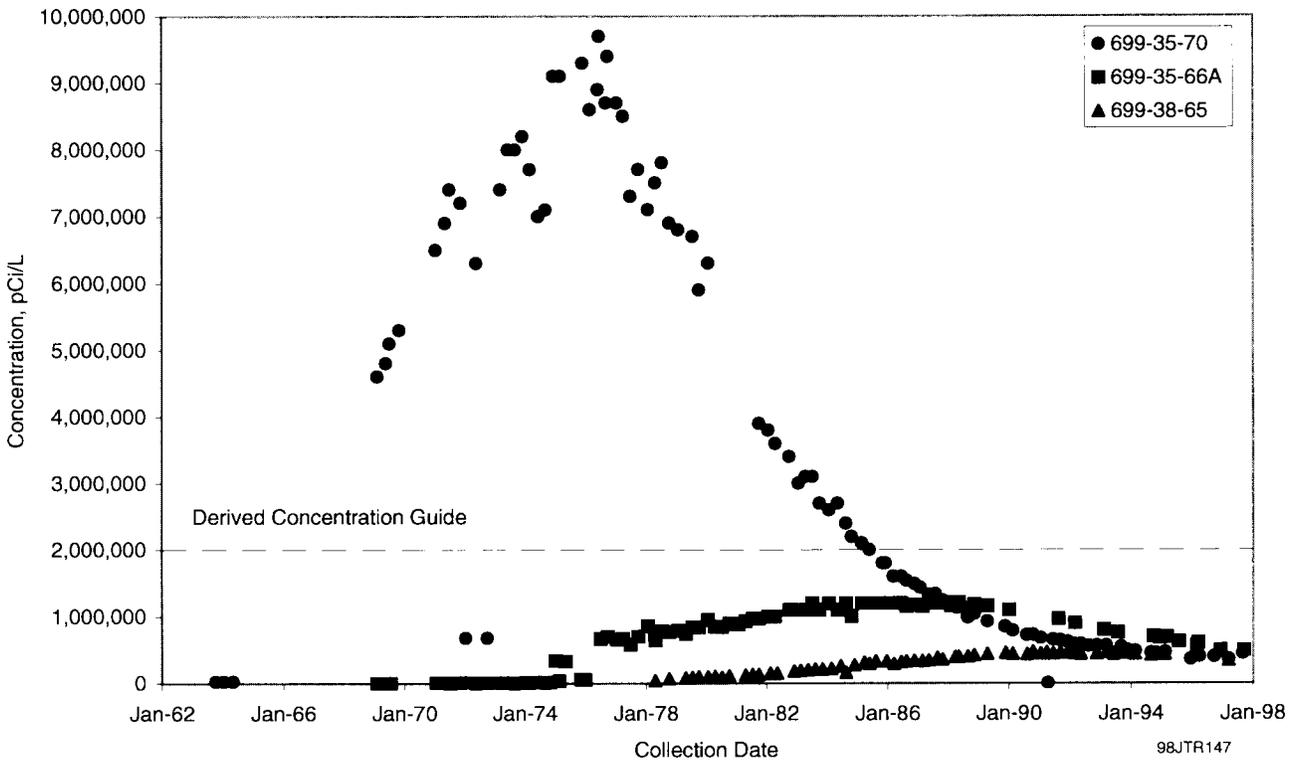


Figure 6.1.18. Tritium Concentrations in Wells 699-35-70, 699-35-66A, and 699-38-65, 1962 Through 1997

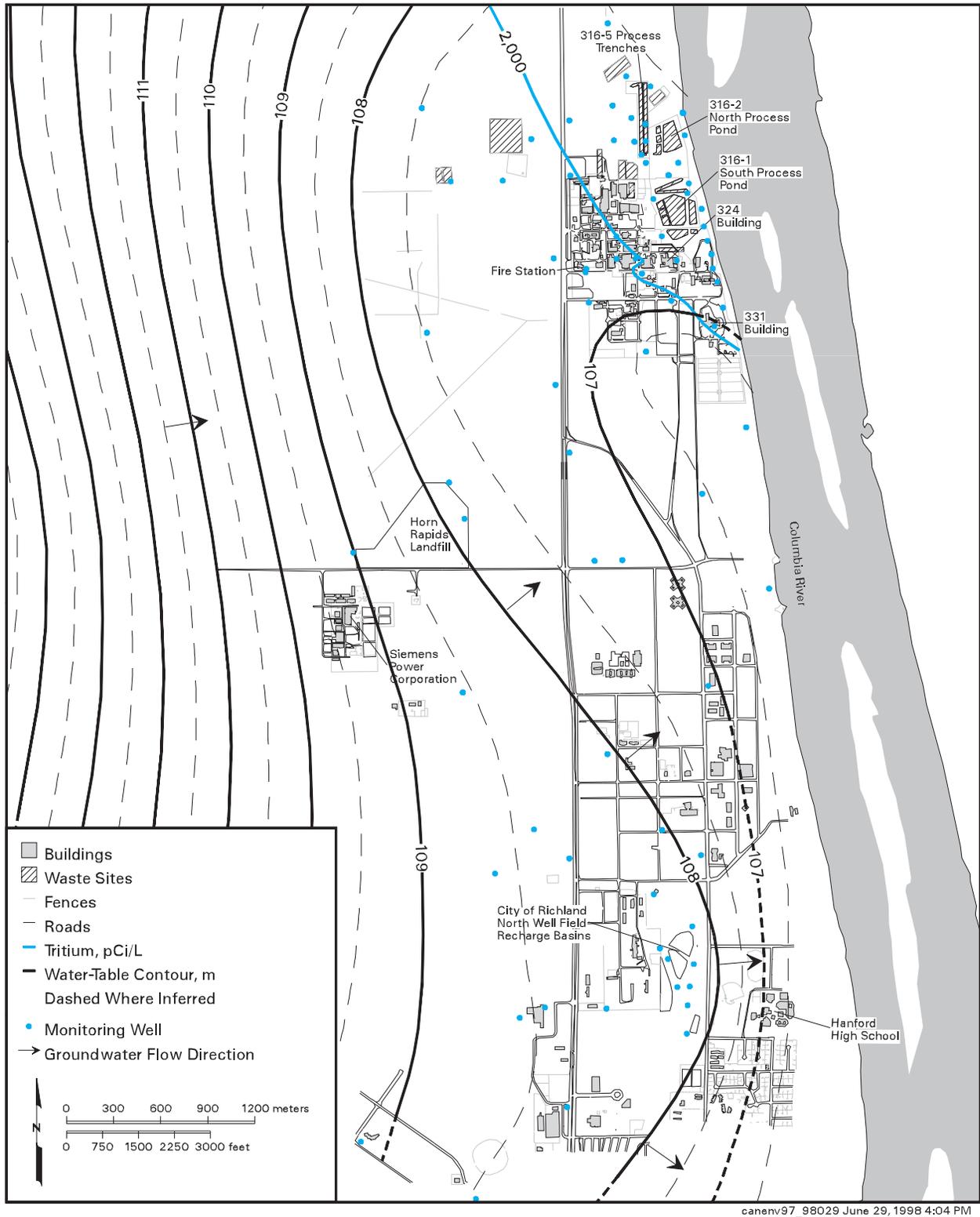


Figure 6.1.19. Tritium Distribution and Groundwater Flow Near the 300 Area, 1997

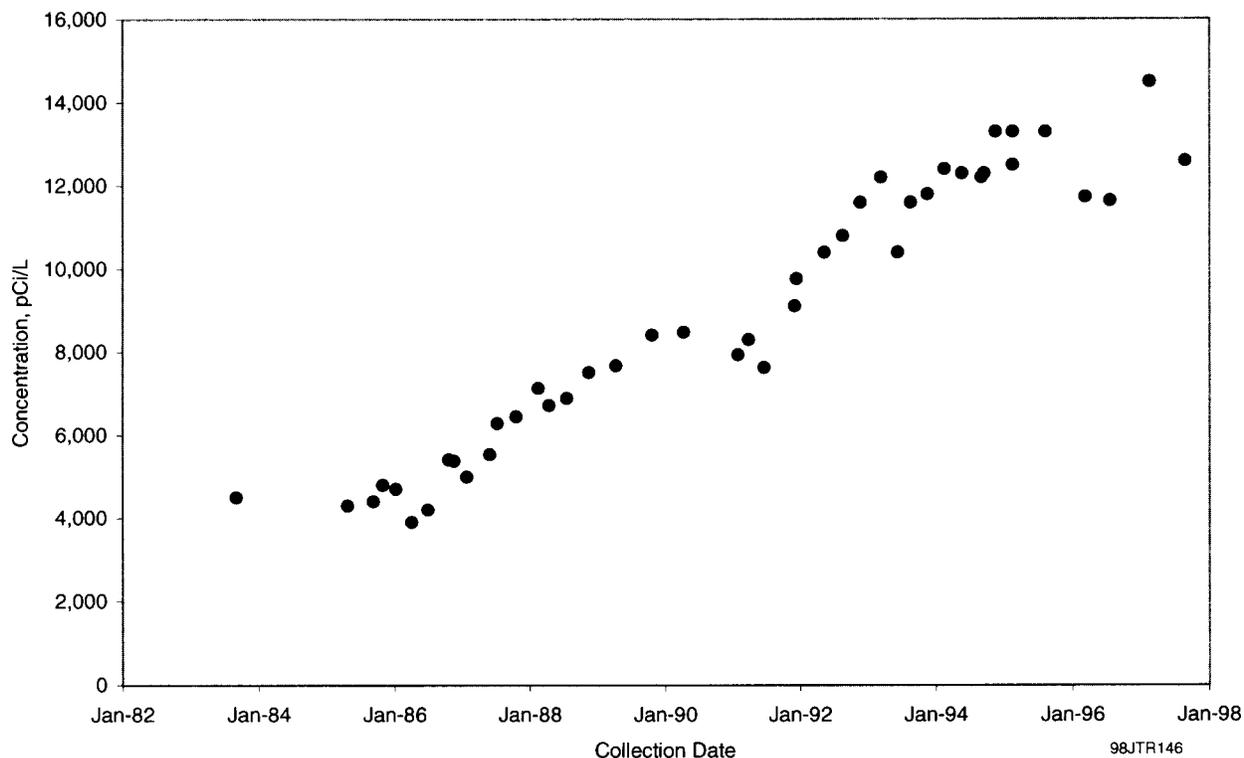


Figure 6.1.20. Tritium Concentrations in Well 699-S19-E13, 1982 Through 1997

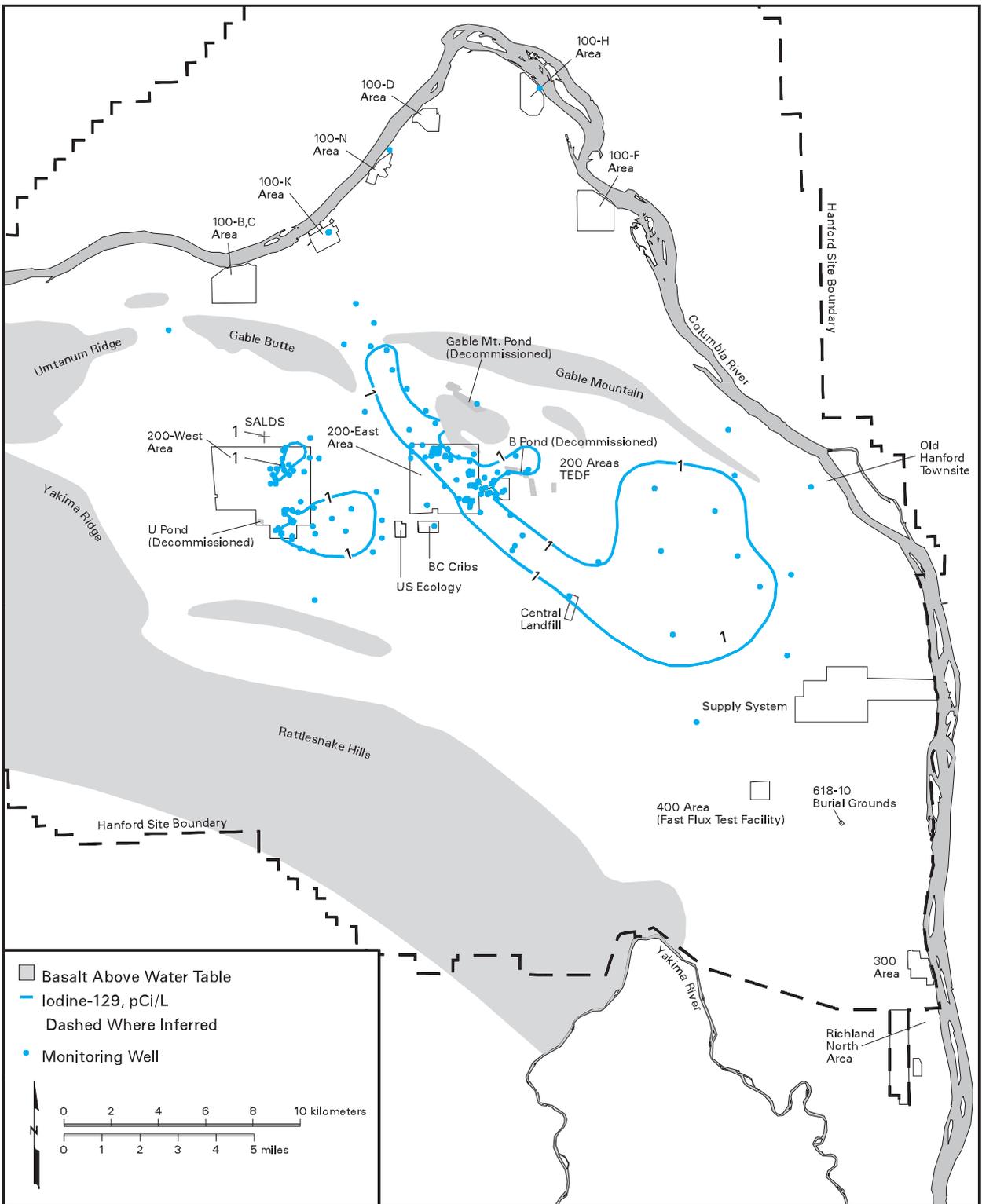
The tritium plume is not expected to impact the well field and recharge basin because of the influence on groundwater flow from the Yakima River and recharge from infiltration ponds at the well field (see Figure 6.1.19). The Yakima River is at a higher elevation and recharges the groundwater in this area. As a result, groundwater flows from west to east (see Figure 6.1.19), minimizing the southward movement of the contaminant plume. The recharge basin is supplied with Columbia River water, which infiltrates to the groundwater. The amount of recharge water exceeds the amount pumped at the well field by a factor of approximately 2:1, resulting in groundwater flow away from the well field. This further ensures that tritium-contaminated groundwater will not reach the well field. Ongoing monitoring is performed to confirm this interpretation.

Tritium in the 400 Area. The tritium plume that originated in the 200-East Area extends under the 400 Area. The maximum concentration observed in this area during 1997 was 38,500 pCi/L at well 499-S1-8K. The primary water supply well for the 400 Area (499-S1-8J) is completed in the lower part of the aquifer and had a maximum tritium concentration of 5,550 pCi/L during 1997. Concentrations at wells used for backup water supply

(499-S0-7 and 499-S0-8) were near or slightly above the 20,000-pCi/L drinking water standard. Additional information on the 400 Area water supply is provided in Section 4.3, "Hanford Site Drinking Water Surveillance."

Iodine-129. Iodine-129 has a relatively low drinking water standard (1 pCi/L), has the potential for accumulation in the environment as a result of long-term releases from nuclear fuel reprocessing facilities (Soldat 1976), and has a long half-life (16,000,000 years). The relatively low fission yield for production of iodine-129 combined with its long half-life limits its specific activity in Hanford wastes. Iodine-129 may be released as a vapor during fuel dissolution and other elevated temperature processes and, thus, may be associated with process condensate wastes. At the Hanford Site, the main contributor of iodine-129 to groundwater has been liquid discharges to cribs in the 200 Areas. Iodine-129 has essentially the same high mobility in groundwater as tritium and nitrate. No iodine-129 samples showed concentrations above the 500-pCi/L derived concentration guide in 1997.

The distribution of iodine-129 in groundwater in the 200-West Area is shown in Figure 6.1.21. The highest iodine-129 concentration observed in 1997 in Hanford



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Figure 6.1.21. Iodine-129 Distribution in the Unconfined Aquifer, 1997

Site groundwater was 30.6 pCi/L in an area southeast of the 200-West Area and east of the Reduction-Oxidation Plant. This plume is essentially coincident with the nitrate and tritium plumes, though there appears to be a contribution from cribs to the north near U Plant. In the northern part of the 200-West Area, a second iodine-129 plume originates near the T Tank Farm and nearby disposal facilities and extends northeast toward T Plant. This plume is coincident with the technetium-99 and tritium plumes in this area.

The distribution of iodine-129 in groundwater in the 200-East Area is shown in Figure 6.1.21. The highest iodine-129 concentrations in the 200-East Area are in the northwest near the BY Cribs and in the southeast near the Plutonium-Uranium Extraction Plant. The maximum concentration of iodine-129 detected in 1997 in the 200-East Area was 18.1 pCi/L south of the Plutonium-Uranium Extraction Plant near the 216-A-10 Crib. The plume extends from the Plutonium-Uranium Extraction Plant area southeast into the 600 Area and appears coincident with the nitrate and tritium plumes (see Figure 6.1.13). The plume appears smaller than the tritium plume because of the lower initial concentration of iodine-129. The iodine-129 contamination can be detected as far east as the Columbia River but at levels below the 1-pCi/L drinking water standard. Current data indicate that iodine-129 at levels above the drinking water standard is approaching the Columbia River (see Figure 6.1.21). The plume likely had the same sources as the nitrate and tritium plumes. Iodine-129 is also present in groundwater at levels above the drinking water standard in the northwestern 200-East Area; however, a definite source for this plume has not been determined. This plume extends northwest into the gap between Gable Mountain and Gable Butte.

Technetium-99. Technetium-99 is produced as a fission byproduct and is present in waste streams associated with fuel reprocessing. Reactor operations may also result in the release of some technetium-99 associated with fuel element breaches. Under the chemical conditions that exist in Hanford Site groundwater, technetium-99 is normally present in solution as anions that sorb poorly to sediments. Therefore, technetium-99 is very mobile in Hanford Site groundwater.

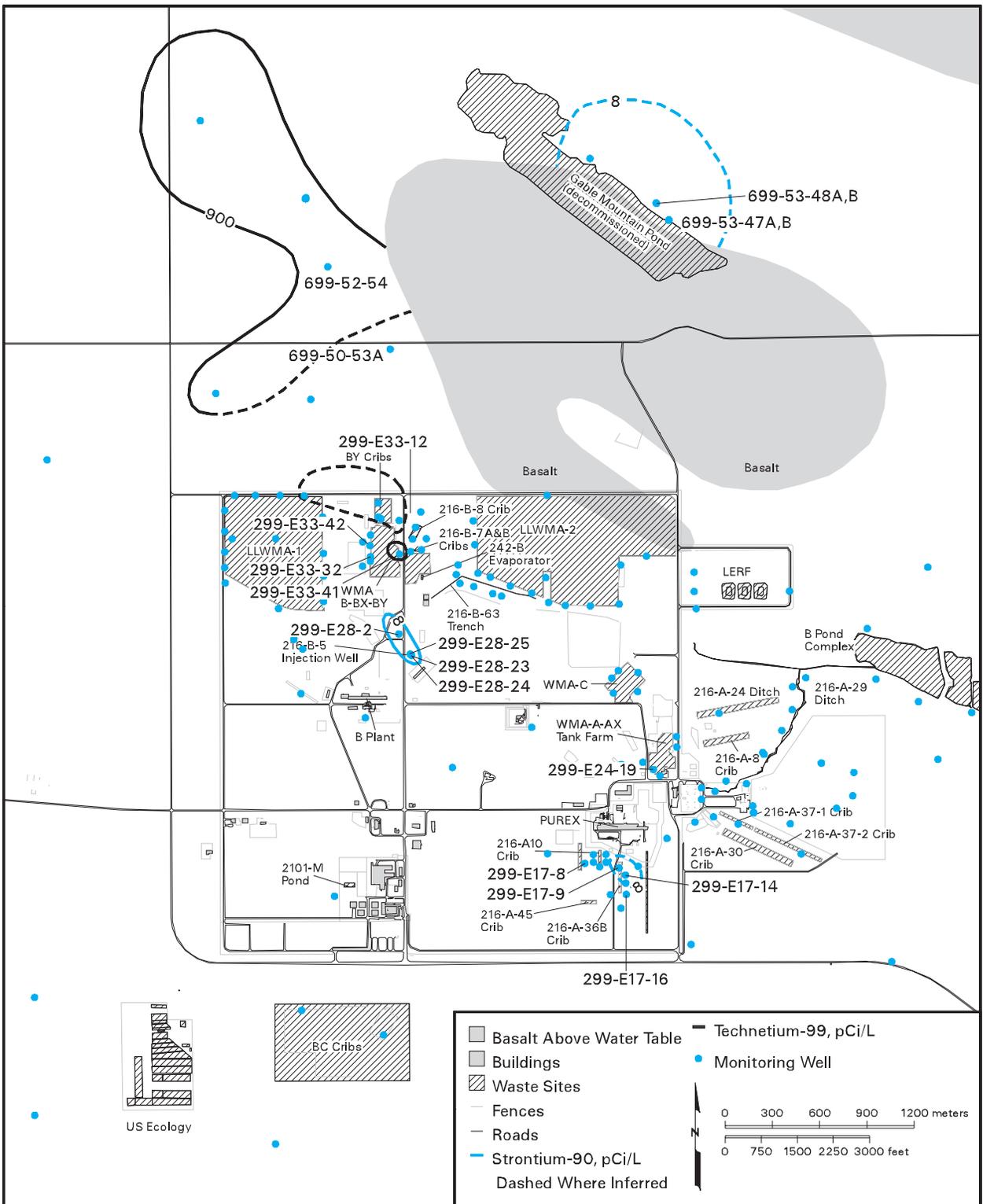
Technetium-99 was found at concentrations greater than the 900-pCi/L interim drinking water standard in the 100-H, 200-East, and 200-West Areas. The highest concentrations were measured in the 200-West Area.

Technetium-99 in the 100-H Area. Technetium-99 concentrations exceeded the 900-pCi/L interim drinking water standard in a localized area downgradient of the former 183-H Solar Evaporation Basins in the 100-H Area. These basins were used for storage of waste primarily from fuel fabrication in the 300 Area. Some of the waste leaked into the subsurface, contaminating the groundwater. The maximum concentration of technetium-99 detected in this area in 1997 was 2,080 pCi/L. The plume, which coincides with the uranium plume, was displaced slightly to the south because of the effects of the unusually high river stage in 1996 and 1997 and by the influence from a pump-and-treat system in the area.

Technetium-99 in the 200-East Area. Groundwater in the northwestern part of the 200-East Area and a part of the 600 Area north of the 200-East Area contains technetium-99 at concentrations above the 900-pCi/L interim drinking water standard (see Figure 6.1.22). The source of these technetium plumes was apparently the BY Cribs (Section 5.8.2 in PNL-10698). The technetium-99 plume is associated with cobalt-60, cyanide, and tritium contamination in groundwater. Near the BY Cribs, the maximum concentration observed was 3,000 pCi/L. The maximum technetium-99 concentration north of the 200-East Area in 1997 was 2,490 pCi/L. This plume appears to be moving through the gap between Gable Mountain and Gable Butte. Completion of a treatability test in 1997 showed technetium-99 concentrations falling below the interim drinking water standard in an extraction well (699-50-53A) north of the 200-East Area.

In 1997, high concentrations of technetium-99 were identified at isolated locations near B-BX-BY Tank Farms. The concentrations varied widely in monitoring well 299-E33-41 on the east side of the BX Tank Farm, ranging from 523 pCi/L to a maximum of 12,000 pCi/L in 1997 (Figure 6.1.23). This well had the highest technetium-99 concentration in the 200-East Area in 1997. On the northwestern side of the B-BX-BY Tank Farms, technetium-99 concentrations continued to rise in 1997 (maximum of 760 pCi/L in well 299-E33-42) after increasing sharply in 1996. Some of this contamination is believed to originate from the B-BX-BY Tank Farms (PNNL-11826).

Technetium-99 in the 200-West Area. Technetium-99 is also detected at levels greater than the 900-pCi/L interim drinking water standard in the 200-West Area and the adjacent 600 Area (Figure 6.1.24). The largest technetium-99 plume in the 200-West Area originates in the cribs that received effluent from U Plant and extends



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Figure 6.1.22. Technetium-99 and Strontium-90 Concentrations in the Unconfined Aquifer Near the 200-East Area, 1997

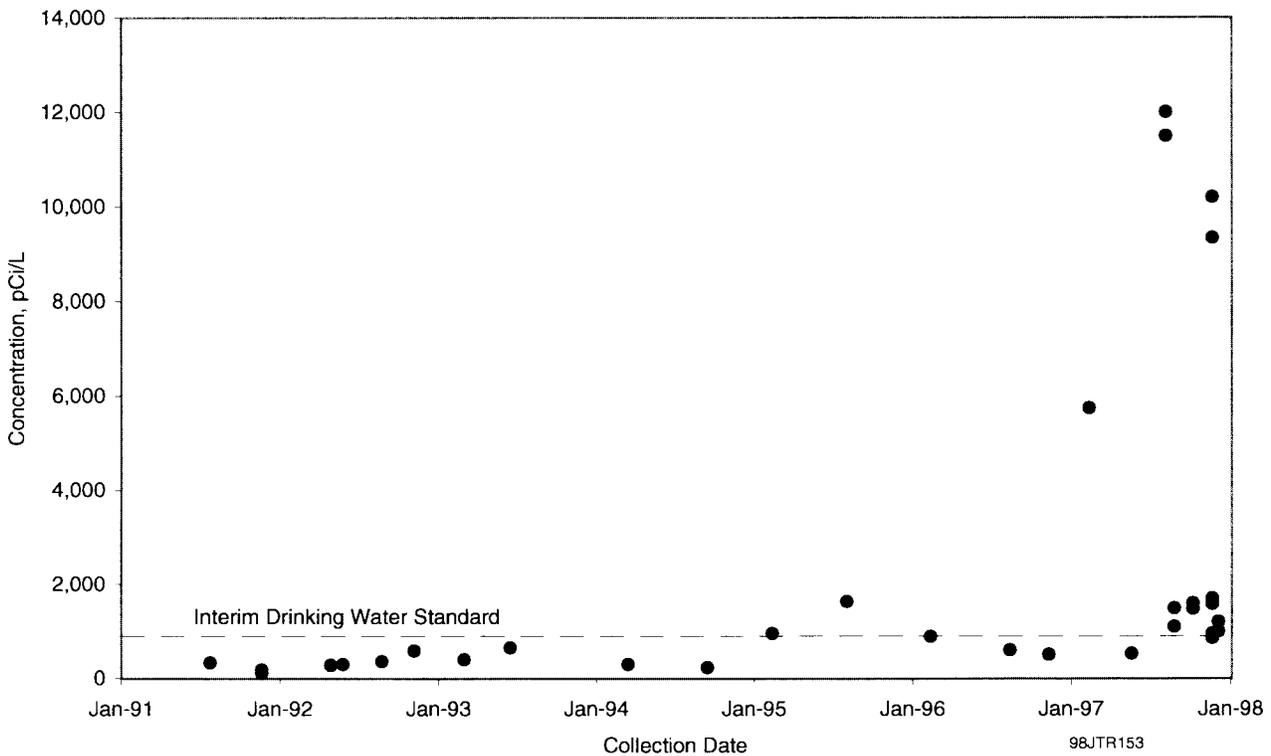


Figure 6.1.23. Technetium-99 Concentrations in Well 299-E33-41, 1991 Through 1997

into the 600 Area to the east. The highest concentrations in this plume in 1997 were measured in several wells in the vicinity of the 216-U-17 Crib, where remediation by the pump-and-treat method is occurring. Concentrations in these wells are increasing, indicating that the core of the plume is moving toward the extraction center (well 299-W19-39). The maximum concentration was detected in well 299-W19-28 at a level of 25,500 pCi/L, the highest observed in the 200-West Area in 1997 (Figure 6.1.25).

A pump-and-treat system was implemented near the 216-U-17 Crib to contain and reduce the highest concentrations in the technetium-99 and uranium plumes (Record of Decision 1997). Extracted groundwater was treated using ion exchange and granular, activated carbon (to filter carbon tetrachloride) and returned to the aquifer using an upgradient injection well. Between March 1994 and February 1997, greater than 131,500,000 L of groundwater had been treated and 37.8 g of technetium-99 had been removed. In February 1997, the pump-and-treat system was shut down to modify the treatment operation. Between April and September 1997, greater than 49,400,000 L of groundwater had been transported to the 200 Areas Effluent Treatment Facility, where 5.6 g of

technetium-99 had been removed (BHI-01126). The upgradient injection well is no longer used.

A technetium-99 plume in the vicinity of the T and TX-TY Tank Farms extends to the north. Two wells that monitor these tank farms consistently showed technetium-99 concentrations above the interim drinking water standard in 1997. Near the TX-TY Tank Farms, well 299-W14-12 consistently showed technetium-99 concentrations at steady levels just above the interim drinking water standard in 1997 after showing a sharp decline in 1995 and 1996. In the northeastern corner of T Tank Farm at well 299-W11-27, technetium-99 levels increased sharply in 1996, reached a maximum of 21,700 pCi/L in early 1997, and then fell to a level just above the interim drinking water standard in late 1997, as shown in Figure 6.1.26. The source of this technetium-99 pulse was assessed, and it was concluded that the T and TX-TY Tank Farms were the sources (PNNL-11809)

The small plume in the southern part of the 200-West Area originates near the S-SX Tank Farms and the 216-S-13 Crib. The maximum concentration detected in this area was approximately 5,000 pCi/L near the southeastern corner of the SX Tank Farm. The concentrations

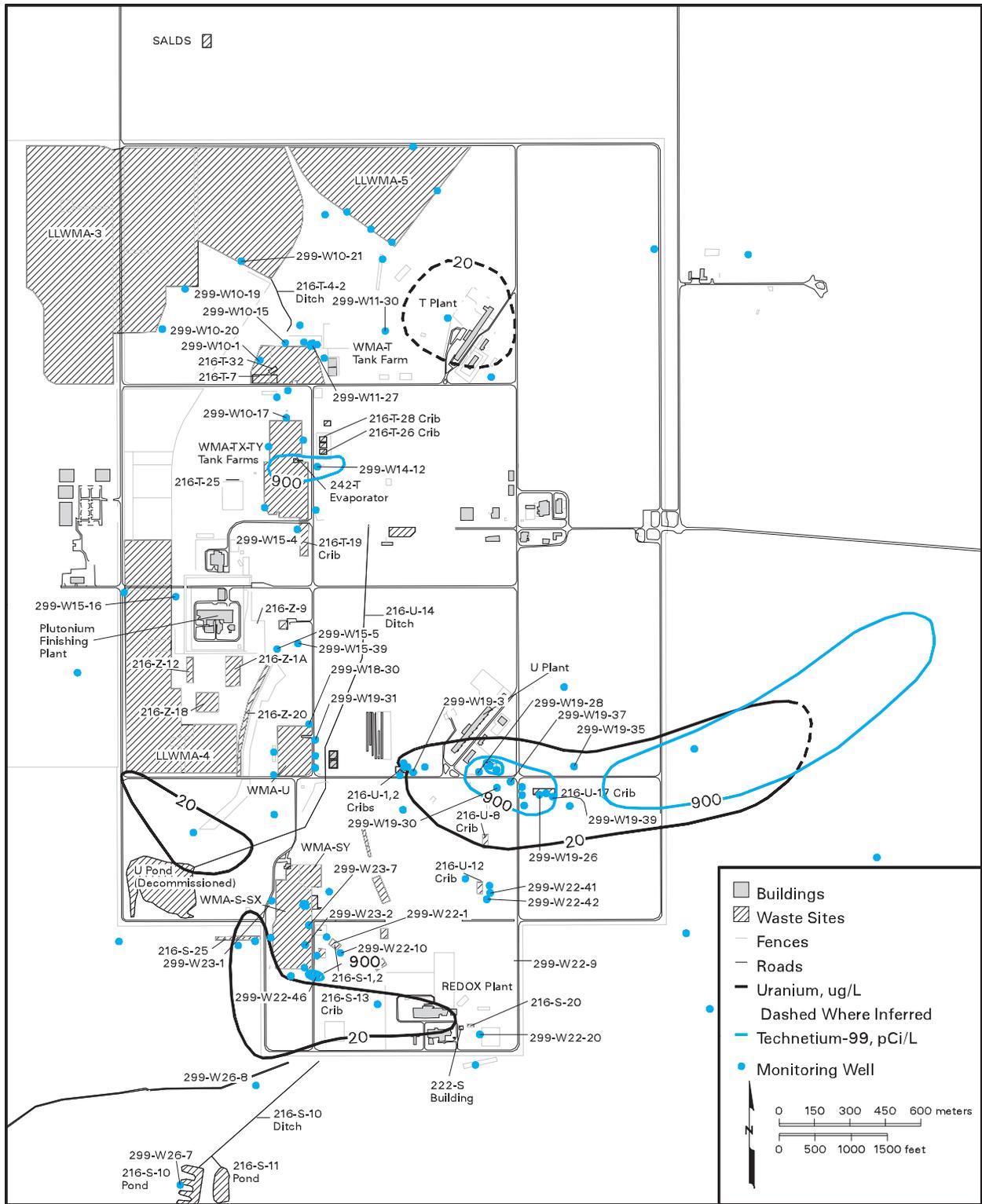


Figure 6.1.24. Technetium-99 and Uranium Concentrations in the Unconfined Aquifer in the 200-West Area, 1997

in this well increased significantly in late 1996 and early 1997. Leakage from the single-shell tanks is believed to be a source of the technetium-99 in this vicinity (PNNL-11810).

Uranium. There are numerous possible sources of uranium released to the groundwater at the Hanford Site, including fuel fabrication, fuel reprocessing, and uranium recovery operations. Uranium may exist in several states, including elemental uranium or uranium oxide as well as tetravalent and hexavalent cations. Only the hexavalent form has significant mobility in groundwater, largely by forming dissolved carbonate species. Uranium mobility is thus dependent on both oxidation state and pH. Uranium is observed to migrate in Hanford Site groundwater but is retarded relative to more mobile species such as technetium-99 and tritium. The EPA's proposed drinking water standard is 20 µg/L for uranium. The derived concentration guide that represents the 100-mrem/yr dose equivalent for uranium is 790 µg/L.

Uranium has been detected at concentrations greater than the proposed drinking water standard in the 100-F, 100-H, 200, 300, and 600 Areas. The highest concentrations detected at the Hanford Site in 1997 were near U Plant in the 200-West Area and were above the derived concentration guide.

Uranium in the 100 Areas. In 1997, uranium was detected at a concentration greater than the 20-µg/L proposed drinking water standard in one well near F Reactor in the 100-F Area (Figure 6.1.27). The maximum concentration detected was 47.6 µg/L.

Uranium was detected at levels higher than the proposed drinking water standard in several wells in the 100-H Area (Figure 6.1.28). The maximum concentration detected in 1997 was 159 µg/L near the 183-H Solar Evaporation Basins. Past leakage from these basins is considered to be the source of the 100-H Area uranium contamination. These basins were remediated in 1996.

Uranium in the 200 Areas. In 1997, several wells in the northwestern part of the 200-East Area contained uranium at concentrations greater than the 20-µg/L proposed drinking water standard. The distribution of uranium in this area suggests that contamination is of limited extent with the highest concentrations in the vicinity of the B-BX-BY Tank Farms, BY Cribs, and 216-B-5 Injection Well that has been inactive since 1947. However, the magnitude and extent of uranium contamination has increased since 1991 north and east of the B-BX-BY Tank

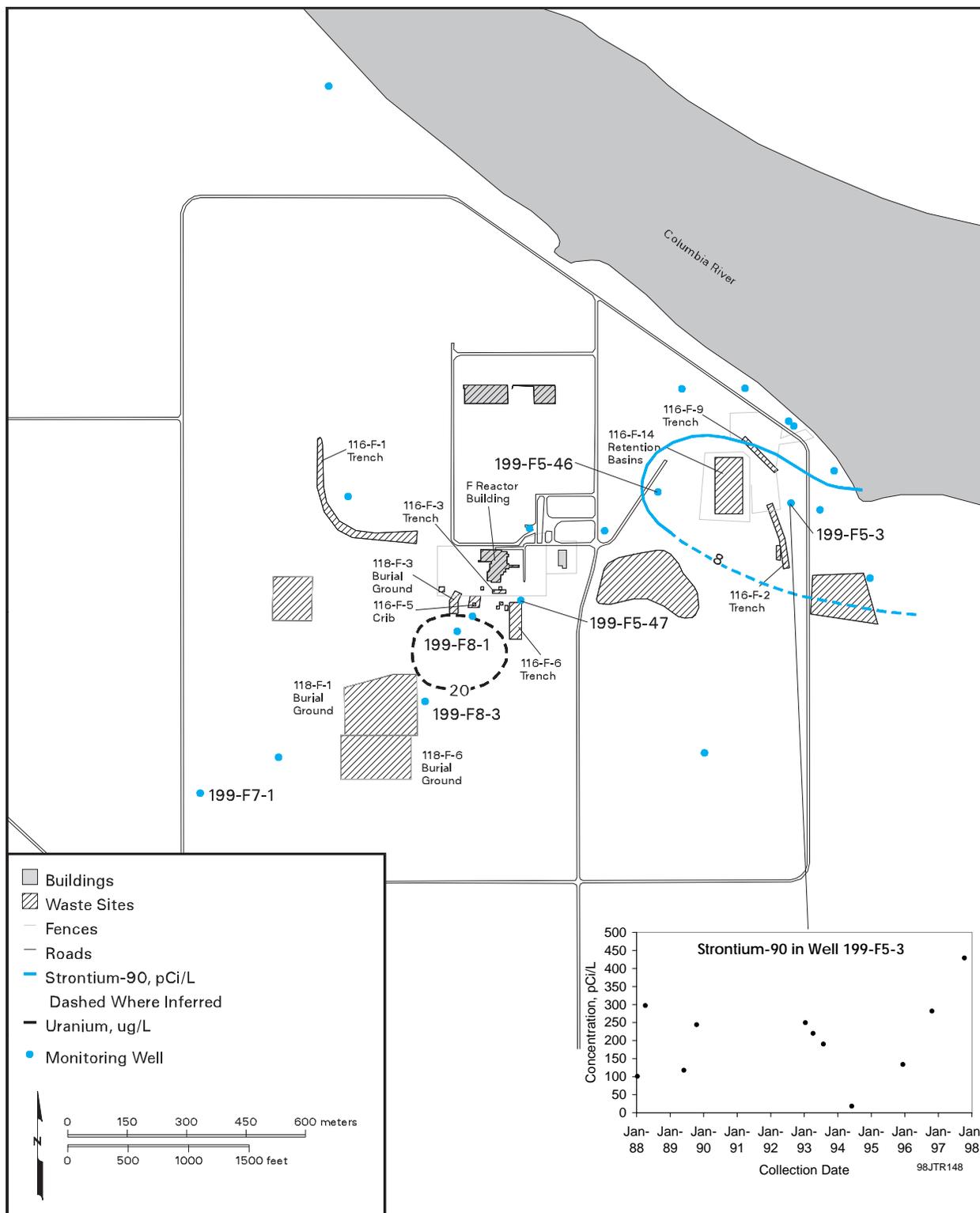
Farms. The highest concentration detected was 203 µg/L northeast of the B-BX-BY Tank Farms (and east of the BY Cribs). The source of the uranium contamination in this area is unclear. Near the inactive 216-B-5 Injection Well, two wells showed uranium concentrations greater than the proposed drinking water standard. The highest concentration was 52 µg/L.

The highest uranium concentrations in Hanford Site groundwater occurred near U Plant in the 200-West Area, at wells adjacent to the inactive 216-U-1, 216-U-2, and 216-U-17 cribs (see Figure 6.1.24). These concentrations exceeded the 790-µg/L derived concentration guide for uranium. The maximum uranium concentration detected in this area in 1997 was 2,870 µg/L west of the 216-U-17 Crib. Uranium concentrations in this area have been increasing as a result of a pump-and-treat operation of an extraction well (299-W19-39) located near the 216-U-17 Crib. These increasing concentrations indicate that the core of the uranium plume is moving toward the extraction center. This uranium plume extends east into the 600 Area along with the technetium-99 plume discussed above.

The pump-and-treat system removed 45.8 kg of uranium between March 1994 and February 1997. Between April and September 1997, 11 kg of uranium had been removed from extracted groundwater (BHI-01126).

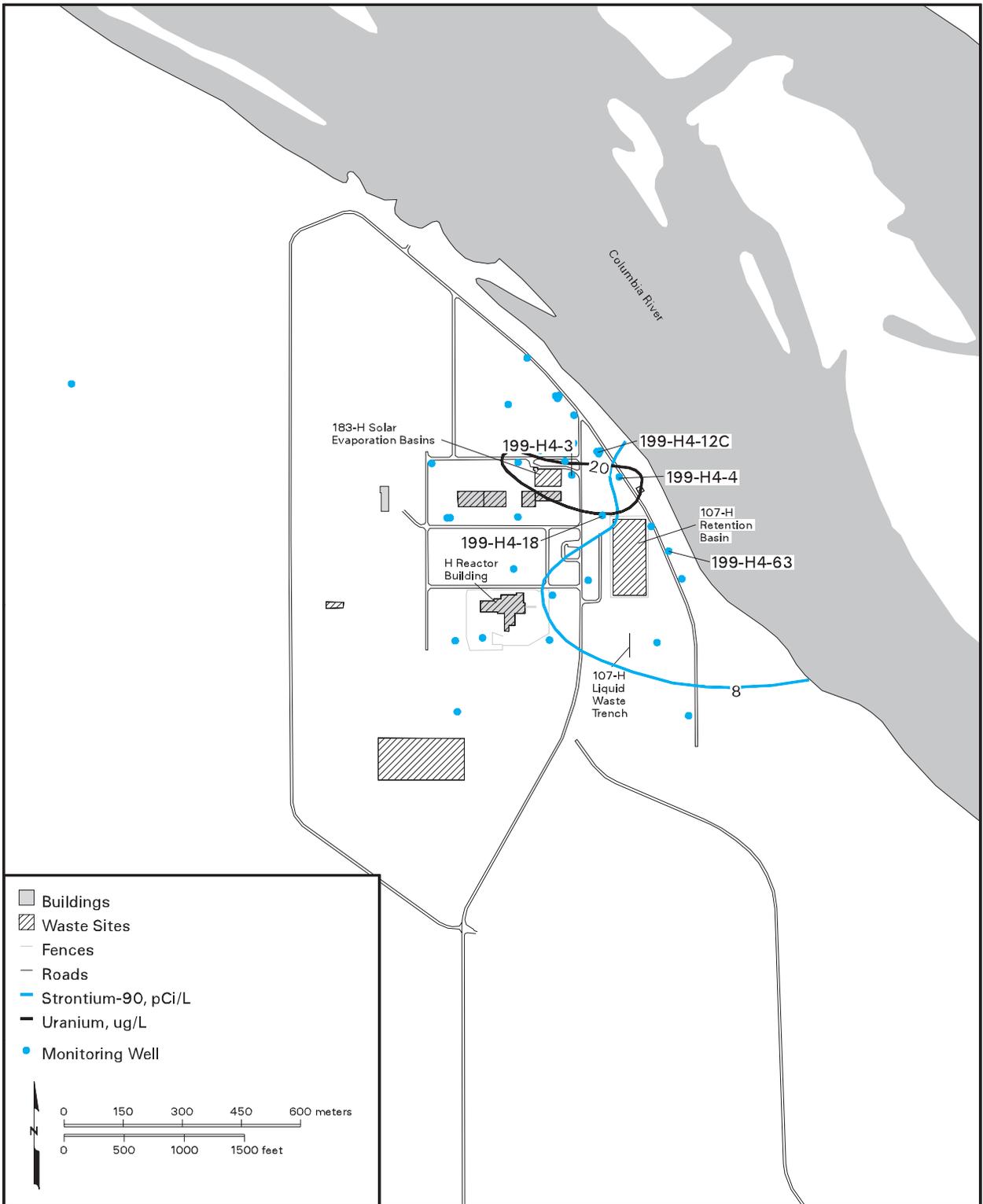
Other areas within the 200-West Area with uranium contamination are also shown in Figure 6.1.24, including fairly widespread areas west and northwest of the Reduction-Oxidation Plant. Uranium concentrations in those areas are considerably lower than the concentrations detected near U Plant. The maximum uranium concentration in these areas is 154 µg/L immediately downgradient of the 216-S-13 Crib (just west of the Reduction-Oxidation Plant). In the northern part of the 200-West Area, a localized area of uranium contamination, where a single sample showed a concentration above the proposed drinking water standard in 1997, was found near T Plant.

Uranium in the 300 Area. A plume of uranium contamination exists in the unconfined aquifer beneath the 300 Area in the vicinity of uranium fuel fabrication facilities and inactive sites known to have received uranium waste. The plume extends downgradient from inactive liquid waste disposal facilities to the Columbia River (Figure 6.1.29). The major source of the contamination is the inactive 316-5 Process Trenches, as indicated by the distribution of the uranium concentrations downgradient from these trenches (see Section 5.13.3.1 in



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Figure 6.1.27. Uranium and Strontium-90 Concentrations in the Unconfined Aquifer in the 100-F Area, 1997, and Concentration Trends in Well 199-F5-3



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Figure 6.1.28. Uranium and Strontium-90 Concentrations in the Unconfined Aquifer in the 100-H Area, 1997

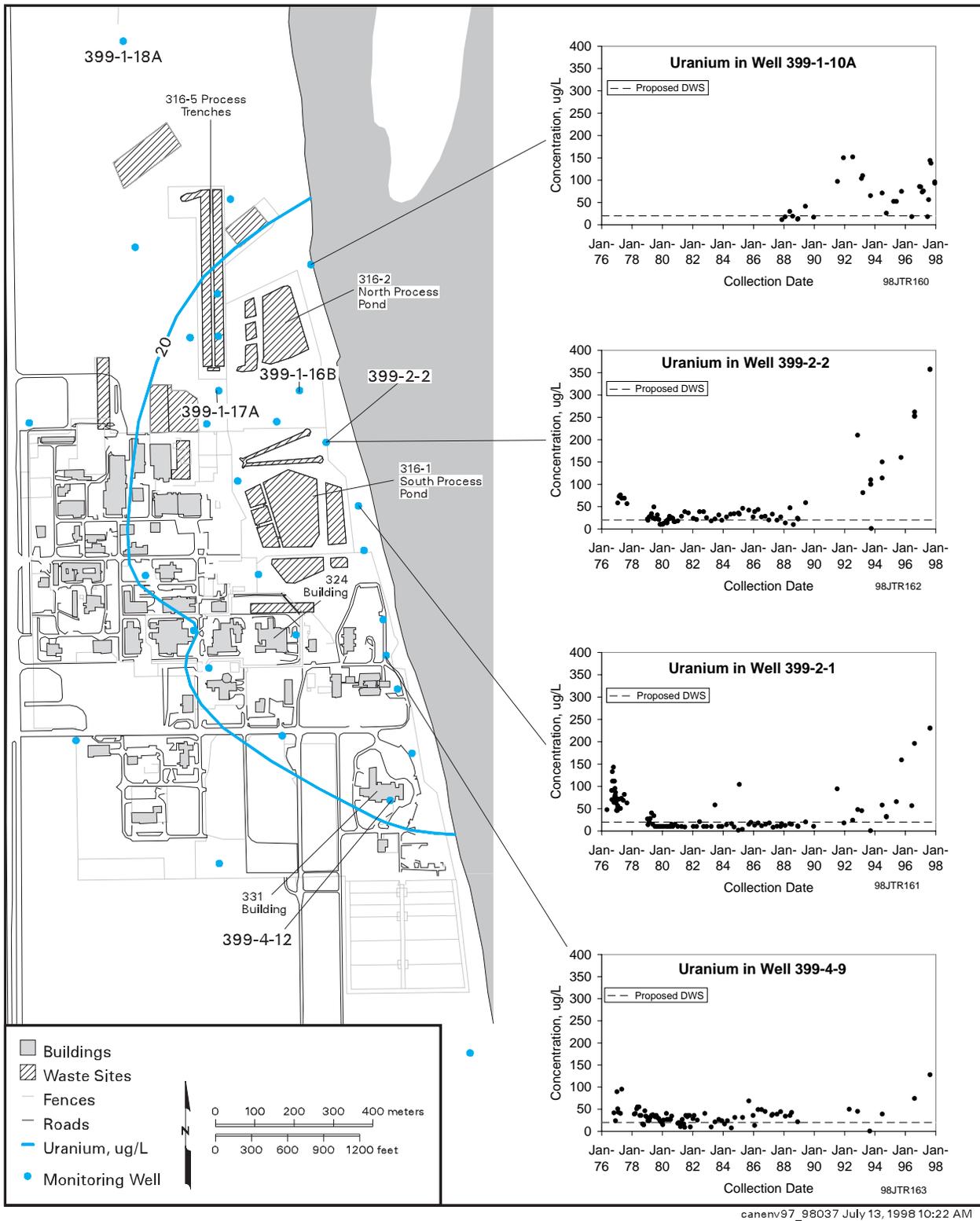


Figure 6.1.29. Uranium Concentrations in the Unconfined Aquifer in the 300 Area, 1997, and Concentration Trends for Selected Wells

PNNL-11793). Movement of the uranium plume toward the Columbia River has resulted in increased uranium concentrations near the Columbia River in recent years, as shown by the trend plots for wells 399-2-1 and 399-2-2 or Figure 6.1.29. The maximum concentration of uranium detected in 1997 was 358 $\mu\text{g/L}$.

An expedited response action performed on the 300 Area process trenches in mid-1991 was aimed at reducing the uranium source in that area. Use of the trenches for disposal of cooling water and small quantities of nonhazardous maintenance and process waste was resumed following completion of the remedial action; however discharge to the trenches was much lower than before the expedited response action. As a result, uranium levels in well 399-1-17A, located closest to the inflow portion of the trenches, dropped to approximately the 20- $\mu\text{g/L}$ proposed drinking water standard following the remedial action (Figure 6.1.30). In late 1994 and early 1995, uranium levels increased sharply in response to a complete cessation of discharge to the trenches in December 1994. The increased uranium concentrations since the discharges were terminated indicate that the soil column is contributing uranium contamination to the groundwater.

Between 1996 and 1997, a localized area of high uranium concentrations (maximum of 130 $\mu\text{g/L}$) near the 324 Building moved downgradient toward the Columbia River (see trend plot in Figure 6.1.29).

Uranium in the 600 Area. The measured uranium concentration in groundwater southeast of the 400 Area dropped from 768 $\mu\text{g/L}$ in 1995 to 108 $\mu\text{g/L}$ in 1996, following renovation of the well. However, the concentration increased to a maximum of 225 $\mu\text{g/L}$ in 1997. The contamination at this well is attributed to the nearby inactive 316-4 Crib (Section 6.12.2.4 in PNNL-11470, Section 5.12.3.3 in PNNL-11793). The retired 618-10 Burial Grounds are also located near this well.

Strontium-90. Strontium-90 was produced as a high yield fission product and was present in waste streams associated with fuel reprocessing. Reactor operations also resulted in the release of some strontium-90 associated with fuel element breaches. Strontium-90 mobility in Hanford Site groundwater is reduced by adsorption onto sediment particles. However, strontium-90 is moderately mobile in groundwater because its adsorption is much weaker than for other isotopes such as cesium-137 and plutonium. Because of sorption, a large proportion of the strontium-90 in the subsurface is not present in solution.

In 1997, concentrations of strontium-90 greater than the 8-pCi/L interim drinking water standard were found in one or more wells in each of the following areas: 100, 200, and 600 Areas. Concentrations of strontium-90 were greater than the 1,000-pCi/L derived concentration guide in the 100-K, 100-N, 200-East, and 600 Areas. Maximum concentrations were detected in the 100-N Area during 1997. The strontium-90 concentrations in the 100-K Area were first detected above the derived concentration guide in 1996.

Strontium-90 in the 100 Areas. Strontium-90 is found at levels greater than the 8-pCi/L interim drinking water standard in the northeastern part of the 100-B,C Area between the B Reactor and the Columbia River. The maximum concentration detected in this area in 1997 was 68 pCi/L at monitoring well 199-B3-1. The extent of strontium-90 contamination greater than the standard in the 100-B,C Area is shown in Figure 6.1.31. The sources for the strontium-90 appear to be liquid waste disposal sites near B Reactor and liquid overflow trenches near the Columbia River (DOE/EIS-0119F).

In the 100-D Area, two wells showed strontium-90 concentrations greater than the 8-pCi/L interim drinking water standard. The maximum level (35.2 pCi/L) was reported in well 199-D8-68, located in the northern part of the 100-D Area near the Columbia River. This is the first time that elevated strontium-90 has been observed in this part of the 100-D Area. Well 199-D8-68 will be sampled for strontium-90 in 1998 to confirm this elevated result. Strontium-90 continues to be detected at levels greater than the interim drinking water standard near the D Reactor fuel storage basin trench.

The 100-F Area strontium-90 plume is shown in Figure 6.1.27. In a small area near the Columbia River, groundwater has strontium-90 concentrations greater than the 8-pCi/L interim drinking water standard. The maximum concentration detected in 1997 was 429 pCi/L. This concentration is an increase from 282 pCi/L measured in 1996, as shown by the trend plot in Figure 6.1.27.

In the 100-H Area, strontium-90 contamination levels greater than the 8-pCi/L interim drinking water standard were present in an area adjacent to the Columbia River near the 107-H Retention Basin, as shown in Figure 6.1.28. The maximum concentration detected in the 100-H Area in 1997 was 51.2 pCi/L between the 107-H Retention Basin and the Columbia River.

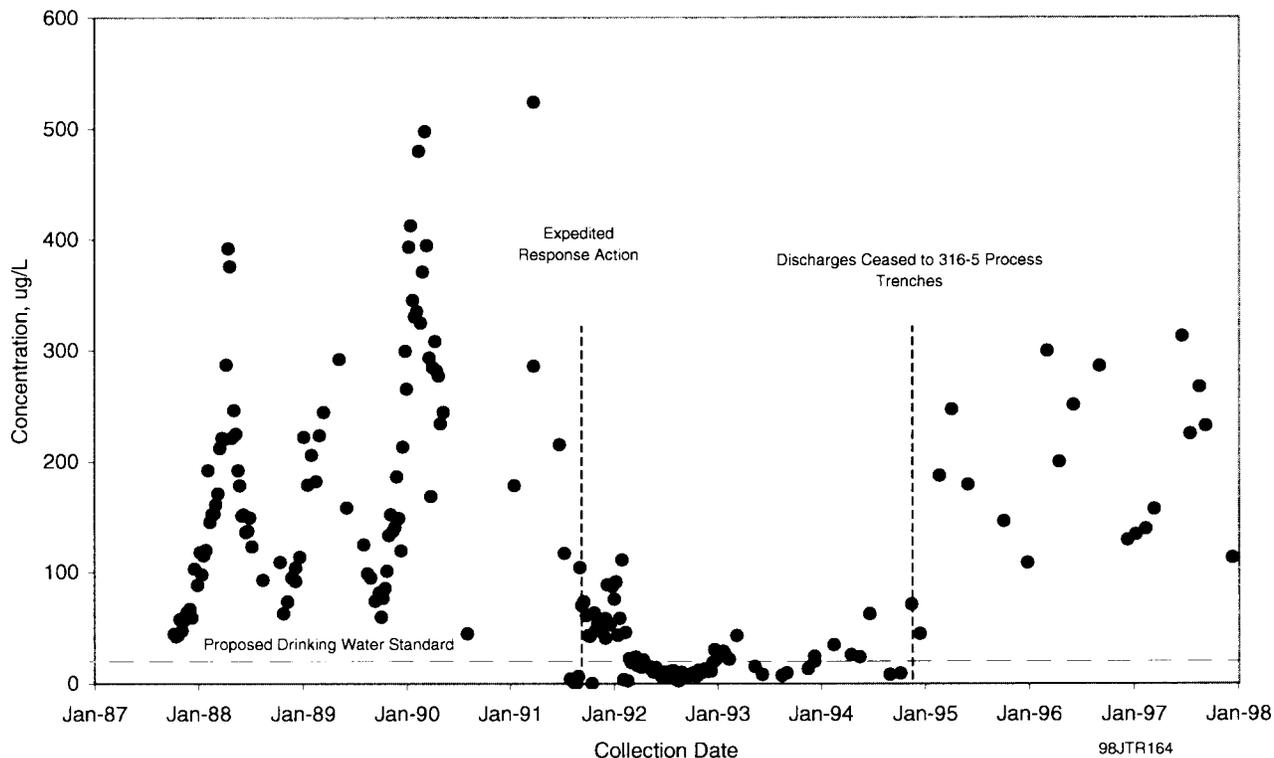


Figure 6.1.30. Uranium Concentrations in Well 399-1-17A, 1987 Through 1997

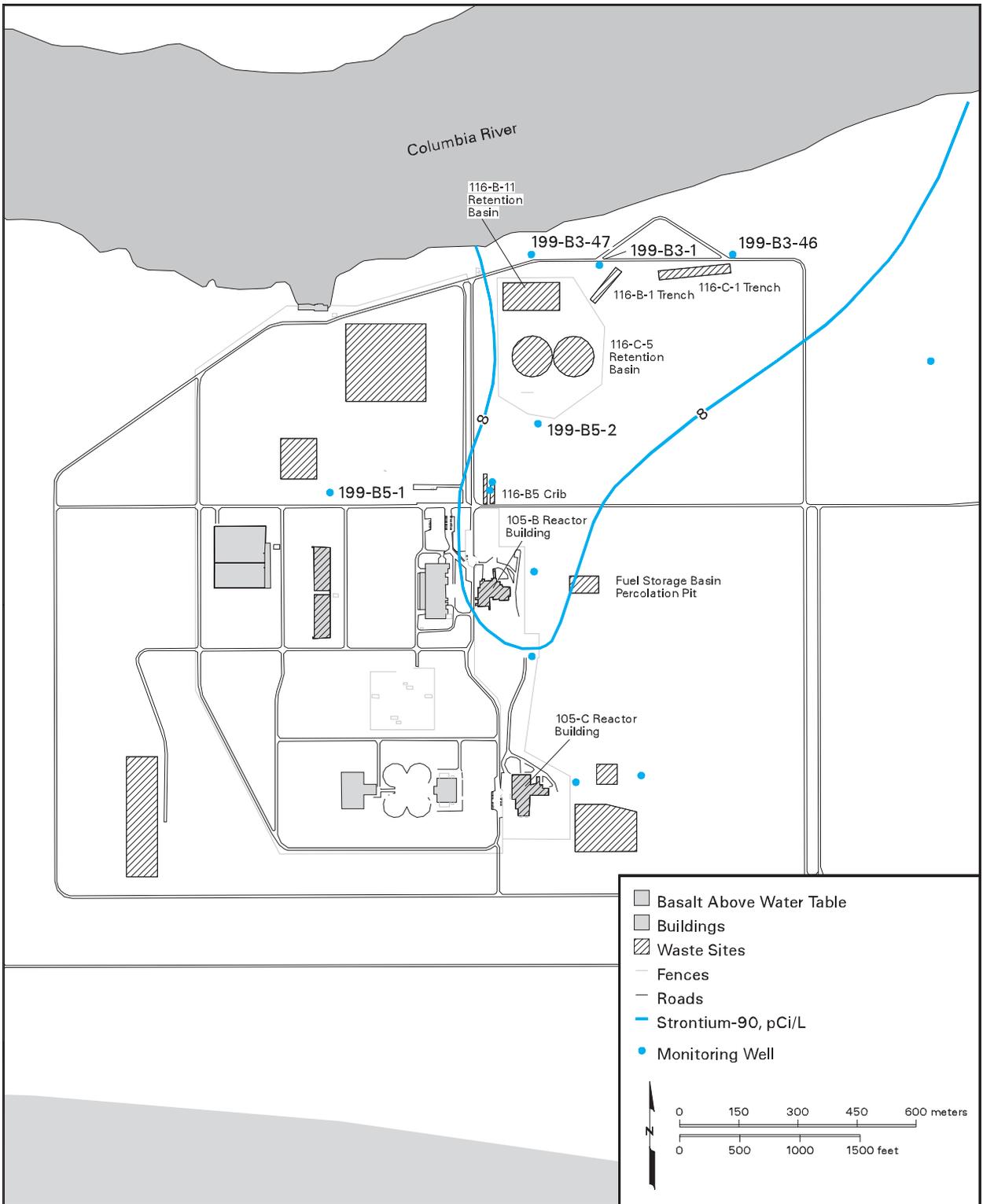
The extent of strontium-90 at levels greater than the 8-pCi/L interim drinking water standard in the 100-K Area is shown in Figure 6.1.32. Localized plumes occur in the vicinity of the KE and KW Reactors and between the 116-K-2 Liquid Waste Disposal Trench and the Columbia River. The maximum concentration detected in 1997 was 18,600 pCi/L at well 199-K-109A, the only well in the 100-K Area where concentrations were above the 1,000-pCi/L derived concentration guide. Maximum strontium-90 concentrations near the KW Reactor and the disposal trench were significantly lower than those near KE Reactor by approximately three orders of magnitude.

In the 100-N Area, strontium-90 was detected at concentrations greater than the 1,000-pCi/L derived concentration guide in approximately 10 wells in 1997. Most of these wells are located between the 1301-N Liquid Waste Disposal Facility, a source of the strontium-90, and the Columbia River. The 1325-N Liquid Waste Disposal Facility is also a source of strontium-90 in groundwater. The average concentrations were generally higher in 1997 than during previous years because of the unusually high river stage during 1997. As the river stage rises, the water table near the river rises into the vadose zone, causing strontium-90 to desorb from the saturated sediments and

to increase the concentrations in groundwater. As water levels fall, strontium-90 adsorbs to sediments that become unsaturated. This is illustrated by Figure 6.1.33, which shows a comparison of the strontium-90 concentrations and water-table elevation at well 199-N-2. The maximum level detected in 1997 was 25,000 pCi/L near the head end of the 1301-N Liquid Waste Disposal Facility (well 199-N-67).

The movement of the strontium-90 plume northward in the 1980s is illustrated by the trend plot for well 199-N-14 in Figure 6.1.32. Strontium-90 discharges to the Columbia River in the 100-N Area through springs along the shoreline. Section 4.2, "Surface Water and Sediment Surveillance" and Section 3.2, "Near-Facility Environmental Monitoring," discuss the results of riverbank springs water sampling.

Remediation of strontium-90 in the 100-N Area by the pump-and-treat method began in 1995 (BHI-01126). The objective is to pump from the extraction wells to create a hydraulic barrier between the river and the 1301-N facility, thus reducing the groundwater discharge rate and strontium-90 flux to the river. The unusually high river stage also contributed to this hydraulic barrier. The



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Figure 6.1.31. Strontium-90 Concentrations in the Unconfined Aquifer in the 100-B,C Area, 1997

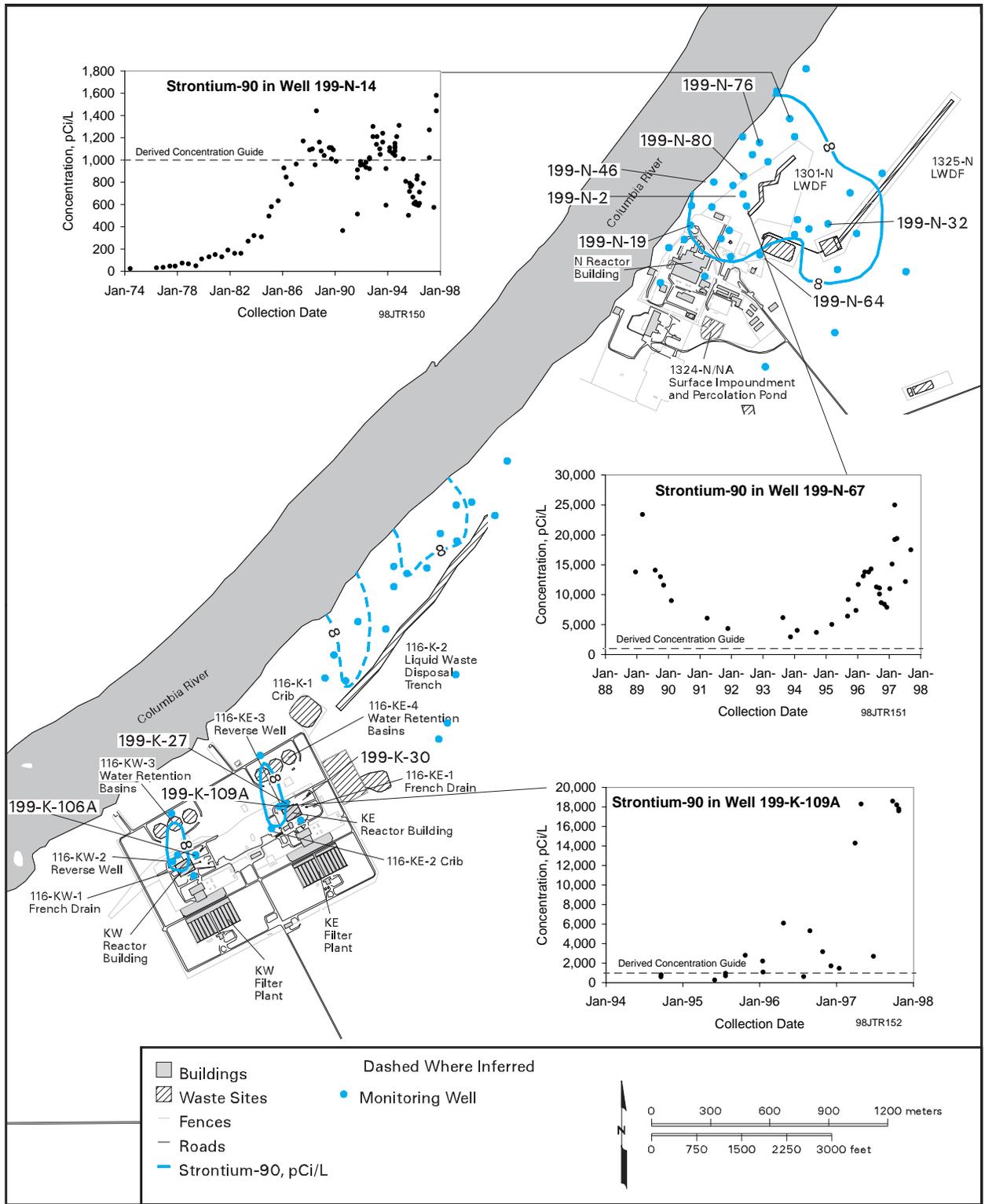


Figure 6.1.32. Strontium-90 Concentrations in the Unconfined Aquifer in the 100-K and 100-N Areas, 1997, and Concentration Trends in Selected Wells

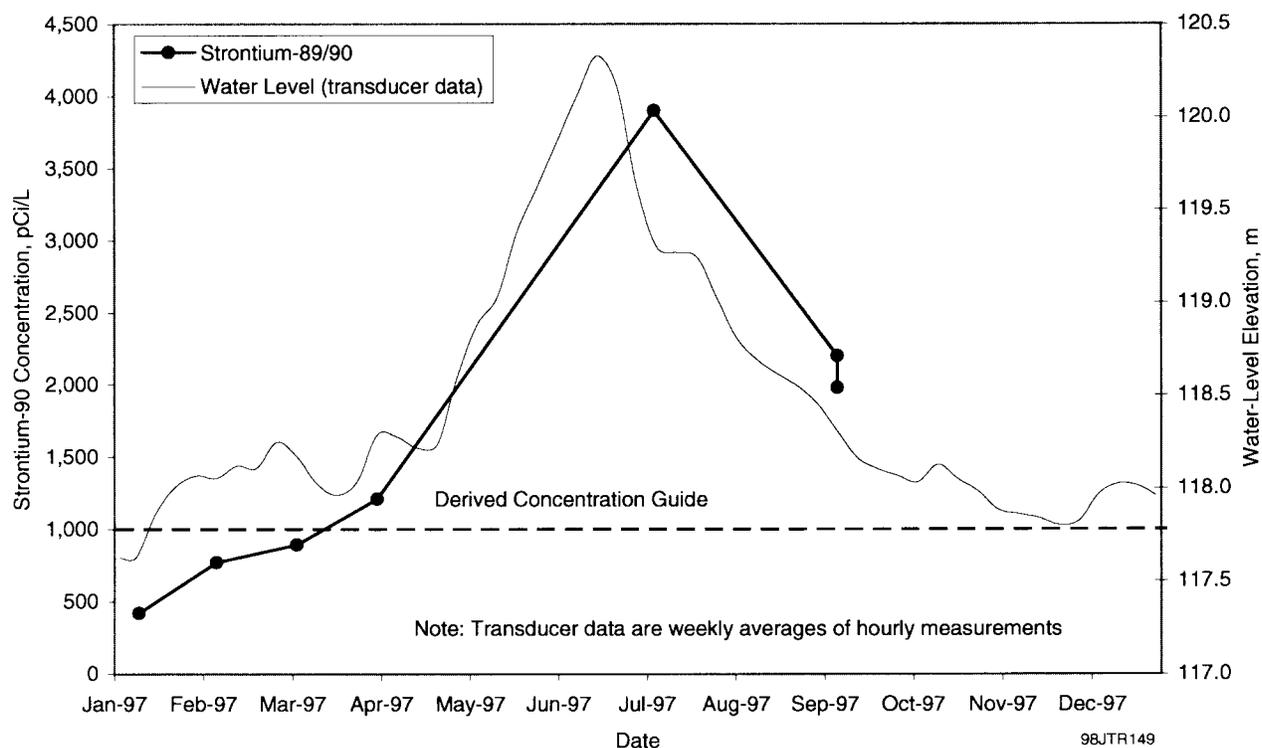


Figure 6.1.33. Strontium-90 Concentrations and Water-Table Elevations in Well 199-N-2, 1997

pump-and-treat system uses ion exchange technology to remove strontium-90 from the extracted groundwater and has performed as planned. During 1997, approximately 0.17 Ci of strontium-90 was removed from groundwater (BHI-01126).

Strontium-90 in the 200 Areas. Strontium-90 distribution in the 200-East Area is shown in Figure 6.1.22. Concentrations of strontium-90 in the 200-East Area were above the 1,000-pCi/L derived concentration guide in two wells near the 216-B-5 Injection Well. The maximum concentration was 9,630 pCi/L in well 299-E28-23. Strontium-90 increased to 145 pCi/L in one well located approximately 150 m (490 ft) from the inactive 216-B-5 Injection Well. Strontium-90 continued to be detected at a level above the 8-pCi/L interim drinking water standard in one well near the Plutonium-Uranium Extraction Plant cribs.

Strontium-90 in the 600 Area. In the 600 Area, the highest concentrations of strontium-90 were detected in four wells in the former Gable Mountain Pond area (see Figure 6.1.22). These concentrations were near or exceeded the 1,000-pCi/L derived concentration guide and reached a maximum of 1,320 pCi/L in 1997.

Strontium-90 contamination in this area resulted from the discharge of radioactive waste to the former Gable Mountain Pond during its early use.

Cesium-137. Cesium-137 is produced as a high yield fission product and is present in waste streams associated with fuel processing. Former reactor operations may have also resulted in the release of some cesium-137 associated with fuel element breaches. Cesium-137 is normally strongly sorbed on soil and, thus, is very immobile in Hanford Site groundwater. The interim drinking water standard for cesium-137 is 200 pCi/L; the derived concentration guide is 3,000 pCi/L.

Cesium-137 was detected in three wells located near the inactive 216-B-5 Injection Well in the 200-East Area. The injection well received cesium-137 bearing wastes from 1945 to 1947. The maximum cesium-137 concentration in 1997 was above the 200-pCi/L interim drinking water standard at a level of 2,250 pCi/L. This is an increase from a concentration of 1,470 pCi/L last measured in 1995. Cesium-137 appears to be restricted to the immediate vicinity of the former injection well because of its extremely low mobility in groundwater.

Cobalt-60. Cobalt-60 is typically associated with wastes generated by reactor effluent. Cobalt-60 is normally present as a divalent transition metal cation and, as such, tends to be highly immobile in groundwater. However, complexing agents may mobilize it. All groundwater samples analyzed for cobalt-60 in 1997 were below the 100-pCi/L interim drinking water standard. The derived concentration guide for cobalt-60 is 5,000 pCi/L.

Cobalt-60 concentrations were less than half the interim drinking water standard in the northwestern part of the 200-East Area and the adjacent 600 Area north of the 200-East Area, which are the same areas where the technetium-99 contamination associated with the BY Cribs is found. Apparently, cobalt in this plume is mobilized by reaction with cyanide or ferrocyanide in the waste stream, forming a dissolved cobalt species. The maximum concentration measured in 1997 was 34 pCi/L. Cobalt-60 was last detected in this area in 1995 at 166 pCi/L, which is above the 100-pCi/L interim drinking water standard (Section 4.8 in PNNL-11139). Because of its relatively short half-life (5.3 years), much of the cobalt-60 in groundwater in this area has decayed.

Plutonium. Plutonium has been released to the soil column in several locations in both the 200-East and 200-West Areas. Plutonium is generally considered to sorb strongly on sediments and, thus, has limited mobility in the aquifer. The derived concentration guide for both plutonium-239 and plutonium-240 is 30 pCi/L. Analytical detection is incapable of distinguishing between plutonium-239 and plutonium-240. Thus, the results are expressed as a concentration of plutonium-239,240. There is no explicit drinking water standard for plutonium-239,240; however, the gross alpha drinking water standard of 15 pCi/L would be applicable at a minimum. Alternatively, if the derived concentration guide, which is based on a 100-mrem dose standard, is converted to the 4-mrem dose equivalent used for the drinking water standard, 1.2 pCi/L would be the relevant guideline.

The only location where plutonium isotopes were detected in groundwater was near the inactive 216-B-5 Injection Well in the 200-East Area. Groundwater sampled during 1997 at wells located near this injection well ranged up to 67 pCi/L of plutonium-239,240. These values are lower than those measured in 1996. Because plutonium is strongly sorbed on sediments and may have been injected into the aquifer as suspended particles, it is likely that the values measured result in part from solid rather than dissolved material. The injection well received an estimated 244 Ci of plutonium-239,240 during its operation from 1945 to 1947 (PNL-6456).

6.1.7 Chemical Monitoring Results for the Unconfined Aquifer

In recent years, chemical analyses performed by various monitoring programs at the Hanford Site have identified several hazardous chemicals in groundwater at concentrations greater than their respective drinking water standards. Nitrate, chromium, and carbon tetrachloride are the most widely distributed of these hazardous chemicals and have the highest concentrations in groundwater at the Hanford Site. Chemicals that are less widely distributed and have lower concentrations in groundwater include chloroform, cis-1,2-dichloroethylene, cyanide, fluoride, and trichloroethylene.

A number of parameters such as pH, specific conductance, total carbon, total organic carbon, and total organic halides are used as indicators of contamination. These are mainly discussed in Section 6.1.9, "Resource Conservation and Recovery Act Summary." Other chemicals and parameters listed in Table 6.1.3 are indicators of the natural chemical composition of groundwater and are usually not contaminants from operations at the Hanford Site. These include alkalinity, aluminum, calcium, iron, magnesium, manganese, potassium, silica, and sodium. Chloride and sulfate occur naturally in groundwater and can also be introduced as contaminants from site operations. There is no primary drinking water standard for chloride or sulfate. The secondary standard for each is 250 mg/L and is based on aesthetic rather than health considerations. Therefore, they will not be discussed in detail. The analytical technique used to determine the concentration of metals in groundwater provides results for a number of constituents such as antimony, barium, beryllium, boron, cadmium, copper, nickel, silver, strontium, vanadium, and zinc that are rarely observed at greater than background concentrations.

The following presents a summary of the chemical constituents occurring in groundwater at concentrations greater than existing or proposed drinking water standards (40 CFR 141 and EPA 822-R-96-001; see Appendix C). Although cyanide concentrations are less than the drinking water standard and have stabilized, a brief discussion of cyanide occurrence in groundwater is presented because of its implications for cobalt-60 mobility.

6.1.7.1 Nitrate

Many groundwater samples collected in 1997 were analyzed for nitrate. Nitrate was measured at concentrations greater than the drinking water standard (45 mg/L as nitrate ion) in wells in all operational areas, except the 100-B,C and 400 Areas. Nitrate is associated primarily with process condensate liquid wastes, though other liquids discharged to the ground also contained nitrate. Nitrate contamination in the unconfined aquifer reflects the extensive use of nitric acid in decontamination and chemical reprocessing operations. However, additional sources of nitrate are located offsite to the south, west, and southwest. The distribution of nitrate on the Hanford Site is shown in Figure 6.1.34; this distribution is similar to previous evaluations. Although nitrate contamination can be detected over large areas of the site, the areas impacted by levels greater than the drinking water standard are small. The widespread distribution of nitrate below the drinking water standard is shown in Figure 5.2-2 of PNNL-11793.

Nitrate in the 100 Areas. Nitrate is found at levels greater than the 45-mg/L drinking water standard in much of the 100-D Area. The highest nitrate concentration found in the 100-D Area in 1997 was 103 mg/L in the southwestern part of the area. Slightly lower concentrations were found in the northeastern part of the 100-D Area.

The central and southern portions of the 100-F Area contain nitrate in groundwater at levels greater than the drinking water standard. This plume appears to extend to the south and southeast into the 600 Area from upgradient sources near F Reactor. In the vicinity of the reactor, groundwater flow was to the southeast in 1997. The maximum nitrate detected in the 100-F Area in 1997 was 287 mg/L in the southwestern part of the 100-F Area.

Nitrate above the drinking water standard in the 100-H Area is restricted to a small area downgradient of the former 183-H Solar Evaporation Basins; however, the concentrations are some of the highest onsite. In this small area, the maximum nitrate concentration was detected at a level of 730 mg/L, which was the maximum concentration reported onsite in 1997. These high levels of nitrate exhibit trends related to groundwater levels and Columbia River stage.

Nitrate at levels greater than the drinking water standard in the 100-K Area is found downgradient of both the KE and KW Reactors. The maximum concentration detected in 1997 was 218 mg/L in a well adjacent to the 116-K-2 Liquid Waste Disposal Trench.

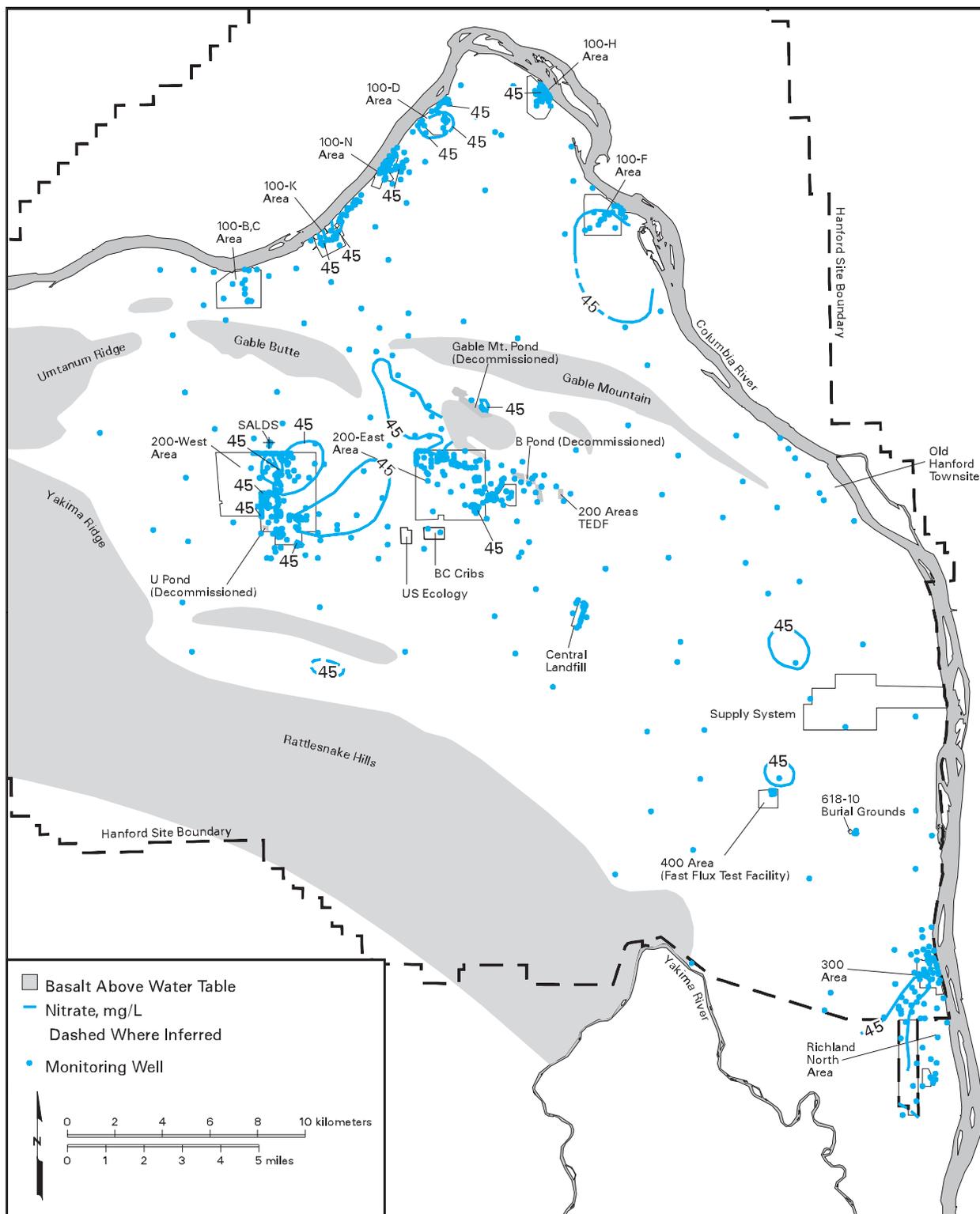
Although detected over most of the 100-N Area, nitrate contamination above the 45-mg/L drinking water standard occurs at isolated locations in the 100-N Area. The 367 mg/L maximum was detected in a 1997 sample from between the 1301-N Liquid Waste Disposal Facility and the Columbia River. Another elevated concentration was 280 mg/L along the Columbia River downgradient of the 1324-N/NA Surface Impoundment and Percolation Pond.

Nitrate in the 200-East Area. The nitrate plume in the 200-East Area covers a nearly identical area to that of the tritium plume. However, the area with nitrate exceeding the 45-mg/L drinking water standard is smaller than the area with tritium exceeding its drinking water standard. Nitrate exceeds the drinking water standard near the Plutonium-Uranium Extraction Plant and near cribs in the northern part of the 200-East Area. In 1997, the highest concentrations were reported in several wells near the 216-B-8 and BY Cribs. The maximum concentration in the 200-East Area was 357 mg/L adjacent to the 216-B-8 Crib. High nitrate concentrations in the 600 Area north of the 200-East Area, ranging up to 120 mg/L, are apparently related to past disposal practices at the BY Cribs.

High nitrate concentrations continued to be found near liquid waste disposal facilities that received effluent from Plutonium-Uranium Extraction Plant operations. Nitrate concentrations in wells near the 216-A-10 and 216-A-36B Cribs generally have tended to decrease in the past few years but remained greater than the drinking water standard even though these facilities were removed from service in 1987. The maximum nitrate concentration detected was 145 mg/L adjacent to the 216-A-10 Crib.

Nitrate is also found in a few wells near the former Gable Mountain Pond north of the 200-East Area. The highest measured concentration in this area in 1997 was 147 mg/L.

Nitrate in the 200-West Area. Nitrate concentrations greater than the 45-mg/L drinking water standard were widespread in groundwater beneath the 200-West Area and adjacent parts of the 600 Area. The major nitrate plumes were found in wells east of U Plant and wells in the north-central part of the 200-West Area. Some of the highest nitrate concentrations across the site continued to be found in wells southeast of U Plant, where the maximum concentration detected in 1997 was 673 mg/L. Near the 216-U-17 Crib, one well showed a concentration of 1,100 mg/L in 1996, but was not sampled during 1997. This 1,100 mg/L concentration was consistent



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Figure 6.1.34. Nitrate Distribution in the Unconfined Aquifer, 1997

with previous data from this well. The presence of nitrate in wells near this crib was observed before February 1988 when the crib went into operation. The source of nitrate is believed to be wastes disposed of in the 216-U-1 and 216-U-2 Cribs southwest of U Plant. These cribs received over 1,000,000 kg (2,200,000 lb) of nitrate bearing chemicals during their operation from 1951 to 1967 (PNL-6456). Nitrate concentrations in wells located near the 216-U-1 and 216-U-2 Cribs continued to decrease, with concentrations in several of the wells dropping to less than the drinking water standard. Between April and September 1997, a pump-and-treat system near the 216-U-17 crib removed 2,260 kg (4,980 lb) of nitrate from extracted groundwater (BHI-01126).

Nitrate concentrations (maximum of 303 mg/L) continued to be above the drinking water standard near other cribs to the south that are associated with the U Plant and Reduction-Oxidation Plant. These elevated levels represent nitrate plumes that coalesce with the plume emanating from the U Plant area. A small, isolated plume of elevated nitrate occurs west of the Reduction-Oxidation Plant near the 216-S-25 Crib and S-SX Tank Farm, where the maximum concentration was 130 mg/L.

A large area, encompassing the northern half of the 200-West Area, continued to contain nitrate in groundwater at concentrations much greater than the 45-mg/L drinking water standard. Wells showing the highest concentrations are located near several inactive liquid waste disposal facilities that received waste from early T Plant operations. A large amount of nitrate was disposed to these cribs (e.g., approximately 2,300,000 kg [5,100,000 lb] of nitrate bearing chemicals to the 216-T-7 Crib). Maximum concentrations in these wells in 1997 ranged up to 437 mg/L west of T Plant near T Tank Farm. High concentrations of nitrate were also found at the northeastern boundary of the 200-West Area at a level of 317 mg/L in 1997.

A smaller area of elevated nitrate concentrations above the drinking water standard is located in the vicinity of the Plutonium Finishing Plant in the central part of the 200-West Area. The highest reported concentration was 478 mg/L near a Plutonium Finishing Plant crib (216-Z-9). This crib had received an estimated 1,300,000 kg (2,900,000 lb) of nitrate bearing chemicals during its operation in the past.

Nitrate in Other Areas. Nitrate concentrations near the city of Richland and in the 1100 Area, Richland North Area, and adjacent parts of the 600 Area are also apparently affected by offsite nitrate sources. These sources

may include agriculture, food processing, urban horticulture, and nuclear fuel manufacturing at offsite commercial facilities. The part of this plume with nitrate concentrations greater than the drinking water standard extends from offsite, south of the Horn Rapids Landfill, to the 300 Area to the northeast. The maximum nitrate concentration in 1997 was 166 mg/L on the northeastern edge of the Horn Rapids Landfill.

Although most nitrate observed onsite is the result of Hanford Site operations, elevated nitrate concentrations in wells in the western part of the site appear to be the result of increasing agricultural activity in offsite areas (e.g., Cold Creek Valley). There is no known source of nitrate in these areas associated with site operations, and the groundwater flow is from the west toward the Hanford Site facilities to the east. Nitrate levels have fluctuated considerably in wells upgradient of the 200 Areas over the past 30 years. In Cold Creek Valley, nitrate levels have been near or greater than the 45-mg/L drinking water standard in one well since 1985. The concentration was 43 mg/L in 1997. A maximum nitrate concentration of 54 mg/L was found in a well located just north of the Rattlesnake Hills.

High nitrate concentrations have been reported offsite in parts of Adams, Franklin, and Grant Counties to the north and east of the Hanford Site. Ryker and Jones (1995) reported that 28% of the wells sampled in this area had nitrate concentrations above the drinking water standard. The nitrate is related, in general, to fertilizer and water usage and has been increasing since the 1950s. This nitrate may impact surface water quality (see Section 4.2, "Surface Water and Sediment Surveillance") and groundwater in the northern part of the Hanford Site north of the Columbia River.

6.1.7.2 Chromium

Chromium use on the Hanford Site has been extensive. In the 100 Areas, sodium dichromate was added to cooling water as a corrosion inhibitor, and some residual chromium remains from that use. Chromium was used for decontamination in the 100, 200, and 300 Area and was used also for oxidation state control in the Reduction-Oxidation Plant process. In the hexavalent form, chromium is present in an anionic state. Thus, hexavalent chromium is freely mobile in the groundwater. The drinking water standard for chromium is 100 µg/L.

Both filtered and unfiltered samples were collected for analyses of chromium and other metals from several of the wells onsite. Unfiltered samples may contain metals

present as particulate matter, while filtered samples are representative of the more mobile dissolved metals. Filtered samples may also contain some colloidal particles that are fine enough to pass through the filter. Drinking water standards are based on unfiltered concentrations; however, differences in well construction and pumping practices between monitoring wells and water supply wells make it difficult to predict potential drinking water concentrations from monitoring well data when the metals are present as particulate matter. In general, filtered samples provide the best indication of groundwater contamination levels for chromium because unfiltered samples are subject to greater variability introduced by the sampling process. Chromium concentrations in filtered samples, which are considered to be representative of dissolved hexavalent chromium, will be used to describe the level of contamination in the discussion below.

Chromium in the 100 Areas. Chromium has been detected above the 100- $\mu\text{g/L}$ drinking water standard in the 100-D, 100-H, and 100-K Areas. Groundwater pump-and-treat systems were implemented in each of these areas in 1997 to reduce hexavalent chromium entering the Columbia River.

The chromium distribution in the 100-D Area is shown in Figure 6.1.35. An area of chromium concentrations greater than the 100- $\mu\text{g/L}$ drinking water standard extends from northeast to southwest across the 100-D Area near the Columbia River. The source of chromium in groundwater is sodium dichromate released to the ground at facilities near D Reactor. In 1997, the maximum chromium concentration from filtered samples was 2,260 $\mu\text{g/L}$ in a well in the vicinity of a chromium hot spot in the southwestern portion of the 100-D Area. In situ redox manipulation technology is currently being demonstrated in the hot spot area to address hexavalent chromium contamination in groundwater. In the area near the former 120-D-1 Ponds, chromium concentrations increased in response to ceased discharges of noncontaminated water to the ponds in 1994, as shown by the trend plot for well 199-D5-13 in Figure 6.1.35. Chromium concentrations began to decrease in late 1997. A pump-and-treat system began operating in July 1997 in the northern part of the 100-D Area downgradient of the retention basins. Groundwater is extracted and piped to the 100-H Area, where chromium is removed using ion exchange technology. A performance evaluation of the pump-and-treat system is planned for 1998.

Many samples from 100-H Area wells contained chromium at levels greater than the drinking water standard (see Figure 6.1.35). In 1997, the maximum chromium concentration from 100-H Area filtered samples collected from

the shallow parts of the unconfined aquifer was 196 $\mu\text{g/L}$ near the former 183-H Solar Evaporation Basins. Chromium was also found at levels above the drinking water standard in one well monitoring the deeper part of the unconfined aquifer in the 100-H Area. Samples from this well, located near the former 183-H Basins, contained up to 256 $\mu\text{g/L}$ of chromium (in filtered samples) in 1997. Potential sources in the 100-H Area include past disposal of sodium dichromate near H Reactor, disposal to the 107-H Liquid Waste Disposal Trench, and chromium in acid wastes stored in the former 183-H basins (Peterson and Connelly 1992). Chromium was also detected in parts of the 600 Area upgradient from the 100-H Area, indicating an upgradient source, which is probably the 100-D Area. Effluent releases at the 100-D Area during operations produced groundwater mounding, which altered flow conditions. This caused the spreading of chromium contamination into the 600 Area.

A groundwater remediation pump-and-treat system to reduce hexavalent chromium entering the Columbia River from the aquifer was implemented in 1997. Groundwater extracted from 100-H Area wells located in the chromium plume is treated using ion exchange technology and then reinjected into the aquifer in the southwestern part of the 100-H Area. Pumping was stopped in one of the 100-H extraction wells because of a slight buildup of technetium-99 in the treatment system. A performance evaluation of the interim action to pump and treat is planned for 1998 (DOE/RL-96-90, Draft A).

Chromium in the 100-K Area occurs in groundwater near or at levels greater than the 100- $\mu\text{g/L}$ drinking water standard (Figure 6.1.36). Two localized areas of chromium contamination occur near the KW Reactor and the former water treatment basins southeast of the KE Reactor. The maximum concentration in 1997 was 191 $\mu\text{g/L}$ near the KW Reactor. A much wider area of chromium contamination is found in the vicinity of the former 116-K-2 Liquid Waste Disposal Trench to the northeast. A pump-and-treat system for treating chromium in groundwater between the trench and the Columbia River began operating in October 1997. Groundwater extracted from a network of wells is treated using ion exchange technology and then returned to the aquifer upgradient of the 116-K-2 trench. An evaluation of performance monitoring data collected from the pump-and-treat system is planned for 1998 (DOE/RL-96-90, Draft A).

Chromium in the 200 Areas. Chromium at concentrations greater than the 100- $\mu\text{g/L}$ drinking water standard in the 200-East Area was found in one well on the southern

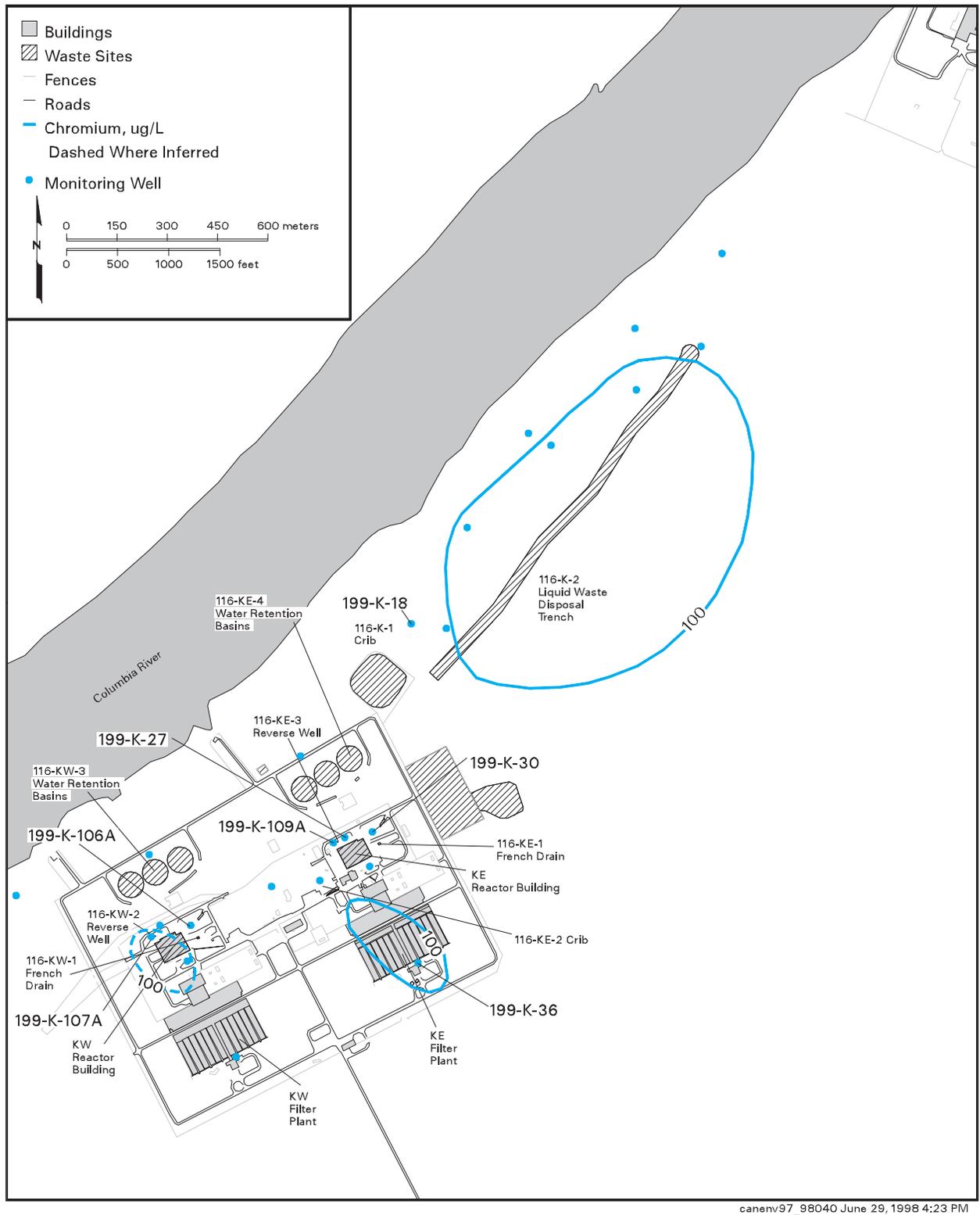


Figure 6.1.36. Filtered Chromium Distribution in the 100-K Area, 1997

boundary of the A-AX Tank Farms. The maximum concentration detected in the sample was 1,660 µg/L. Chromium concentrations in this well decreased between 1992 and 1996 but increased to 1,660 µg/L in 1997 (Figure 6.1.37). Releases from the A-AX Tank Farms are a potential source of this chromium contamination.

Chromium contamination in groundwater has been found at several locations in the 200-West Area. Areas where concentrations exceeded the 100-µg/L drinking water standard in 1997 include the retired 216-S-10 Pond and T-TX-TY Tank Farms. The highest filtered chromium concentration observed in the 200-West Area in 1997 was 576 µg/L adjacent to the 216-S-10 Pond. The highest concentration found in the vicinity of T Tank Farm in 1997 was 155 µg/L. Filtered samples from wells monitoring the TX-TY Tank Farms showed a maximum concentration of 306 µg/L, which is much higher than in previous years.

Chromium in the 300 Area. Chromium is occasionally detected at concentrations greater than the 100-µg/L drinking water standard in unfiltered samples from the 300 Area. In 1997, filtered and unfiltered samples from the 300 Area showed chromium concentrations below the standard. High chromium concentrations found in

unfiltered samples represent particulate matter and are affected by the stainless steel well construction purging procedures, time between samples, and other factors that do not reflect groundwater quality.

Chromium in Other Areas. Filtered chromium was detected in several wells located downgradient (east) of the southern part of the 200-West Area in 1997. The maximum concentration detected in filtered samples in this area during 1997 was 226 µg/L. The extent of chromium contamination in this area is poorly defined, and the source has not been determined.

6.1.7.3 Carbon Tetrachloride and Chloroform

Carbon tetrachloride contamination above the 5-µg/L drinking water standard was found in the unconfined aquifer beneath much of the 200-West Area. The bulk of the contamination is believed to be from waste disposal operations associated with the Plutonium Finishing Plant in the west-central part of the 200-West Area. Carbon tetrachloride was used as the carrier solvent for tributyl phosphate in the final purification of plutonium. Carbon tetrachloride was also used in the same facility as a

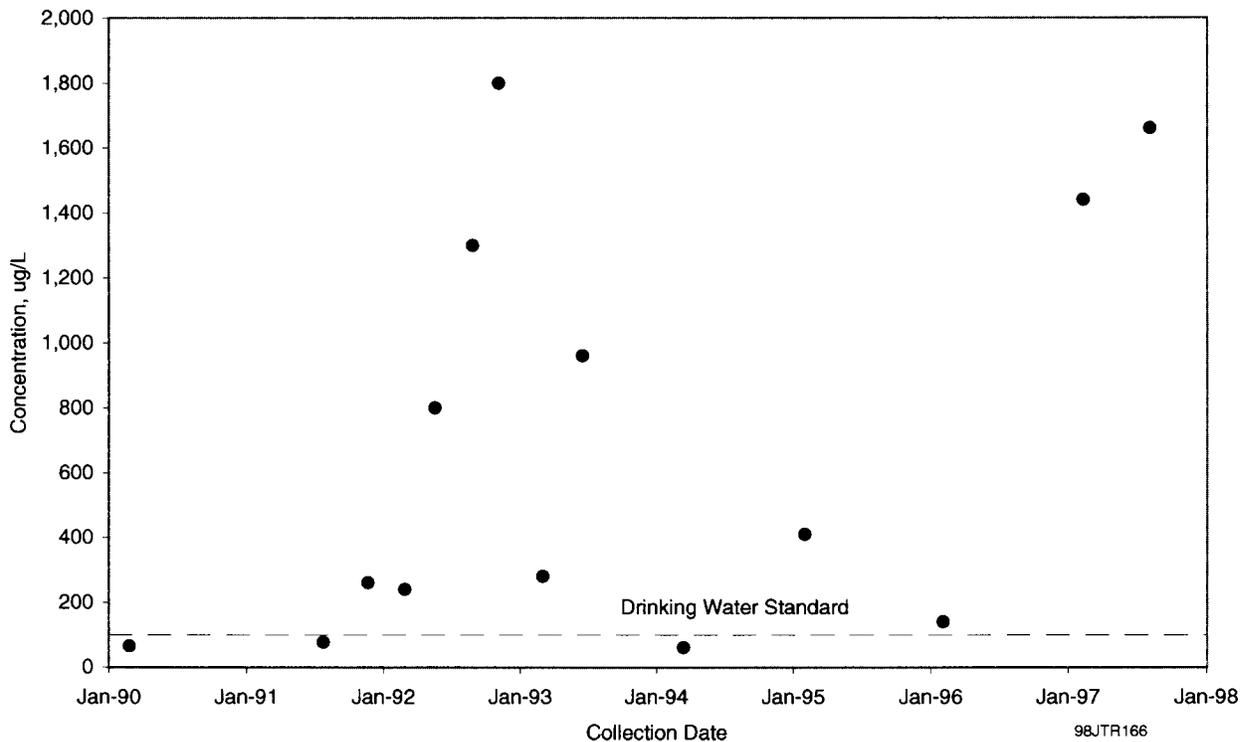


Figure 6.1.37. Filtered Chromium Concentrations in Well 299-E24-19, 1990 Through 1997

nonflammable thinning agent while machining plutonium. A minor source of carbon tetrachloride is a waste disposal crib near T Plant. Carbon tetrachloride is immiscible in water but exhibits a relatively high solubility (805,000 µg/L at 20°C [68°F]). Carbon tetrachloride has been found to have a relatively high degree of mobility in groundwater. Mobilization above the water table can also occur through vapor transport.

The carbon tetrachloride plume in the 200-West Area covers a large area that is over 10 km² (4 mi²). However, the overall carbon tetrachloride distribution in the groundwater (Figure 6.1.38) has changed slowly since the presence of the contaminant plume was first noted in 1987. This slow change is illustrated in Figure 6.1.38 by the trends in carbon tetrachloride concentrations through time for wells at various locations within the plume.

Wells in the vicinity of the Plutonium Finishing Plant showed the highest concentrations in the carbon tetrachloride plume, with levels exceeding the 5-µg/L drinking water standard by more than 3 orders of magnitude. The maximum concentration was 8,200 µg/L in one pump-and-treat extraction well east of the Plutonium Finishing Plant near the 216-Z-9 Crib. Carbon tetrachloride concentrations have increased in several of the extraction wells since the pump-and-treat operation began in 1994. Carbon tetrachloride concentrations in the injection wells southwest of the Plutonium Finishing Plant continued to decline in 1997 as a result of injection of the treated water in these wells. As of September 1997, greater than 259,000,000 L (68,400,000 gal) of extracted groundwater have been treated, resulting in the removal of approximately 860 kg (1,900 lb) of carbon tetrachloride.

The pump-and-treat system near the 216-U-17 Crib in the southeastern part of the 200-West Area removed 10.6 kg (23.3 lb) of carbon tetrachloride from the extracted groundwater between March 1994 and February 1997. Between April and September 1997, 0.89 kg (2.0 lb) of carbon tetrachloride had been removed (BHI-01126).

The extent of carbon tetrachloride contamination, as defined by the 5-mg/L contour is poorly defined in the east-central part of the 200-West Area because of the lack of monitoring wells (see Figure 6.1.38). There is considerable uncertainty regarding the extent of contamination in deeper parts of the aquifer because of the limited amount of carbon tetrachloride concentration data from depths below the water table.

Changes in groundwater flow since decommissioning U Pond may be influencing the plume configuration and the concentrations at particular locations. Another potential influence is the continued spreading of carbon tetrachloride above the water table, in either the aqueous or vapor phase. Although free-phase liquid carbon tetrachloride above and possibly below the water table has not been observed, the carbon tetrachloride concentrations in the aqueous and vapor phases and the conceptual understanding of contaminant behavior suggest that a continuing source of contamination exists. Therefore, lateral expansion of the carbon tetrachloride plume is expected to continue.

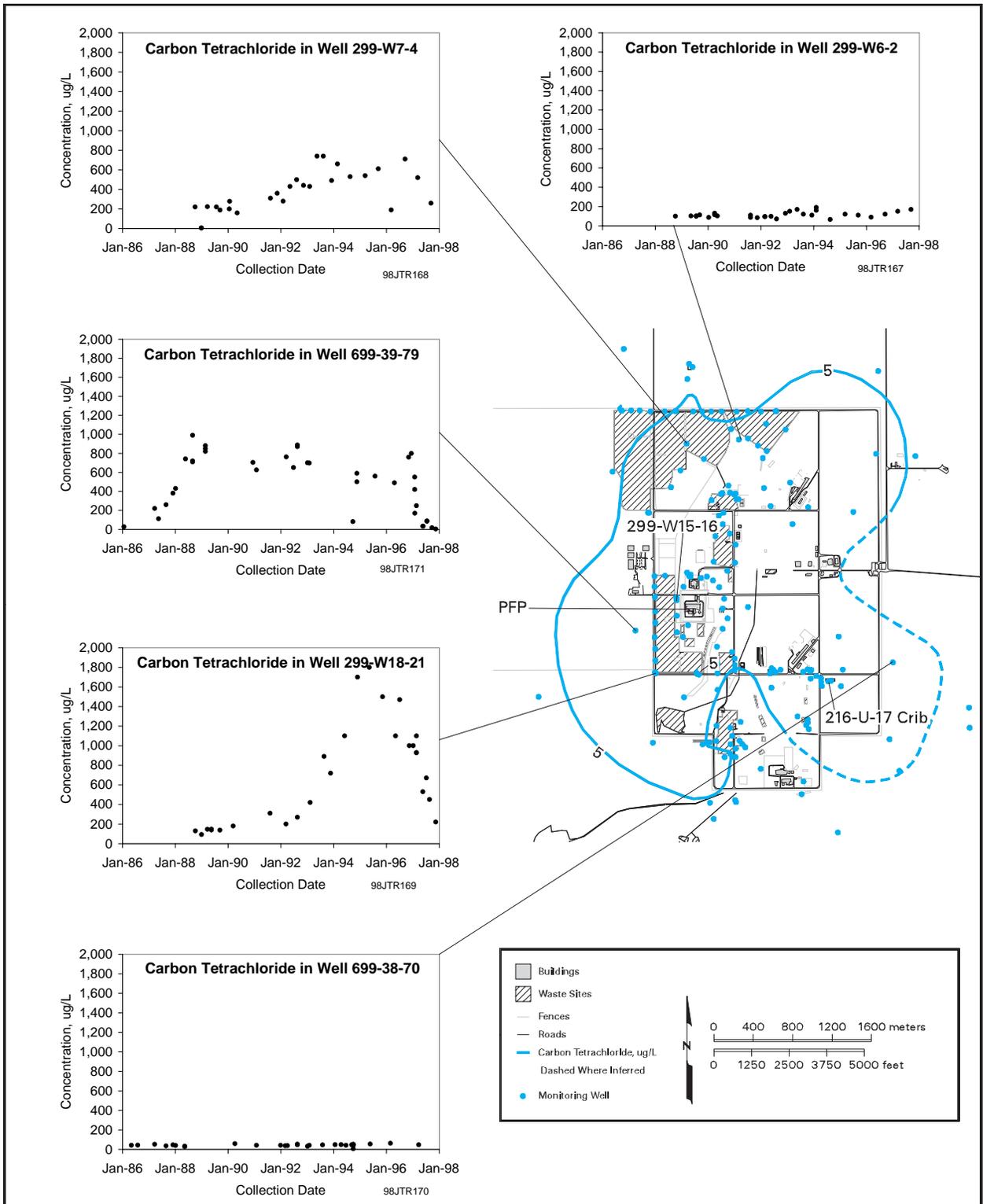
In addition to carbon tetrachloride, lesser amounts of chloroform were found in 200-West Area groundwater. The chloroform plume appears to be associated with, but not exactly coincident with, the carbon tetrachloride plume, as shown by Figure 5.3.6 in PNL-10698. The highest chloroform concentrations appear to be located in the vicinity of the Plutonium Finishing Plant. The highest chloroform level recorded in 1996 was 250 µg/L; however, in 1997, the distribution of chloroform in this area could not be defined because high carbon tetrachloride concentrations interfered with the analyses. The drinking water standard for chloroform is 100 µg/L (total trihalomethanes), which is 20 times higher than that for carbon tetrachloride. The origin of the chloroform is unknown but is suspected to be a degradation product of carbon tetrachloride.

6.1.7.4 Trichloroethylene

Trichloroethylene, which is a commonly used organic solvent, has a drinking water standard of 5 µg/L. In 1997, trichloroethylene was detected at levels greater than the drinking water standard in wells in the 100-F, 100-K, 200-West, and 300 Areas and parts of the 600 Area.

Trichloroethylene in the 100 Areas. Trichloroethylene was detected in 1997 at levels greater than the 5-µg/L drinking water standard in the southwestern corner of the 100-F Area and in the adjacent 600 Area. The maximum concentration detected in this area was 20 µg/L in 1997. No specific sources of this contamination have been identified.

In the 100-K Area, two wells sampled in 1997 contained trichloroethylene at levels above the drinking water standard, with a maximum concentration of 18 µg/L. This trichloroethylene level represents a localized area of contamination near the KW Reactor.



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Figure 6.1.38. Carbon Tetrachloride Distribution in the Unconfined Aquifer in the 200-West Area, 1997, and Concentration Trends for Several Wells Within the 200-West Area

Trichloroethylene in the 200 Areas. Trichloroethylene is known to occur at levels greater than the 5- $\mu\text{g/L}$ drinking water standard in several areas of the 200-West Area, as shown by 1996 data (Section 6.9.3.1 in PNNL-11470). The first area extends from the Plutonium Finishing Plant, west of T Plant, and past the northern boundary of the 200-West Area. Two smaller areas of trichloroethylene contamination occur east of U Plant and east of the Reduction-Oxidation Plant. In 1996, trichloroethylene concentrations in these areas ranged up to 26 $\mu\text{g/L}$. In 1997, samples were collected and analyzed for trichloroethylene in these areas. However, high carbon tetrachloride concentrations in many of the samples interfered with the analyses of low levels of trichloroethylene. Thus, the 1997 analytical data cannot be used to contour the trichloroethylene concentrations in these areas.

Trichloroethylene in the 300 Area. Trichloroethylene was detected in one well in 1997 in the 300 Area at concentrations above the 5- $\mu\text{g/L}$ drinking water standard. The maximum concentration was 10 $\mu\text{g/L}$ in well 399-1-16B. This well monitors the base of the unconfined aquifer downgradient of the former 316-5 Process Trenches.

Trichloroethylene in the 600 Area. Trichloroethylene was found at levels above the drinking water standard in a number of wells in the vicinity of the former Horn Rapids Landfill in the southern part of the site (Richland North Area). This contamination forms an elongated plume that extends from an area just south of the former landfill to the 300 Area and appears to have an origin off the Hanford Site (Figure 6.1.39). The trichloroethylene plume as defined by the 5- $\mu\text{g/L}$ contour extended into the southwestern part of the 300 Area between 1996 and 1997. Trend plots in Figure 6.1.39 provide an indication of the migration of the trichloroethylene plume toward the northeast in this vicinity. The maximum trichloroethylene contamination detected in this plume in 1997 was 12 $\mu\text{g/L}$ on the northeastern side of the former Horn Rapids Landfill.

6.1.7.5 cis-1,2-Dichloroethylene

Concentrations of cis-1,2-dichloroethylene biodegradation product of trichloroethylene are increasing in well 399-1-16B located near former process trenches and ponds. This well is completed in the deeper part of the unconfined aquifer in the 300 Area and is the only well onsite where this constituent is found at levels above the 70- $\mu\text{g/L}$ drinking water standard. In 1997, a maximum of 190 $\mu\text{g/L}$ of cis-1,2-dichloroethylene was detected in well 399-1-16B.

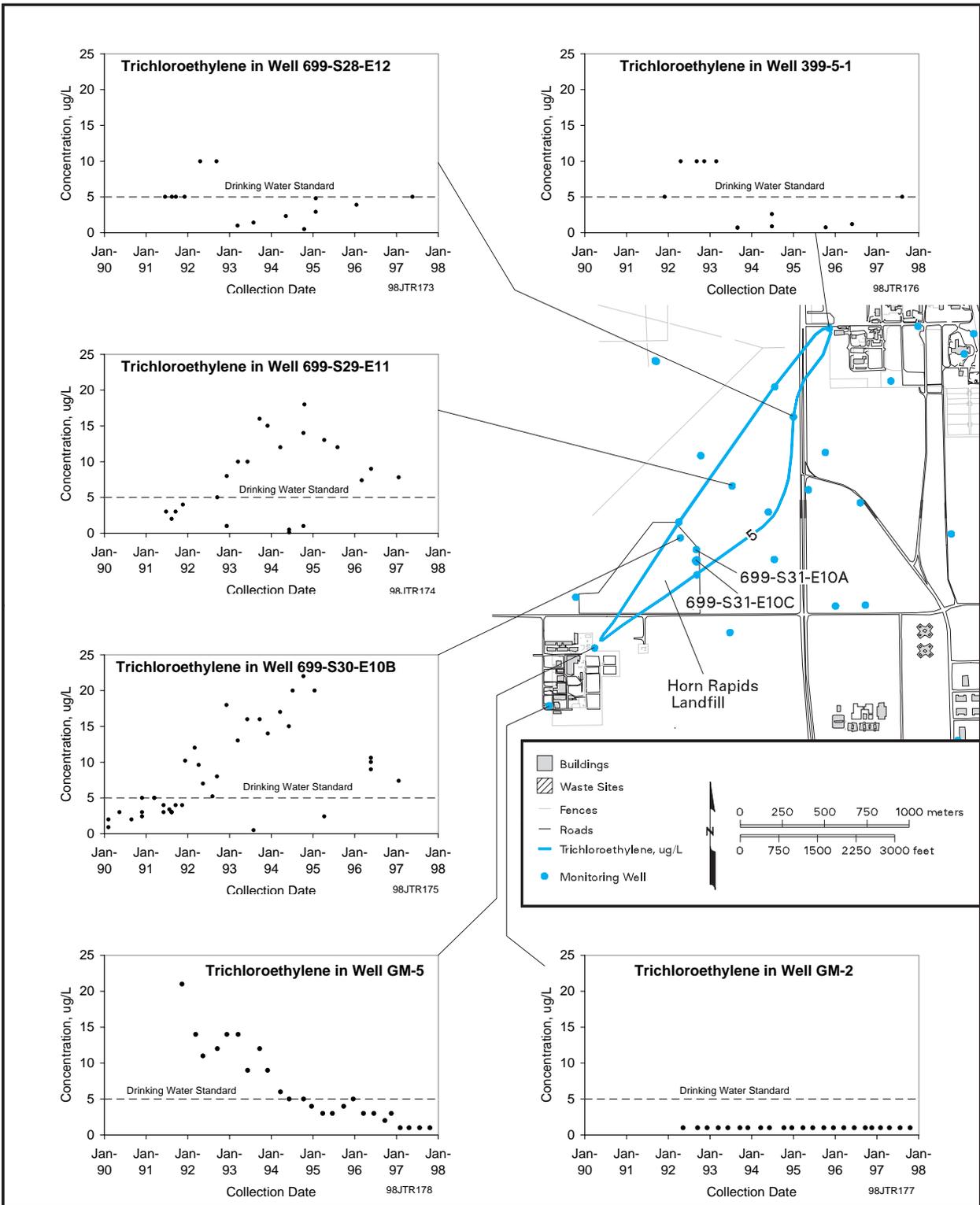
6.1.7.6 Cyanide

Waste fractionation activities performed in the late 1950s used large quantities of sodium and nickel ferrocyanide to recover cesium-137. Large volumes of aqueous supernatant waste containing excess ferrocyanide were disposed to the ground in both the north and south portions of the 200-East Area. Smaller quantities were also disposed to cribs in the 200-West Area. Procedures used to analyze for cyanide do not distinguish between ferrocyanide and free cyanide. Cyanide results reported here are, thus, normally assumed to be residual ferrocyanide associated with the discharges from the waste fractionation activities performed more than 30 years ago. A chemical speciation study performed in 1988 indicated that approximately one-third of the cyanide in groundwater is present as free cyanide and the rest may be present as ferrocyanide (Section 4.1 in PNL-6886 and Section 3.2.2 in PNL-7120). The drinking water standard for cyanide is 200 $\mu\text{g/L}$.

The highest cyanide levels were detected in samples collected from wells in the northwestern part of the 200-East Area and in the 600 Area north of the 200-East Area. However, no samples collected in 1997 contained cyanide at levels above the drinking water standard. The highest cyanide concentration in groundwater was 130 $\mu\text{g/L}$ in the 600 Area north of the 200-East Area. The highest cyanide concentration in the 200-East Area was 113 $\mu\text{g/L}$ near the BY Cribs. Wells containing cyanide often contain concentrations of several radionuclides, including cobalt-60. Although cobalt-60 is normally immobile in the subsurface, it appears to be chemically complexed by cyanide or ferrocyanide. The complexed chemical species is more soluble and more mobile in groundwater.

6.1.7.7 Fluoride

Fluoride currently has a primary drinking water standard of 4.0 mg/L and a secondary standard of 2.0 mg/L. Secondary standards are based primarily on aesthetic rather than health considerations. Fluoride was detected at a maximum level equal to the primary drinking water standard at one well near T Tank Farm in the 200-West Area in 1997. This well showed a maximum fluoride concentration of 4.0 mg/L. This is a decrease from the maximum level of 7.8 mg/L that was above the primary standard in 1996. Aluminum fluoride nitrate used in the 200-West Area processes is the probable source of the fluoride contamination.



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Figure 6.1.39. Trichloroethylene Distribution in the Vicinity of the Former Horn Rapids Landfill and Richland North Area, 1997, and Concentration Trends for Selected Wells

6.1.8 Radiological and Chemical Monitoring Results for the Basalt-Confined Aquifer

Aquifers confined below the uppermost basalt layers show much less impact from Hanford Site contamination than the unconfined aquifer system within the overlying sediments. The minor contamination found in the basalt-confined aquifers may be attributed to several factors. These factors include areas where the confining layers of basalt have been eroded away, areas where disposal of large amounts of water resulted in downward gradients, and areas where wells penetrating to the confined aquifers provided pathways for contaminant migration. These factors produced intercommunication between the aquifers, meaning they permitted the flow of groundwater from the unconfined aquifer to the underlying confined aquifer, thereby increasing the potential to spread contamination. Because fewer wells are available to evaluate contamination in the confined aquifer, it is important to consider contamination in the confined aquifer even where the levels are well below drinking water standards. The concentration distribution of tritium and other detected contaminants in the upper basalt-confined aquifer are shown in Figure 6.1.40.

Intercommunication between the unconfined and basalt-confined aquifers in the vicinity of the northern part of the 200-East Area was identified in RHO-BWI-ST-5 and RHO-RE-ST-12 P. The hydrochemical and hydrogeologic conditions within the upper basalt-confined aquifer system and the potential for offsite migration of contaminants through confined aquifer pathways were evaluated in PNL-10817.

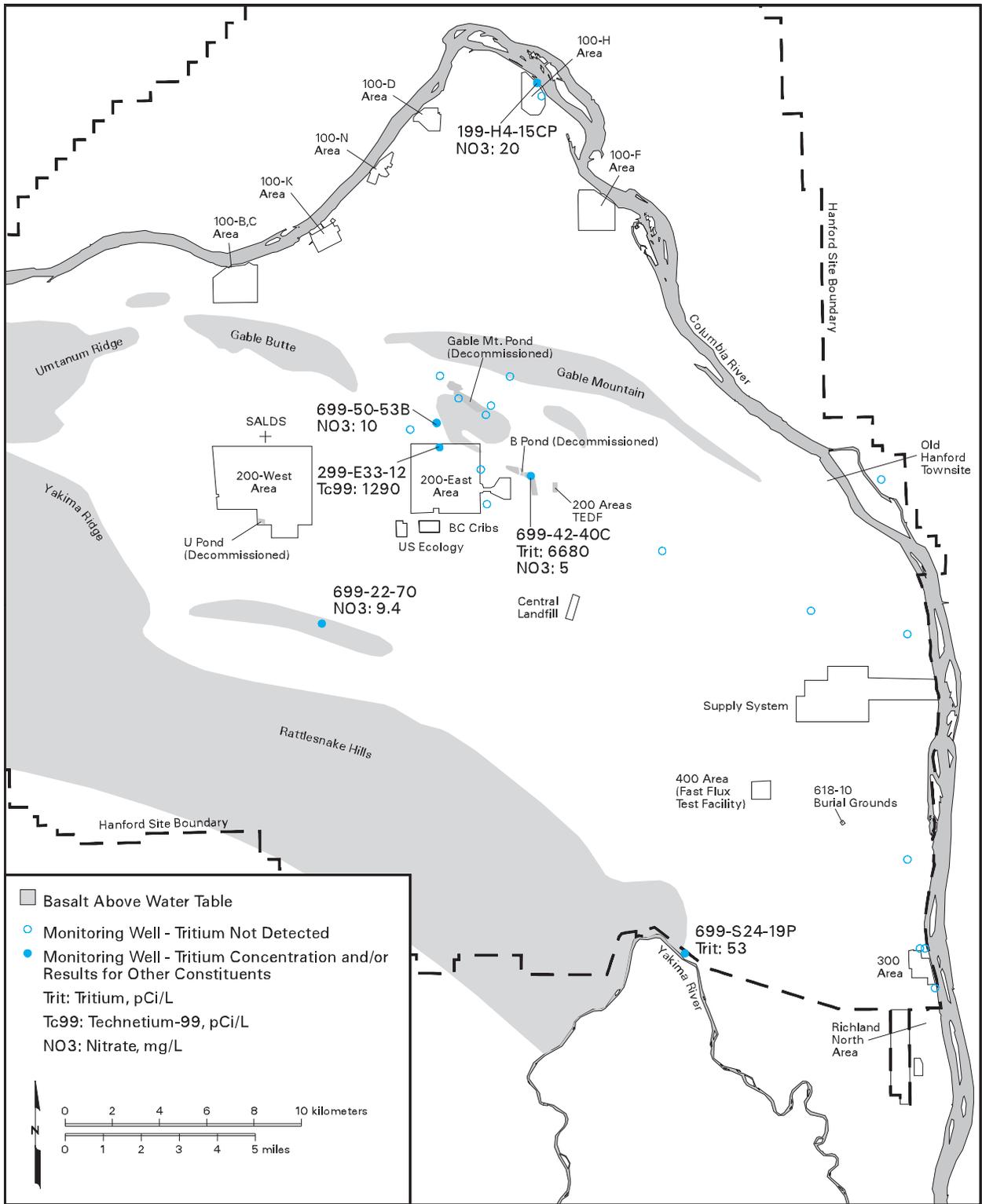
Several confined aquifer wells north and east of the 200-East Area that show evidence of intercommunication with the overlying unconfined aquifer were identified in PNL-10817. Intercommunication between the unconfined and confined aquifers in the area north and east of the 200-East Area has been attributed to erosion of the upper Saddle Mountains Basalt and downward vertical gradients resulting from groundwater mounding associated with waste disposal. Groundwater chemical data from most confined aquifer wells in other areas of the Hanford Site do not exhibit evidence of contamination, with the exception of wells that were previously open to both the unconfined and confined aquifers, thus providing conduits for the downward transport of contamination.

Results of the 1995 sampling and analyses of groundwater from the upper basalt-confined aquifer indicated only a few areas of concern that warranted continued annual monitoring. Consequently, the number of wells sampled during 1997 was reduced to include only those with groundwater contamination or those downgradient from areas with historical indications of contamination. Prominent analytical results and trends arising from 1997 sampling are discussed below. The locations of wells used for monitoring confined aquifer groundwater chemistry were given in Figure 6.1.11.

Contamination has also been identified in the confined aquifer in the northern part of the 200-East Area and adjacent parts of the 600 Area. The highest levels of contamination detected in the confined aquifer in this vicinity were in well 299-E33-12. Contamination in this well is attributed to migration of high salt waste down the borehole during construction when it was open to both the unconfined and confined aquifers (RHO-RE-ST-12 P). During 1997, technetium-99 was detected in well 299-E33-12 at a concentration of 1,290 pCi/L, which is above the 900-pCi/L drinking water standard. Cobalt-60 was detected in this well at a concentration of 12.9 pCi/L in 1997. In 1995, cobalt-60 was detected at a concentration of 154 pCi/L in the confined aquifer at well 699-49-55B north of the 200-East Area. However, this well was not sampled for cobalt-60 in 1996 and 1997. The cobalt-60 contamination at this well may be related to the use of neighboring well 699-49-55A, which was completed in the unconfined aquifer for injection of water from a pump-and-treat test for groundwater remediation in 1994.

Well 699-42-40C monitors the confined aquifer adjacent to the former B Pond. Tritium at this well declined from 8,284 pCi/L in 1996 to 6,680 pCi/L in 1997. Iodine-129, which showed a high of 0.36 pCi/L in 1996, was not detected in well 699-42-40C in 1997. The drinking water standard for iodine-129 is 1 pCi/L.

Wells 699-20-82 and 699-22-70 are completed in the basalt-confined aquifer near the base of the Rattlesnake Hills in an area where pervasive downward flow from the unconfined aquifer recharges the upper portion of the confined aquifer (PNL-10817). Samples from well 699-22-70 contained up to 9.4 mg/L of nitrate in 1997, well below the 45-mg/L drinking water standard. In past years, samples from well 699-20-82 contained as much as 23.9 mg/L of nitrate. Nitrate in the overlying unconfined aquifer in the Dry Creek Valley area and in



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Figure 6.1.40. Tritium and Other Contaminants Detected in Confined Aquifer Wells, 1997

wells 699-20-82 and 699-22-70 may result from agricultural sources to the south and west and is not believed to originate from sources on the Hanford Site.

6.1.9 Resource Conservation and Recovery Act Summary

More than 60 treatment, storage, and disposal units are recognized under the Hanford Facility Resource Conservation and Recovery Act permit. Of these, 25 required groundwater monitoring during 1997. Locations of these groundwater monitoring sites were given in Figure 6.1.12. This section provides a summary of groundwater monitoring activities and results for these sites. Additional information on Resource Conservation and Recovery Act groundwater monitoring, including complete listings of radioactive and chemical constituents measured in monitoring wells from October 1996 through September 1997, is available in PNNL-11793. Any significant changes in Resource Conservation and Recovery Act groundwater monitoring results that occurred from October through December 1997 are noted below.

Resource Conservation and Recovery Act groundwater monitoring is conducted under one of three phases: 1) indicator parameter/detection, 2) groundwater quality assessment/compliance, or 3) corrective action. Initially, a detection program is developed to monitor the impact of facility operations on groundwater. During the indicator parameter/detection phase, groundwater parameters established for the particular site are measured in wells upgradient and downgradient from the site. Statistical tests are applied to the monitoring results to calculate "critical mean" values for each monitoring parameter. These values represent the background water quality for the site. Subsequent monitoring data are compared to the critical mean values to determine if there has been a statistically significant increase (or pH decrease) in the concentrations of key indicator parameters or dangerous waste constituents in the groundwater. The statistical methods used to calculate critical means and compare with monitoring data are described in Appendix B in PNNL-11793. If a statistically significant increase (or pH decrease) from the "critical mean" is observed, then a groundwater quality assessment/compliance phase of monitoring and investigation is initiated. During this phase, groundwater monitoring is designed to determine if groundwater protection standards have been exceeded. If the source of the contaminants is determined to be the treatment, storage, and disposal unit, and concentrations

exceed maximum contaminant levels defined in the monitoring plan or permit, then the Washington State Department of Ecology may require corrective action to reduce the contaminant hazards to the public and environment. Groundwater monitoring during the corrective action phase is designed to assess the effectiveness of the corrective action. Table 2.2.3 listed the phase pertaining to each of the Resource Conservation and Recovery Act groundwater monitoring projects at the end of 1997.

6.1.9.1 100 Areas Facilities

1301-N and 1325-N Liquid Waste Disposal Facilities.

The 1301-N facility was the primary liquid waste disposal site for N Reactor from 1963 until 1985. Discharges were primarily radioactive fission and activation products. Minor amounts of dangerous waste and other constituents may also have been discharged, including ammonium hydroxide, cadmium, diethylthiourea, lead, morpholine, phosphoric acid, and sodium dichromate. The 1301-N facility consists of a concrete basin with an unlined, zigzagging extension trench, covered with concrete panels.

The 1325-N facility was constructed in 1983 and also received effluent from N Reactor. In 1985, discharge to 1301-N ceased, and all effluent was sent to 1325-N. All discharge to 1325-N ceased in late 1991. The facility consists of a concrete basin with an unlined extension trench, covered with concrete panels.

The indicator parameters of specific conductance, pH, total organic carbon, and total organic halide measured in downgradient wells remained below the critical mean values at both facilities during 1997. Groundwater at these facilities is also analyzed for other constituents that were discharged to them, including cadmium, chromium, lead, nitrate, and phosphate. Cadmium, lead, and phosphate (in filtered samples) were not detected in groundwater at these facilities in significant concentrations. Nitrate was detected at levels greater than the EPA maximum contaminant level in 1997 but the sources are uncertain.

1324-N and 1324-NA Ponds. The 1324-N Pond was a treatment facility that was in service from May 1986 to November 1988. This facility is a double-lined pond that was used for neutralizing high and low pH waste from a demineralization plant. The 1324-NA Pond is unlined and was used for treating waste from August 1977 to May 1986 and for disposing of treated waste from May 1986 to August 1990. The effluent to both facilities

contained sulfuric acid and sodium hydroxide, and the pH was occasionally high or low enough to classify the effluent as a dangerous waste.

Specific conductance measured in 1997 in wells downgradient from these ponds was higher than the background critical mean value. The increase in this indicator parameter was expected because the 1324-NA Pond introduced nondangerous constituents (e.g., sodium, sulfate) to groundwater. Total organic carbon was detected above the background critical mean value in one downgradient well in 1997. This exceedance was part of an increasing trend and was confirmed by resampling in January 1998. As a result, a groundwater quality assessment was initiated in 1998. Downgradient measurements of pH and total organic halide were below critical mean values.

120-D-1 Ponds. The 120-D-1 Ponds were constructed in 1977 for disposal of nonradioactive effluent derived from operating facilities in the 100-D,DR Area. This facility is located in the former 188-D Ash Disposal Basin and includes settling and percolation ponds separated by a dike. Effluent to the ponds originated from two sources: the 183-D Filter Plant and the 189-D Building engineering testing laboratories. Some past discharges contained hydrochloric acid, sodium hydroxide, and sulfuric acid. Before 1986, the effluent may have had a >12.5 or <2.0 pH and, thus, may have been dangerous waste. There was also a potential for up to 2.3 kg (5 lb) of mercury to have been discharged to the ponds. Between 1986 and 1994, the effluent discharged to the ponds included chlorine and flocculating agents such as aluminum sulfate. Effluent discharge to the ponds ceased in 1994. Contaminated soils were removed from the ponds in 1996.

In 1997, specific conductance, pH, total organic carbon, and total organic halide in wells downgradient from the 120-D-1 Ponds continued to be below the background critical mean values. Mercury is the only listed waste that may have been discharged to these ponds but it was not detected in any of the downgradient monitoring wells in 1997. The site remains in indicator parameter monitoring.

183-H Solar Evaporation Basins. This facility, which is now remediated, consisted of four separate concrete basins surrounded by an earthen berm. Between 1973 and 1985, the basins were used to store liquid waste in the 100-H Area, primarily from nuclear fuel fabrication activities conducted in the 300 Area. Volume reduction occurred by solar evaporation. The waste was predominantly acid etch solution that had been neutralized with

sodium hydroxide before being discharged into the basins. The solutions included chromic, hydrofluoric, nitric, and sulfuric acids and also contained various metallic and radioactive constituents.

Groundwater in the vicinity of the 183-H Basins is characterized by elevated levels of chromium, nitrate, sodium, sulfate, technetium-99, and uranium. All of these constituents were present in waste discharged to the basins when they were in use. The Resource Conservation and Recovery Act groundwater monitoring plan for these basins (WHC-SD-EN-EV-027) identifies four contaminants of concern (waste indicators) for statistical evaluations under WAC 173-303-645(10): chromium, nitrate, technetium-99, and uranium. The concentrations of the waste indicators typically are highest immediately downgradient of the basins. Although the concentrations decreased several orders of magnitude in this area since the basins ceased operation, they remained above their respective drinking water standards for most of 1997.

In 1986, the Washington State Department of Ecology issued a compliance order that placed the 183-H Basins into interim-status assessment monitoring. The basins were incorporated into the Hanford Facility Resource Conservation and Recovery Act permit in September 1994 and became subject to final-status monitoring.

Results of the September through December 1996 and March through June 1997 sampling events indicated that concentration limits for chromium, nitrate, technetium-99, and uranium were exceeded in one or more downgradient wells and that concentrations continue to follow previously observed trends. The Washington State Department of Ecology was notified of the exceedances in 1996 and in May 1997, a corrective action groundwater monitoring plan was released. The monitoring plan was implemented in early 1998 after the 183-H corrective action plan was incorporated into a revision of the Hanford Facility Resource Conservation and Recovery Act permit. The new monitoring plan takes into account the effects of a pump-and-treat system that began operation in 1997.

6.1.9.2 200 Areas Single-Shell Tank Farms

Single-shell tanks are located in the A, AX, B, BX, BY, C, S, SX, T, TX, TY, and U Tank Farms, which have been designated as part of Resource Conservation and Recovery Act Waste Management Areas A-AX, B-BX-BY, C,

S-SX, T, TX-TY, and U, respectively. Waste Management Areas A-AX, B-BX-BY, and C are located in the 200-East Area; Waste Management Areas S-SX, T, TX-TY, and U are in the 200-West Area. Each waste management area includes tanks and associated ancillary systems (e.g., pipelines). The single-shell tanks store a mixture of dangerous chemical and radioactive wastes generated by reprocessing fuel irradiated in Hanford Site reactors. The single-shell tanks received mixtures of organic and inorganic liquids containing radionuclides, solvents, and metals that were originally discharged to the tanks as alkaline slurries. Subsequent waste management operations have combined waste streams from different processes. In many tanks, wastes have been concentrated by removing water vapor.

Waste Management Area A-AX. Critical mean values of the indicator parameters specific conductance, pH, total organic carbon, and total organic halide were not exceeded during 1997. Iodine-129 showed concentration values above the 1-pCi/L interim drinking water standard in the monitoring wells because of a plume extending through this area from other sources. Tritium levels, though considerably less than the drinking water standard, have been historically greater in one upgradient well versus downgradient wells at Waste Management Area A-AX. Chromium and nickel exceedances continue to be observed in one of the network wells.

In one downgradient well, the technetium-99 concentration rose sharply in February 1997, reached a maximum of 374 pCi/L in August 1997, and then dropped to 112 pCi/L in December 1997. The increase in technetium-99 concentration may be associated with a rise in the nitrate concentration that began in 1994. The nitrate concentration peaked at approximately 13 mg/L in February 1997, then fell with the technetium-99 concentration between August and December 1997. These concentrations are below their respective drinking water standards.

Waste Management Area B-BX-BY. A Phase I groundwater quality assessment was conducted between June 1996 and August 1997 after elevated specific conductance was observed in a downgradient well (PNNL-11826, WHC-SD-EN-AP-002). The indicator parameter specific conductance has been increasing in downgradient wells since monitoring began in 1990 and exceeded the critical mean value in several wells in 1997. The rise in specific conductance appears to be related to an increase in chloride, nitrate, sodium, and sulfate. Several other downgradient wells have displayed trends of increasing

chloride and nitrate with corresponding increases in specific conductance since 1992. Also, specific conductance periodically fluctuates above and below the critical mean value. There were no exceedances of critical means for the indicator parameters pH, total organic carbon, or total organic halide during 1997.

Technetium-99 is a long-lived, mobile fission product that was first identified in an old well inside the S Tank Farm in 1985. The concentrations in this well showed an upward trend and exceeded the interim drinking water standard, reaching a maximum of 1,500 pCi/L in 1997. Since 1986, concentration transients of 1 to 2 years in duration have occurred in 4 other wells within the boundary of Waste Management Area S-SX. The most recent transient occurred in the southeastern corner of the SX Tank Farm, where the peak concentration was 5,000 pCi/L in 1997. Chromium reached a maximum of 39 µg/L in the southeastern corner of the SX Tank Farm. Cesium-137 was not detected in any of the Resource Conservation and Recovery Act wells monitoring Waste Management Area S-SX in 1997.

Technetium-99 concentrations continued to rise in several of the monitoring wells in 1997. In one well (299-E33-41) technetium-99 levels increased sharply in February 1997 and again in August 1997. Results of the Phase I groundwater quality assessment in PNNL-11826 showed that Waste Management Area B-BX-BY was a likely source of the high technetium-99 concentrations observed. A sharp uranium spike of 81 mg/L measured in one monitoring well in November 1997 will be investigated during the Phase II assessment, planned for 1998 to further investigate the rate of groundwater movement and the source(s), nature, and extent of groundwater contamination attributed to Waste Management Area B-BX-BY.

Waste Management Area C. Critical mean values of the indicator parameters specific conductance, pH, total organic carbon, and total organic halide were not exceeded during 1997. Iodine-129 showed concentrations above the 1-pCi/L drinking water standard in the monitoring wells because of a plume extending through this area from other sources.

Waste Management Area S-SX. A groundwater quality assessment program was initiated in 1996 in response to a directive from the Washington State Department of Ecology. This directive cited anomalous trends in technetium-99 and elevated specific conductance in groundwater. In response to the directive, a groundwater quality assessment plan (WHC-SD-EN-AP-191) was prepared

and submitted to the Washington State Department of Ecology. The first phase of this assessment was conducted in 1996 and 1997. The findings of the first phase assessment showed that the S and SX Tank Farms contributed to groundwater contamination (PNNL-11810). However, multiple source locations are needed to explain the data. A second phase assessment will be conducted to determine the nature, extent, and source(s) of groundwater contamination attributed to Waste Management Area S-SX.

Waste Management Areas T and TX-TY. In November 1992, the critical mean for specific conductance was exceeded in downgradient wells 299-10-15 (at Waste Management Area T) and 299-W10-17 and 299-W14-12 (at Waste Management Area TX-TY). Verification sampling placed these waste management areas into the groundwater quality assessment phase of monitoring. Quarterly sampling along with historic trends and waste management data identified calcium, chloride, magnesium, and nitrate as the primary constituents contributing to the elevated specific conductance. Elevated nitrate is widespread in the groundwater in the northern part of the 200-West Area (see Figure 6.1.34) because of the discharge of large amounts of nitrate bearing chemicals to nearby trenches and cribs in the mid-1950s.

A number of other constituents exceeded regulatory limits in the vicinity of these waste management areas. These included carbon tetrachloride, filtered chromium, filtered iron, fluoride, iodine-129, nickel, technetium-99, and tritium. Some of these contaminants follow the same historical trend as nitrate, indicating a source more extensive than the tank farms. At Waste Management Area T, well 299-W11-27 showed large increases in several chemical species in late 1995 and 1996, including specific chromium, cobalt-60, nitrate, conductance, technetium-99, and tritium. In 1997, levels of these chemical species decreased slightly. Based on an assessment study in 1993 to 1997, contaminants in well 299-W11-27 are most likely the result of sources within the T Tank Farm (PNNL-11809). Therefore, a second phase of assessment, which is being planned in 1998, will be performed. Well 299-W11-27 is going dry as the water table continues to decline and is planned to be replaced by a new monitoring well. The assessment study also showed that contaminants in well 299-W10-15 are a result of sources external to the T Tank Farm. Wells 299-W10-15 and 299-W11-27 are located north and northeast, respectively, of Waste Management Area T.

At Waste Management Area TX-TY, well 299-W14-12 showed elevated concentrations of cobalt-60, iodine-129, technetium-99, and tritium. Based on an assessment study in 1993 to 1997, these contaminants are consistent with a source within the TX-TY Tank Farm (PNNL-11809); therefore, a second phase of assessment will be conducted. However, upgradient sources may also be contributing to the contamination. The assessment study also indicated that contaminants in well 299-W10-17 are a result of sources external to the TX-TY Tank Farm. Wells 299-W14-12 and 299-W10-17 are located north and east, respectively, of Waste Management Area TX-TY.

Waste Management Area U. This waste management area, located southeast of the Plutonium Finishing Plant in the south-central part of the 200-West Area, is currently under a detection-level monitoring program. There was a general increase in total organic halide concentrations across Waste Management Area U, resulting in several critical mean exceedances for this contamination indicator parameter. The exceedances are a result of a carbon tetrachloride plume that originated in the area of the Plutonium Finishing Plant and are not related to the U Tank Farm (Section 5.9.3.4 in PNNL-11793).

6.1.9.3 200 Areas Liquid Effluent Disposal Facilities

216-A-10, 216-A-36B, and 216-A-37-1 Cribs. These deactivated cribs in the 200-East Area received liquid waste from the Plutonium-Uranium Extraction Plant. The waste stream at the 216-A-10 Crib was characteristically acidic and contained concentrated salts, hydrocarbon compounds, organic complexants, plutonium, uranium, and other radionuclides. The 216-A-36B Crib received ammonia scrubber distillate from nuclear fuel decladding operations, in which zirconium cladding was removed from irradiated fuel by boiling in a solution of ammonium fluoride and ammonium nitrate. Other waste stream constituents included cobalt-60, strontium-90, ruthenium-106, iodine-129, cesium-137, tritium, and uranium. The 216-A-37-1 Crib received process condensate from the 242-A Evaporator. The process condensate contained radionuclides, spent halogenated and nonhalogenated solvents, and ammonia. The radionuclides included cobalt-60, strontium-90, ruthenium-106, cesium-137, plutonium, and uranium.

The 216-A-10 and 216-A-36B Cribs were in indicator parameter evaluation status through the end of June 1997.

Beginning in July 1997, these cribs and the 216-A-37-1 Crib were combined into one groundwater quality assessment program (PNNL-11523). Prior to July, the 216-A-37-1 Crib was monitored under the operational monitoring program. Groundwater monitoring changed from indicator parameter evaluation status to groundwater quality assessment because of known groundwater contamination and the high probability that a new indicator parameters program for the cribs would show that critical means are exceeded. Constituents, including strontium-90, iodine-129, nitrate, and tritium are detected at levels that exceed their respective drinking water standards. However, the source of these groundwater contaminants is uncertain because they are present within large plumes in this area.

216-A-29 Ditch. This is a deactivated earthen ditch approximately 2 km (1.2 mi) long that conveyed Plutonium-Uranium Extraction Plant chemical waste to the 216-B-3 Pond from 1955 to 1986. The ditch received effluents that contained dangerous chemical and radioactive contaminants. Of primary concern for Resource Conservation and Recovery Act regulations were discharges of sodium hydroxide and sulfuric acid, which occurred daily as a result of ion exchange regeneration at the Plutonium-Uranium Extraction Plant.

In 1990, specific conductance increased beyond the critical mean, and an assessment monitoring program was initiated. The assessment program confirmed that the ditch was the likely source of the elevated specific conductance. However, the constituents contributing to the high conductance were determined to be calcium, sodium, and sulfate, which are nonregulated substances. The groundwater monitoring program subsequently reverted to the indicator parameter monitoring phase, and specific conductance declined steadily in both upgradient and downgradient wells at the site. However, in 1997, specific conductance increased in nearly all network wells. During the fourth quarter of 1997, total organic carbon exceeded the critical mean in one downgradient well. However, this exceedance was not consistent with the total organic carbon trend observed in this well. Resampling in early 1998 confirmed that the exceedance was an error.

216-B-3 Pond. The former 216-B-3 Pond (B Pond) was located immediately east of the 200-East Area and consisted of a main pond and three expansion ponds (216-B-3A, 216B-3B, and 216-B-3C). The main pond began operating in 1945 and the expansions were built in the 1980s. In 1994, the main pond ceased operating and

the waste streams were rerouted to the 216-B-3C Expansion Pond and the 200 Areas Treated Effluent Disposal Facility. In August 1997, waste streams received by the expansion pond were diverted to the 200 Areas Treated Effluent Disposal Facility, thus ending operation of the B Pond system. In the past, B Pond received liquid waste from B Plant and the Plutonium-Uranium Extraction Plant, consisting of chemical sewer waste, cooling water, and steam condensate. These waste streams contained aluminum nitrate, nitric acid, potassium hydroxide, sulfuric acid, tritium, and other acids. More recently, B Pond received nondangerous, nonradioactive effluent primarily from the Plutonium-Uranium Extraction Plant and B Plant.

In 1990, groundwater monitoring at the B Pond system was changed to assessment level because of elevated total organic carbon and total organic halide concentrations in downgradient wells 699-43-41E and 699-43-41F. In 1997, the assessment findings indicated that these elevated levels were isolated and were not attributed to groundwater contamination by hazardous waste (PNNL-11604). Thus, the assessment program was discontinued in October 1997, and a detection-level program was restored.

The only contaminants consistently detected in groundwater that could be attributed to B Pond operations were nitrate and tritium; however, these constituents have shown downward trends since monitoring began at B Pond.

216-B-63 Trench. This trench, in the north-central part of the 200-East Area, received liquid effluent from the B Plant chemical sewer from March 1970 to February 1992. The liquid effluent consisted of a mixture of steam condensate and water. Past releases to the trench also included aqueous sulfuric acid and sodium hydroxide solutions. Radioactive soils were dredged from the trench in August 1970 but no records exist of radioactive waste disposal to the trench.

Groundwater monitoring continues to show no evidence that dangerous nonradioactive constituents from the site entered the groundwater from this trench. There were no exceedances in the indicator parameters pH, specific conductance, total organic carbon, or total organic halide in 1997.

216-U-12 Crib. This crib, south of U Plant in the 200-West Area, received wastewater containing both dangerous chemical wastes and radionuclides from April 1960 until February 1988. This facility has been in the groundwater quality assessment phase of monitoring

since 1993. Site-specific waste indicators include technetium-99, iodine-129, gross alpha, gross beta, nitrate, and tritium. Technetium-99, iodine-129, nitrate, and tritium are detected repeatedly in groundwater. The findings of the first two phases of the assessment monitoring program indicate that the 216-U-12 Crib is a source of nitrate and technetium-99 detected in the downgradient wells (PNNL-11574). Because of these findings, the crib must continue in groundwater quality assessment monitoring. The sources of the iodine-129 and tritium are upgradient locations near the Reduction-Oxidation Plant. Of the waste indicator parameters specific conductance, total organic halide, total organic carbon, pH, gross alpha, and gross beta monitored at the crib, only specific conductance exceeded the 458-mS/cm critical mean in the downgradient wells in 1997. Nitrate is the only constituent with consistently elevated concentrations in the downgradient wells and is the most significant contributor to the elevated specific conductance.

216-S-10 Pond and Ditch. This former facility was located south-southwest of the 200-West Area, directly outside the perimeter fence. The facility consisted of an open, unlined ditch approximately 686 m (750 yd) long and an open, unlined percolation pond approximately 2.0 ha (4.9 acres) in size at the southwestern end of the ditch. The pond and ditch received radioactive and dangerous chemical waste from the Reduction-Oxidation Plant from 1951 until 1985, when the pond and the lower part of the ditch were decommissioned and backfilled. The upper part of the ditch continued to receive nondangerous unregulated wastewater after 1985.

The indicator parameters for this facility are specific conductance, pH, total organic carbon, and total organic halide. All indicator parameters were below their respective critical mean values in 1997.

6.1.9.4 200 Areas Low-Level Burial Grounds

All low-level waste management areas at the Hanford Site are in the indicator parameter phase of Resource Conservation and Recovery Act groundwater monitoring. A number of burial grounds are included within each low-level waste management area (see Figure 5.1.12).

Low-Level Waste Management Area-1. This waste management area consists of the 218-E-10 Burial Ground in the northwestern corner of the 200-East Area. Disposal activities began in 1960 and continue today. Materials

placed in this facility are primarily failed equipment and mixed industrial waste from the Plutonium-Uranium Extraction Plant, B Plant, and N Reactor.

Critical means for the contamination indicator parameters established for this area were not exceeded during 1997. Although there is no evidence of any contaminant contribution from this area, contaminant plumes from other sources affect groundwater quality.

Low-Level Waste Management Area-2. This waste management area is located in the northeastern corner of the 200-East Area and includes all of the 218-E-12B Burial Ground, which has been in use since 1968. The waste consists primarily of miscellaneous dry waste and submarine reactor compartments. Parts of two trenches contain transuranic waste.

In 1997, specific conductance was the only contamination indicator parameter that exceeded the critical mean established for this area. This exceedance was primarily the result of an increase in sulfate, which is not a regulated constituent in groundwater. Because the increase occurred in an upgradient well, assessment monitoring will not be required. Values for iodine-129 were above the 1-pCi/L interim drinking water standard in several wells along the southern boundary of this area. However, this is related to the widespread iodine-129 plume beneath the 200-East Area, and there is no evidence of groundwater contamination from this waste management area.

Low-Level Waste Management Area-3. The 218-W-3A, 218-W-3AE, and 218-W-5 burial grounds make up this area in the north-central portion of the 200-West Area. These facilities cover 74.3 ha (181.4 acres). The 218-W-3A Burial Ground began accepting waste in 1970 and received primarily ion exchange resins and failed equipment (e.g., tanks, pumps, ovens, agitators, heaters, hoods, vehicles, accessories). The 218-W-3AE Burial Ground began operation in 1981 and contains low-level and mixed waste, including rags, paper, rubber gloves, tools, and industrial waste. The 218-W-5 Burial Ground first received waste in 1986, and contains low-level and low-level-mixed waste, including lead bricks and shielding.

Carbon tetrachloride and nitrate are consistently above their respective drinking water standards of 5 µg/L and 45 mg/L in monitoring wells in this waste management area. However, the elevated values can be attributed to contaminant plumes originating to the south of the area. There appears to be no groundwater contamination directly attributable to this waste management area, and

there were no exceedances of the critical mean values for indicator parameters in 1997.

Low-Level Waste Management Area-4. This area consists of the 218-W-4B and 218-W-4C Burial Grounds, which cover 24.4 ha (60 acres) in the south-central portion of the 200-West Area. The 218-W-4B Burial Ground first received waste in 1968 and contains mixed and retrievable transuranic waste in trenches and 12 caissons. One caisson is believed to contain mixed waste. Wastes were first deposited in the 218-W-4C Burial Ground in 1978 and were classified as transuranic, mixed, or low-level and included contaminated soil, decommissioned equipment, and remote-handled transuranic waste.

There appears to be no groundwater contamination directly attributable to this waste management area. Samples from downgradient wells did not exceed the critical means established for indicator parameters in 1997. Concentrations of carbon tetrachloride above the 5- $\mu\text{g/L}$ drinking water standard were found in most wells in 1997. However, the source of the carbon tetrachloride is past disposal of liquid waste near the Plutonium Finishing Plant. Nitrate also exceeded the 45-mg/L drinking water standard in several wells. The source of the contamination is the nitrate plume emanating from the vicinity of the Plutonium Finishing Plant.

Low-Level Waste Management Area-5. Located in the northern part of the 200-West Area, this waste management area was eliminated from further groundwater monitoring because no waste has been disposed to this facility and there are no plans for its use.

6.1.9.5 200 Areas Liquid Effluent Retention Facility

This facility consists of three lined surface impoundments (basins) located east of the 200-East Area and serves as temporary storage for condensate from the 242-A Evaporator. Constituents detected in the effluent stream from the 242-A Evaporator were acetone, aluminum, ammonium, 1-butanol, 2-butanone, strontium-90, ruthenium-106, cesium-137, and tritium.

Groundwater monitoring at this facility is in the indicator parameter monitoring phase. The indicator parameters are specific conductance, pH, total organic carbon, and total organic halide. There were no exceedances of the critical mean values for these parameters, which indicates that no dangerous nonradioactive constituents have been released by the facility to groundwater.

6.1.9.6 300 Area Process Trenches

The site of the 316-5 Process Trenches in the northern part of the 300 Area was under groundwater quality assessment between June 1995 and December 1996. Since December 1996, the process trenches have been under final-status compliance monitoring. These two unlined trenches were used for the disposal of most liquid wastes generated in the 300 Area beginning in 1975 and received uranium and other radioactive and chemical constituents. Uranium concentrations were higher than the 20- $\mu\text{g/L}$ proposed drinking water standard at several wells near this facility in 1997.

One downgradient well showed concentrations that exceeded the required limits of 70 mg/L and 5 mg/L for cis-1,2-dichloroethylene and trichloroethylene, respectively. In 1997, these exceedances were confirmed by additional sampling. As required, the groundwater monitoring plan (WHC-SD-EN-AP-185) was modified for corrective action, which is scheduled for late 1998 after the permit modification becomes effective.

6.1.9.7 Nonradioactive Dangerous Waste Landfill

The former Nonradioactive Dangerous Waste Landfill (Central Landfill) in the 600 Area southeast of the 200-East Area is in the indicator parameter phase of groundwater monitoring. None of the indicator parameters specific conductance, pH, total organic carbon, or total organic halide exceeded critical mean values during 1997. Chlorinated hydrocarbons were detected in a few wells at concentrations below their respective drinking water standards.