2.3 100-KR-4 Operable Unit

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The 100-KR-4 Operable Unit includes groundwater affected by contaminant releases from facilities and waste sites within the 100-K Area. Most of the facilities and waste sites are associated with former operation of the KE and KW Reactors and their support facilities. The operable unit lies within a larger 100-KR-4 groundwater interest area, informally defined to facilitate scheduling, data review, and interpretation (Figure 1.0-1). Figure 2.3-1 shows facilities, monitoring wells, shoreline monitoring sites, and waste sites.

Groundwater beneath the 100-K Area generally flows toward the northwest to the Columbia River (Figure 2.3-2). Groundwater flow in 100-K Area is affected by two pump-and-treatment systems. The larger system has extraction wells between the 116-K-2 Trench and the Columbia River and injection wells upgradient of the trench. A water-table mound has formed, causing a radial flow pattern to develop around the injection sites. The mound (Figure 2.3-2) was estimated using an analytical method that considered injection rates, transmissivity, and specific yield, as documented in PNNL-14031, *Evaluation of Potential Sources for Tritium Detected in Groundwater at Well 199-K-111A, 100-K Area*. A second pump-and-treat system is located downgradient of the KW Reactor building. Treated water is injected into wells south (upgradient) of the reactor building.

Hexavalent chromium is the principal contaminant of concern in 100-K Area groundwater. Two pump-and-treat systems are cleaning up the aquifer.

An upward hydraulic gradient exists in the 100-K Area near the Columbia River, based on data from wells 199-K-32A and 199-K-32B. Well 199-K-32B is completed ~31 m deeper than well 199-K-32A. The upward gradient in March 2008 was 0.09, and in July 2008 was 0.08.

Some of the main concepts associated with the 100-KR-4 Operable Unit include the following.

- Principal sources of groundwater contamination included former liquid waste disposal facilities (trenches, cribs, fuel retention basins). These facilities are inactive, but contamination remains in the vadose zone.
- Contaminated shielding water was removed from KE Basin, which had leaked in the past, and the basin was filled with a sand-grout mixture. The KW Basin remains water-filled, but there is no evidence that it has leaked.
- Hexavalent chromium is the principal contaminant of concern in groundwater. The contamination is distributed in three plumes. Two of them are being remediated by pump-and-treat systems.
- The pump-and-treat systems removed 33.2 kg of chromium in fiscal year (FY) 2008, and 361 kg since 1997. Concentrations in groundwater remained above the remedial action goal of 22 μg/L in some wells. The U.S. Department of Energy (DOE) is expanding the pump-and-treat systems to improve their effectiveness.
- The largest chromium plume in 100-K Area is shrinking and concentrations are decreasing overall.
- Carbon-14, nitrate, strontium-90, and tritium contamination also is present in groundwater at concentrations above drinking water standards.

- Twenty-seven new wells were installed in FY 2008. Two of these detected higher levels of tritium contamination than previously recorded.
- All but one of the monitoring wells are screened at the top of the unconfined aquifer, which is ~27 m thick in the 100-K Area. One well is screened ~34 m below the water table in the Ringold upper mud unit, and it does not detect any contamination.

The following sections provide details about the operable unit activities. Groundwater monitoring in the 100-K Area is conducted under two regulatory drivers: the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) governs the 100-KR-4 Operable Unit, while the *Atomic Energy Act of 1954* provides the basis for monitoring the fuel storage basins at each reactor building (i.e., KE and KW Basins). CERCLA requirements are further subdivided into monitoring conducted to characterize and track contaminants of concern or potential concern in the operable unit, and evaluate the performance of the pump-and-treat systems that remove hexavalent chromium from groundwater. There are no *Resource Conservation and Recovery Act of 1976* sites requiring groundwater monitoring in the 100-K Area.

2.3.1 Groundwater Contaminants

Wells in the 100-KR-4 Operable Unit are sampled for constituents of concern provided in EPA/ROD/R10-96/134, *Declaration of the Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units*. Hexavalent chromium has been identified as a contaminant of concern that warrants interim remedial action. This contaminant is of potential concern to salmon and other aquatic life. Other constituents of interest in the operable unit include tritium, carbon-14, strontium-90, nitrate, and trichloroethene. These constituents are being monitored during waste sites remediation and facility decontamination and decommissioning.

Plume areas (square kilometers) in the 100-KR-4 Operable Unit:
Carbon-14, 2,000 pCi/L — 0.09
Chromium, 100 µg/L — 0.14
Chromium, 20 µg/L — 2.02
Nitrate, 45 mg/L — 0.11
Strontium-90, 8 pCi/L — 0.07
Trichloroethene, 5 µg/L — 0.02
Tritium, 20,000 pCi/L — 0.24

The following descriptions of contaminants in the 100-K Area groundwater refer to conditions at wells that monitor the uppermost part of the unconfined aquifer. The 100-K Area contains only one well (199-K-32B) that is completed to monitor conditions below the upper aquifer; groundwater at this well is essentially free of contamination from past operations.

2.3.1.1 Chromium

Sodium dichromate was used in large quantities as a corrosion inhibitor at the KE and KW Reactors during their years of operation (1955 through 1971). The hexavalent form of chromium is soluble in water and is toxic to aquatic organisms and humans. The Washington State aquatic standard for hexavalent chromium is 10 µg/L, and the drinking water standard for total chromium is 100 µg/L. Chromium is a contaminant of concern for the 100-KR-4 Operable Unit interim action (EPA/ROD/R10-96/134) with a cleanup goal of 22 µg/L.

Figure 2.3-3 illustrates the extent of chromium contamination beneath the 100-K Area in FY 2008. The largest area of contamination is associated with the 116-K-2 Trench. A smaller plume with higher concentrations is downgradient of the KW Reactor building. Three wells near the KE Reactor building also have elevated chromium.

Chromium concentrations are elevated in some of the 100-K Area aquifer tubes. Figure 2.3-4 shows cross sections parallel to the river shore, with chromium concentrations at various depths in the aquifer tubes. Chromium concentrations in near-river monitoring wells are projected onto the cross section. At some tube sites, the chromium concentration is highest in the deepest tube (AT-K-3, AT-26). At other locations, the shallow or mid-depth tube has higher concentrations (AT-K-1, AT-K-5, and AT-K-6).

Chromium near KW Reactor. Chromium concentrations in a plume originating near KW Reactor exceed the drinking water standard in several wells (Figure 2.3-3). In early FY 2008, concentrations exceeded 3,000 µg/L in well 199-K-137, located south of the reactor building. Concentrations declined later in the year (Figure 2.3-5). The suspected source for this contamination is sodium dichromate in the vadose zone at unidentified locations. Candidate locations include the storage tank and transfer station at the southeastern side of the 183-KW Water Treatment Plant, and the underground piping used to add sodium dichromate to coolant water during operations. Chromium concentrations in well 199-K-107A were ~500 µg/L, but declined to 150 µg/L by the end of FY 2008 (Figure 2.3-5). Concentrations in three of the four extraction wells in the KW plume also were above the drinking water standard after well installation, but declined during FY 2007 and leveled off in FY 2008 (Figure 2.3-6). Currently well 199-K-139 is the only KW extraction well with concentrations above the drinking water standard. Excluding erroneous data, chromium concentrations in aquifer tubes downgradient of the KW plume typically are low (less than 10 µg/L).

Chromium concentrations in a well south of KW Reactor building exceeded 3,000 µg/L, but declined in FY 2008.

Chromium near KE Reactor. Three wells near the KE Reactor have chromium concentrations above background levels, while other wells have concentrations near detection limits. Well 199-K-36, near a former water treatment plant upgradient of the KE Reactor, had chromium concentrations exceeding 1,000 µg/L as recently as FY 2001. In FY 2008, concentrations ranged from 13 to 43 µg/L. Well 199-K-23, west of the KE Reactor building, had a concentration of 30 µg/L in FY 2008. Nearby wells had lower concentrations.

Well 199-K-141, downgradient of the KE Reactor, had chromium levels above the drinking water standard, with a maximum concentration of 400 µg/L. Chromium and specific conductance levels dropped abruptly in July 2008 (Figure 2.3-7). Nearby well 199-K-142 had chromium concentrations of less than 20 µg/L and low specific conductance since it was first sampled in FY 2007. The low specific conductance suggests the possibility of an unknown source of fresh water diluting groundwater near the wells.

The chromium contamination in well 199-K-141 does not appear to be connected to contamination in wells 199-K-36 and 199-K-23, because wells located between these locations have very low chromium levels. Well 199-K-32A, located farther downgradient of the KE Reactor, had low levels of chromium in FY 2008 (~11 µg/L filtered). Chromium usually is not detected at aquifer tube sites AT-18 and AT-K-2.

Data from new wells along the 116-K-2 Trench helped define the chromium plume map. The pump-and-treat system in this region is being expanded.

Chromium Beneath the 116-K-2 Trench. The plume originating at the 116-K-2 Trench is the largest in the area, but has relatively low concentrations (less than 200 µg/L; Figure 2.3-3). This trench received large volumes of reactor coolant water from 1955 to 1971. The trench plume is the target of interim remedial action, which was expanded in FY 2008 (Section 2.3.2). Groundwater extraction and injection have split the plume into two portions, with an area of clean groundwater near the middle of the trench.

Data from recently installed extraction and monitoring wells helped refine the plume map in FY 2008. Most of the new wells had chromium concentrations between 20 and 90 µg/L. Data from new wells 199-K-154 and 199-K-163 (east of the trench), show that an area of the plume with concentrations greater than 100 µg/L is larger than previously known. Chromium contamination east of the trench was pushed inland by radial flow around the large groundwater mound present during the operating years (HW-77170, *Status of the Ground Water Beneath Hanford Reactor Areas, January, 1962 to January, 1963*). The northern edge of the plume is delimited by new wells 199-K-159 and 199-K-160, which will be used for injection of treated water from the 100-KR-4 Pump-And-Treat System. They are located at the southern end of the 100-N Area. Chromium concentrations were less than 10 µg/L.

Chromium concentrations in wells between the 116-K-2 Trench and the river are typically less than the drinking water standard and appear to be stable or decreasing, with exceptions at several locations. The overall decrease in the level of contamination is a combined consequence of the pump-and-treat operation and dispersion. Figures 2.3-8 through 2.3-10 illustrate concentration trends for southwestern, central, and northeastern groups of wells, respectively.

At the southwestern edge of the plume, well 199-K-18 presents an exception to the generally decreasing trends. Concentrations have been increasing, with a maximum FY 2008 value of 168 µg/L (Figure 2.3-8). The start of the increasing trend at this location correlates with the start of the pump-and-treat system in October 1997, indicating a relationship to the changes in groundwater flow patterns because of groundwater extraction and injection. Chromium concentrations also are relatively high at nearby aquifer tube site AT-K-3 (81 µg/L in the deep tube in FY 2008).

In the central portion of the plume, chromium levels have declined by an order of magnitude in extraction well 199-K-125A and in well 199-K-117A (Figure 2.3-9). Levels remained above the drinking water standard in well 199-K-22 (near the trench) and fluctuated seasonally in extraction well 199-K-114A (near the river). Aquifer tubes monitoring the central portion of the trench show decreasing chromium trends. The decline may be a result of the effects of the pump-and-treat system (Section 2.3.2.2).

At the northeastern end of the trench, chromium concentrations are declining in monitoring wells (Figure 2.3-10). However, aquifer tube AT-26 has had increasing chromium concentrations since FY 2002, with a maximum of 64 µg/L in November 2007. Levels decreased in May and August 2008 (Figure 2.3-11). The overall increase may indicate northward migration of the plume.

2.3.1.2 Tritium

Tritium was common in liquid effluent discharged to the ground during 100-K Reactor operations. However, some of the tritium currently observed in groundwater was introduced after the shutdown of the reactors in 1971. Current sources and potential sources for providing tritium to groundwater include loss of shielding water from the KE and KW Basins, the soil columns beneath the former gas condensate cribs located to the east of each reactor building, and possibly irradiated materials contained in the 118-K-1 Burial Ground. The drinking water standard for tritium is 20,000 pCi/L.

Tritium forms three plumes in the 100-K Area.

Figure 2.3-12 shows the distribution of tritium in groundwater beneath the 100-K Area. Few wells had average concentrations above the drinking water standard in FY 2008. Some of the highest tritium concentrations are immediately downgradient of the 116-KE-1 and 116-KW-1 Cribs. During operating years, the cribs received liquid effluent containing high concentrations of tritium and carbon-14. These waste sites were excavated and backfilled with clean material during FY 2004. Some contaminated soil remained at the bottom of the excavations.

Because high concentrations of tritium are present in the shielding water of each fuel storage basin, groundwater is monitored for evidence of shielding water loss to the ground (PNNL-14033, *Groundwater Monitoring and Assessment Plan for the 100-K Area Fuel Storage Basins*). Also, tritium from materials in the 100-K Burial Ground may be impacting groundwater in the area north of the burial ground.

Tritium near KW Reactor. The plume near the KW Reactor is most likely associated with effluent disposed during the operating years to the former 116-KW-1 Condensate Crib. In FY 2008, the highest concentration was 210,000 pCi/L in well 199-K-106A, located downgradient of the crib. This was the only KW well in which the tritium concentration exceeded the drinking water standard. An unexplained increase in tritium concentrations at well 199-K-106A began in 2001, peaked sharply in 2003 and early 2005, and subsequently declined (Figure 2.3-13). Other constituents showing a similar trend include specific conductance, anions (including nitrate), and technetium-99. Carbon-14, which was disposed to the crib but is less mobile than tritium, does not follow the tritium trend. The cause for the trend at well 199-K-106A is presumed to be mobilization of contaminants associated with the crib and underlying soil column, although a driving mechanism has not been identified.

There is no evidence in groundwater monitoring data to suggest water loss to the ground from the KW Basin in recent years. Wells 199-K-34 and 199-K-107A are most likely to detect shielding water. The maximum FY 2008 tritium concentrations were 2,800 pCi/L in well 199-K-34 and 910 pCi/L in well 199-K-107A.

Aquifer tubes downgradient of the KW Reactor have low tritium concentrations, ranging from below detection limits to 640 pCi/L in FY 2008.

Tritium near KE Reactor. The KE tritium plume was formed from past disposal to the former 116-KE-1 Condensate Crib, leaks to the ground from KE Basin (1976 to 1979, and again in 1993), and possibly mobilization of contamination from the vadose zone beneath the 116-KE-3 Drain Field and associated catch tank. The tritium distribution pattern reflects a coalescing of plumes from these sources.

Only one well near the reactor building had tritium concentrations above the drinking water standard in FY 2008. Figure 2.3-14 shows concentration trends for tritium and co-contaminant carbon-14 at well 199-K-30. Tritium concentrations in FY 2008 ranged from 88,600 to 410,000 pCi/L, about the same as the previous five years.

The leading edge of the tritium plume created by the 1993 leak from the KE Basin is believed to have reached the Columbia River. In 1994, concentrations peaked in well 199-K-27, near the basins (Figure 2.3-15). Concentrations in well 199-K-32A, located 280 m downgradient, peaked in 2001 at a much lower level. The estimated groundwater velocity based on movement of the tritium peak is 40 m/year. At this velocity, the 1994 tritium peak would have been expected to reach the river (540 m from well 199-K-27) in FY 2008. However, aquifer tube sites AT-18, T-K-2, and SK-068 continued to show only low levels of tritium (hundreds of picocuries per liter) in FY 2008.

The highest tritium concentrations were in two new wells installed near the southern end of the 116-K-2 Trench. The concentrations in the new wells were about ten times higher than in nearby wells.

Increases in tritium concentrations in well 199-K-27 and other wells near KE Reactor that started in early 2003 (Figure 2.3-15) remain unexplained. There was no evidence from facility operations suggesting a significant loss of shielding water. The 2003 tritium peak in well 199-K-27 has not reached downgradient well 199-K-32A. Well 199-K-27 and nearby well 199-K-109A were decommissioned in FY 2008.

Tritium near the 118-K-1 Burial Ground and 116-K-2 Trench. A third region of tritium at levels above the drinking water standard is near the southern end of the 116-K-2 Trench, downgradient of the 118-K-1 Burial Ground (Figure 2.3-12). At the northwestern corner of the burial ground, tritium concentrations at well 199-K-111A began rising abruptly in mid-2000 to a peak value of 98,200 pCi/L in April 2002. Since that time, concentrations declined to a level of less than 10,000 pCi/L. The source for tritium in groundwater near the burial ground was the subject of a multifaceted investigation during 2002 and 2003 (PNNL-14031). Results suggested the likelihood of a tritium source in the burial ground, along with an underlying groundwater plume.

Several wells at the southern end of the 116-K-2 Trench had tritium concentrations above the drinking water standard in FY 2008. The plume, as previously defined, had concentrations between 20,000 and 40,000 pCi/L. However, two new wells in this region had much higher levels in FY 2008.

- Well 199-K-144 had a tritium concentration of 286,000 pCi/L in April 2008. The sample was reanalyzed and the result was confirmed. A sample from early FY 2009 had a tritium concentration of 200,000 pCi/L.
- Well 199-K-157 was sampled three times in FY 2008, and tritium concentrations varied: 621,000 pCi/L in May; 21,000 pCi/L in July; and 620,000 pCi/L in September.

The tritium source for the wells is uncertain; it may represent past disposal to the 116-KE-1 Crib or 116-K-2 Trench, or tritium from a source farther inland, such as the 118-K-1 Burial Ground.

2.3.1.3 Carbon-14

Condensate from gas circulated through the KE and KW Reactors contained carbon-14 (along with tritium) and was discharged to infiltration cribs at the east side of each reactor building. Release of carbon-14 from the cribs, which were excavated and backfilled during FY 2004, is the source for the carbon-14 plumes near each reactor. The drinking water standard (2,000 pCi/L) continued to be exceeded during FY 2008 at several wells that monitor these plumes. The half-life for carbon-14 is 5,730 years. This radionuclide exchanges with carbon in carbonate minerals, so its movement is more restricted and variable than a nonexchanging constituent like tritium.

Carbon-14 forms two small plumes with sources near the KE and KW Reactors. Levels have declined over time.

The two plumes are positioned between the crib source locations and the Columbia River. The KW plume is larger than the KE plume, extending downgradient to well 199-K-132. Concentrations in wells near the source area (i.e., well 199-K-106A) have declined in the past 10 years (Figure 2.3-16).

Carbon-14 concentrations also exceeded the drinking water standard in some samples from wells southwest of the 116-KW-1 Crib (Figure 2.3-17). Concentrations exceeded the drinking water standard in the 1990s in well 199-K-108A. During the period 2000 to 2004, groundwater at this location was diluted by clean water from an unknown source, and contamination indicators were dramatically reduced in concentration. In 2005, dilution by clean water stopped, and monitoring results began to return to previous levels. Since FY 2006, carbon-14 concentrations in this well have been near the drinking water standard (FY 2008 averaged 1,700 pCi/L). New well 199-K-137 also had some FY 2008 results above the standard.

Aquifer tube AT-17-D, downgradient of the KW Reactor, typically detects concentrations of carbon-14 in the hundreds of picocuries per liter, which are above background levels.

The KE carbon-14 plume only exceeded the standard in two wells (199-K-29 and 199-K-30). Concentrations have declined in the past 10 years (Figure 2.3-14). Aquifer tubes downgradient of the KE plume show carbon-14 near detection limits.

2.3.1.4 Strontium-90

In the 100-K Area, strontium-90 concentrations exceed the 8 pCi/L drinking water standard in wells near KW Reactor, KE Reactor, and the 116-K-2 Trench. Strontium-90 primarily was released to the environment at 100-K Area via used reactor coolant. It also may have been present in fuel storage basin shielding water, which was discharged to nearby drain fields and injection wells during the reactor operating period. The radionuclide is moderately mobile in the environment and has a half-life of ~29 years.

Strontium-90 near the KW Reactor. Strontium-90 concentrations exceeded the drinking water standard in wells 199-K-34 and 199-K-107A near the KW Reactor. The maximum concentration in FY 2008 was 37.3 pCi/L in well 199-K-34, an increase from the previous few years. Analytical results from downgradient extraction wells 199-K-139 and 199-K-140 ranged from undetected to 3.4 pCi/L.

Strontium-90 near the KE Reactor. The highest concentrations in 100-K Area groundwater have been observed at well 199-K-109A near the northwestern corner of the KE Reactor. The peak in strontium-90 concentrations in the mid-1990s corresponded to a period of higher water levels. Strontium-90 concentrations continued to fluctuate in this well and averaged over 1,000 pCi/L (the derived concentration guide) in FY 2008. Nearby wells have concentrations near or below the detection limit. The presumed source is contamination in the vadose zone beneath the former drain field/injection well.

The highest strontium-90 concentrations are in a well near the northwest corner of the KE Reactor.

Strontium-90 near the 116-K-2 Trench. The effluent disposed to the trench contained strontium-90, which is detected at relatively low levels in a few scattered wells. The highest concentration was 32.5 pCi/L in well 199-K-21, downgradient of the central portion of the trench. Concentrations are declining gradually.

In FY 2008, the maximum concentration of strontium-90 in 100-K Area aquifer tubes was 1.77 pCi/L in AT-19-M.

2.3.1.5 Nitrate

Nitrate is widely distributed beneath the 100-K Area, mostly at levels below the 45 mg/L drinking water standard. Potential sources include currently active septic systems and past-practice waste sites, but the distribution pattern and trends do not clearly indicate specific sources. Three wells near the KW Reactor (199-K-34, 199-K-106A, and 199-K-108A) and three wells near the KE Reactor (199-K-11, 199-K-23, and 199-K-30) had concentrations above the drinking water standard.

The highest concentration in FY 2008 was 139 mg/L in well 199-K-106A, located near KW Reactor. At the southern end of the 116-K-2 Trench, well 199-K-18 also had concentrations exceeding the standard.

Northeast of the 116-K-2 Trench, new well 199-K-159 had a nitrate concentration of 58.9 mg/L. This well is located in the southern part of the 100-N Area and may relate to nitrate contamination there (Section 2.4).

2.3.1.6 Trichloroethene

Samples from wells 199-K-106A and 199-K-132, located downgradient of the former 116-KW-1 Condensate Crib, routinely are monitored for trichloroethene. In well 199-K-106A, located nearest the crib, levels have declined from ~30 µg/L in the mid-1990s to 4.6 µg/L in FY 2008. Extraction well 199-K-132, located farther downgradient, had a concentration of 7.7 µg/L in FY 2008, an increase from the previous year. The drinking water standard for trichloroethene is 5 µg/L.

2.3.2 Operable Unit Activities

This section summarizes the status of CERCLA five-year review action items and interim remedial action in the 100-KR-4 Operable Unit.

The remedial action objectives for the 100-KR-4 Operable Unit (EPA/ROD/R10-96/134) are as follows.

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

The contaminant of concern is hexavalent chromium. The record of decision specifies 22 µg/L as the concentration at compliance wells that is protective of aquatic organisms in the river environment.

Interim remedial action under CERCLA at the 100-KR-4 Operable Unit initially targeted the chromium plume beneath the 116-K-2 Trench. A pump-and-treat system removes hexavalent chromium from extracted groundwater and injects the treated effluent upgradient of the former trench (Figure 2.3-1). The system began operating in October 1997. An expansion to this system was under construction during FY 2008 to provide additional treatment capacity in the vicinity of the 116-K-2 Trench. A second area of contamination, near the KW Reactor complex, was added to the interim remedial action, and a pump-and-treat system began to operate in FY 2007. The remedial action objectives and criteria for success remain the same as for the initial target plume.

As described in DOE/RL-96-84, *Remedial Design and Remedial Action Work Plan for 100-HR-3 And 100-KR-4 Groundwater Operable Units' Interim Action*, the performance criteria for these pump-and-treat systems include achieving hexavalent chromium concentrations that do not exceed 22 µg/L in near-river wells.

2.3.2.1 Status of CERCLA Five-Year Review Action Items

The second CERCLA five-year review was published in November 2006 (DOE/RL-2006-20). The review identified four actions pertaining to the 100-K Area.

- **Action 3-1.** Install three additional wells to further delineate the 116-K-2 Trench chromium plume (August 2008). Wells 199-K-153, 199-K-154, and 199-K-163 were installed to complete this action.

- **Action 4-1.** Construct a new pump-and-treat facility to address the chromium groundwater plume in the KW Reactor area (August 2008). The KW Pump-and-Treat System began operating in January 2007. Section 2.3.2.3 provides more information.
- **Action 5-1.** Expand the 100-KR-4 Pump-and-Treat System by 378.5 L/min to enhance remediation of the plume between the 116-K-2 Trench and the N Reactor perimeter fence (August 2008). Construction of a 2,271 L/min system was completed in September 2008. It will begin to operate in FY 2009.
- **Action 5-2.** Add wells between the 116-K-2 Trench and the N Reactor perimeter fence for groundwater extraction, and connect the additional wells to the pump-and-treat system (March 2007). Wells 199-K-130, 199-K-131, 199-K-147, 199-K-148, and 199-K-149 were installed and will be connected to the expanded pump-and-treat system.

The DOE expanded the 100-KR-4 Pump-and-Treat System in FY 2008. New extraction wells will begin to operate in FY 2009.

2.3.2.2 116-K-2 Trench Pump-and-Treat System

The original 100-KR-4 Pump-and-Treat System, which remediates groundwater around the 116-K-2 Trench, has been operating since 1997. The DOE expanded the pump-and-treat system in FY 2008 to fulfill five-year review action items 5-1 and 5-2. Twenty-three new wells were installed as part of this expansion (Chapter 4.0). The new extraction and injection wells will begin operating in FY 2009. DOE/RL-2006-75, *Supplement to the 100-HR-3 and 100-KR-4 Remedial Design Report and Remedial Action Workplan for the Expansion of the 100-KR-4 Pump and Treat System*, describes the design of the expansion and monitoring requirements. In FY 2008, two wells were sampled less frequently than planned (Appendix A). Two monthly samples were missed in well 199-K-18 and one monthly sample was missed in well 199-K-20 because of conflicts in scheduling field staff.

DOE/RL-2008-05, *Calendar Year 2007 Annual Summary Report for the 100-HR-3, 100-KR-4, and 100-NR-2 Operable Unit Pump-and-Treat Operation*, presents results of operational monitoring and additional details about the pump-and-treat systems for calendar year 2007. Results for calendar year 2008 will be included in an upcoming report on the 100 Area Pump-and-Treat Systems. Appendix A includes lists of sampling frequencies and analyses.

During FY 2008, the pump-and-treat system at the 116-K-2 Trench involved nine extraction wells, five injection wells, and an ion-exchange resin treatment system. The system treated 502 million liters of groundwater and removed 17.9 kg of chromium. Since the startup of operations in October 1997, the system has treated ~4.65 billion liters of groundwater and removed ~330 kg of chromium.

Chromium concentrations within the target plume area show generally decreasing or stable trends (Section 2.3.1.1 and Figures 2.3-8 through 2.3-10). Of the 16 wells monitored for compliance[1] in FY 2008 (Appendix A), only wells 199-K-117A and 199-K-20 had concentrations consistently at or below the remedial action goal.

Two pump-and-treat systems have removed 361 kg of chromium from 100-K Area groundwater.

2.3.2.3 KW Pump-and-Treat System

The DOE began to operate a pump-and-treat system for the chromium plume (Section 2.3.1.1) near the KW Reactor in January 2007. DOE/RL-2006-52, *The*

1 Certain monitoring wells are designated as "compliance wells" in the interim action record of decision. Chromium concentrations in samples from these wells are compared to the remediation goal (22 µg/L) to determine if the remedial action is effective.

KW Pump and Treat System Remedial Design and Remedial Action Work Plan, Supplement to the 100-KR-4 Groundwater Operable Unit Interim Action, describes the system. In FY 2008, the system included four extraction wells, two injection wells, and ion-exchange treatment equipment similar to that previously used in the 100-KR-4 and 100-HR-3 Operable Units. Initial treatment capacity was 379 L/min.

Plans are underway to increase the KW Pump-and-Treat System treatment capacity to 757 L/min by September 2009. A second 379 L/min treatment train will be added to the existing system. Four new wells were drilled in August and September 2008 around the KW Reactor, three of which will be converted to extraction wells. Chromium concentrations in these four wells were greater than 50 µg/L, so none can be used for injection. One new well, 199-K-165 (Figure 2.3-1), had chromium at concentrations up to 3,020 µg/L during initial sampling in August 2008. This well expands the high-concentration part of the plume towards the south. To aid injection, two new wells will be drilled upgradient of the current plume in FY 2009.

In FY 2008, the KW Pump-and-Treat System extracted 197 million liters of water and removed 15.3 kg of hexavalent chromium. Since startup, the system has treated 320 million liters of water and removed 31.1 kg of chromium.

By the end of FY 2008, hexavalent chromium concentrations in near-river extraction wells 199-K-132 and 199-K-138 were ~40 µg/L (Figure 2.3-6). Concentrations declined in inland extraction well 199-K-139 (between 100 and 150 µg/L), and were stable at ~25 µg/L in inland extraction well 199-K-140. Upgradient monitoring well 199-K-137 had much higher chromium concentrations (Figure 2.3-5). Well 199-K-137 and other wells in the more highly concentrated portion of the plume will be connected to the expanded KW Pump-And-Treat System during FY 2009.

2.3.2.4 Calcium Polysulfide Treatability Test

This test, initiated in 2005, evaluated the practicality of treating chromium in the groundwater as an alternative to pump-and-treat systems. The study concluded that hexavalent chromium effectively was eliminated from the treated portion of the aquifer (DOE/RL-2006-17, *Treatability Test Report for Calcium Polysulfide in the 100-K Area*). The aquifer was chemically reduced and was expected to remain a permeable reactive barrier that will treat groundwater as it flows through.

Four wells adjacent to polysulfide injection well 199-K-126 were sampled twice in FY 2008. Chromium concentrations in well 199-K-126 were 30 to 46 µg/L. Surrounding wells had no detectable chromium, with one exception. Well 199-K-136 had a chromium result of 682 µg/L in November 2007 and was not detected in May 2008. The high value is flagged as an error, as it is much higher than concentrations in the surrounding plume.

Total organic carbon increased in the test site monitoring wells in FY 2008, with a maximum of over 400 mg/L in well 199-K-134. This is a residual effect from the test, when vegetable oil was injected to stimulate bacterial growth to moderate sulfate levels. Groundwater samplers observed oil in the water when they sampled the wells.

2.3.3 Facility Monitoring — KE and KW Basins

D. G. Horton

The fuel storage basins located within the KE and KW Reactor buildings were used from the late 1970s to 2004 to store irradiated fuel from the 100-N Reactor, along with other miscellaneous fuel recovered during remedial actions at other reactor areas. Each basin holds ~4.9 million liters of shielding water that is highly contaminated with long-lived radionuclides, some of which are mobile in the environment (e.g., tritium, strontium-90). Leaks at the KE Basin have affected groundwater. The vadose zone beneath the basin also is known to contain radionuclides that are absorbed onto the soil. Tri-Party Agreement (Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*) Milestone M-34-00 covers the fuel removal and basin cleanup project, the latter now referred to as the K Basins Closure Project.

Website
More information on K Basins cleanup and demolition is available at http://www.hanford.gov/rl/?page=220&parent=0.

During FY 2008, all shielding water was removed from the KE Basin and the basin was filled with a sand-grout mixture. The sand-like material provides shielding from contamination embedded in the basin's walls, as well as a platform for heavy machinery to drive on as the superstructure is demolished. Demolition of the superstructure began in FY 2008.

The KE and KW Basins sampling and analysis schedule complements other schedules associated with the 100-KR-4 Operable Unit. The monitoring plan for KE and KW Basins (PNNL-14033) describes the following objectives for the monitoring.

- Characterize groundwater conditions between KE and KW Basins and the Columbia River to provide a periodic status of current conditions and the attenuation of plumes.
- Distinguish basin-related groundwater contamination from other contamination to help guide operational and remedial action decisions.
- Maintain a strategy for the potential expansion of monitoring capabilities to respond to future basin-related issues.

These objectives were valid as long as shielding water remained in the basins. Now that the shielding water has been removed from the KE Basin and demolition of the basin has begun, the strategy and objectives for groundwater monitoring need to be reviewed. This work is planned for FY 2009.

Shielding water has been removed from the KE Basin and demolition of the basin has begun. The strategy and objectives for groundwater monitoring need to be reviewed.

The primary indicator for detecting shielding water in groundwater is tritium, which is present at concentrations in the millions of picocuries-per-liter at the KW Basin. Before demolition began, the KE Basins water had similar concentrations. Other less mobile radionuclides (e.g., strontium-90, cesium-137) also are present at relatively high concentrations in shielding water. However, if small volumes or low rates of leaks were to occur, the strontium-90 and cesium-137 might not reach groundwater because they would be retained in the vadose zone, and tritium levels might be too low to detect. One additional tracer for shielding water is technetium-99, which is mobile (like tritium), but is at relatively low concentrations in the shielding water.

Wells 199-K-27 and 199-K-109A were located adjacent to the KE Basin in a position most likely to detect basin leaks. Both of these wells were decommissioned in May 2008 in preparation for demolishing the KE Basin. Decommissioning of these wells was anticipated and replacement wells 199-K-141 and 199-K-142 were drilled further downgradient in FY 2007. During FY 2008, tritium concentrations remained relatively constant at levels below the drinking water standard in all four wells, although the concentration increased in well 199-K-109A from 3,000 pCi/L during FY 2007 to 9,600 pCi/L during FY 2008 (Section 2.3.1.2 and Figure 2.3-18). The average annual tritium concentration decreased in well 199-K-27 from 6,800 pCi/L during FY 2007 to 3,800 pCi/L during FY 2008. There is still no clear source to explain the abrupt increase in concentrations that started in January 2003 at these wells. There has been no unexplained loss of water from the basin to account for the trend changes in groundwater.

Near the KW Reactor, tritium concentrations at well 199-K-106A, located downgradient of the former 116-KW-1 Condensate Crib began to rise in 2001 and spiked in mid-2003 and 2005 to over 1 million pCi/L (Figure 2.3-13). Levels declined in FY 2006 and 2007 and have remained relatively constant since January 2008. The likely source for the tritium is the vadose zone beneath the former crib and not related to potential water loss from the KW Basin.

The annual average concentration of strontium-90 exceeded the drinking water standard (8 pCi/L) in two wells monitoring the KW Reactor area and one well monitoring the KE Reactor area (Section 2.3.1.4). The highest concentrations were in the KE Reactor area where strontium-90 averaged 1,100 pCi/L in well 199-K-109A prior to decommissioning in May 2008. This was up substantially from 480 pCi/L during FY 2007, but similar to an average of 1,200 pCi/L during FY 2006. Wells 199-K-34 and 199-K-107A, located in KW Reactor area, averaged 37 and 24 pCi/L in FY 2008.

Groundwater monitoring in the 100-KR-4 groundwater interest area includes the following activities.

CERCLA Long-Term Monitoring (Appendix A)

- ***Thirty-three wells are scheduled for monthly to biennial sampling. All wells were sampled as planned.***

CERCLA Interim Action Monitoring (Appendix A)

- ***Twenty-eight wells are scheduled for monthly to annual sampling. Two wells were not sampled as frequently as planned in FY 2008.***
- ***The DOE installed 27 new wells to support pump-and-treat activities and 29 new aquifer tubes to help define plumes.***

Facility Monitoring (Appendix B)

- ***Fourteen wells are scheduled for quarterly to semiannual sampling to detect potential shielding water loss to the ground from the KW and KE Basins. The wells were sampled as planned.***
- ***Four wells are scheduled for monthly sampling during basin cleanout. One monthly sample was not collected.***
- ***Two of the wells were decommissioned for basin decommissioning.***

Figure 2.3-1. Facilities and Groundwater Monitoring Wells in the 100-K Area.

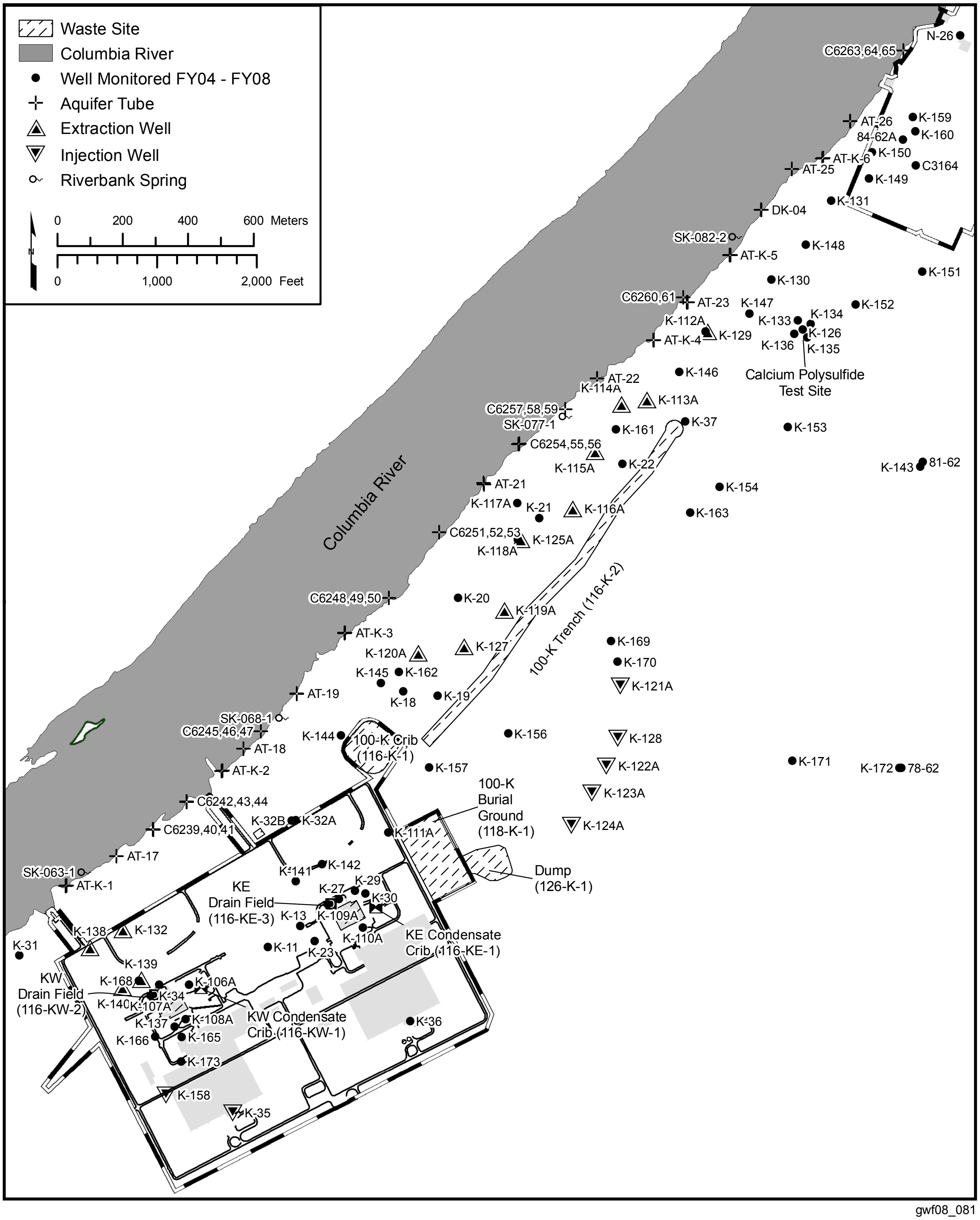
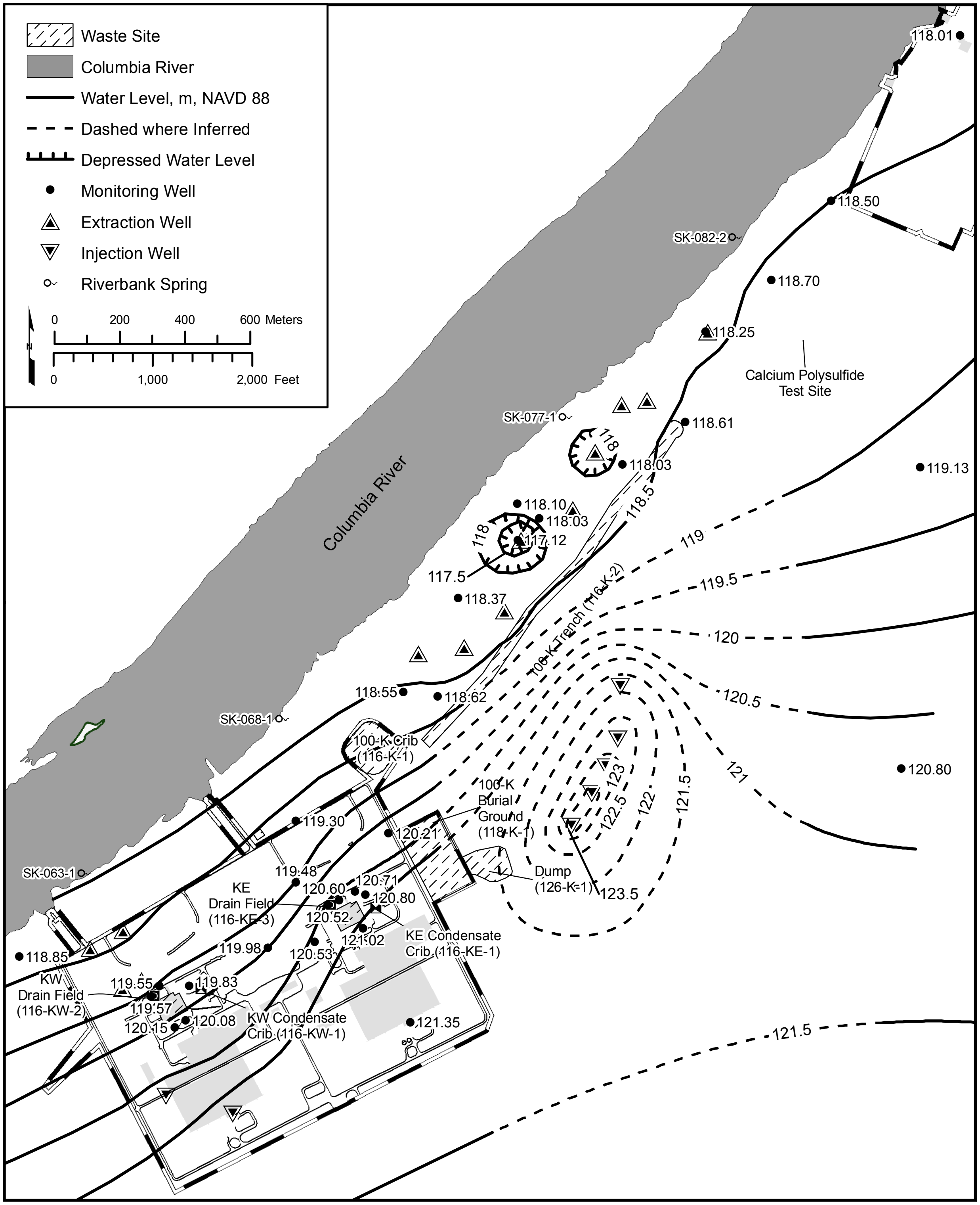


Figure 2.3-2. 100-K Area Water-Table Map, March 2008.



gwf08_082

Figure 2.3-3. Average Chromium Concentrations in the 100-K Area, Upper Part of Unconfined Aquifer.

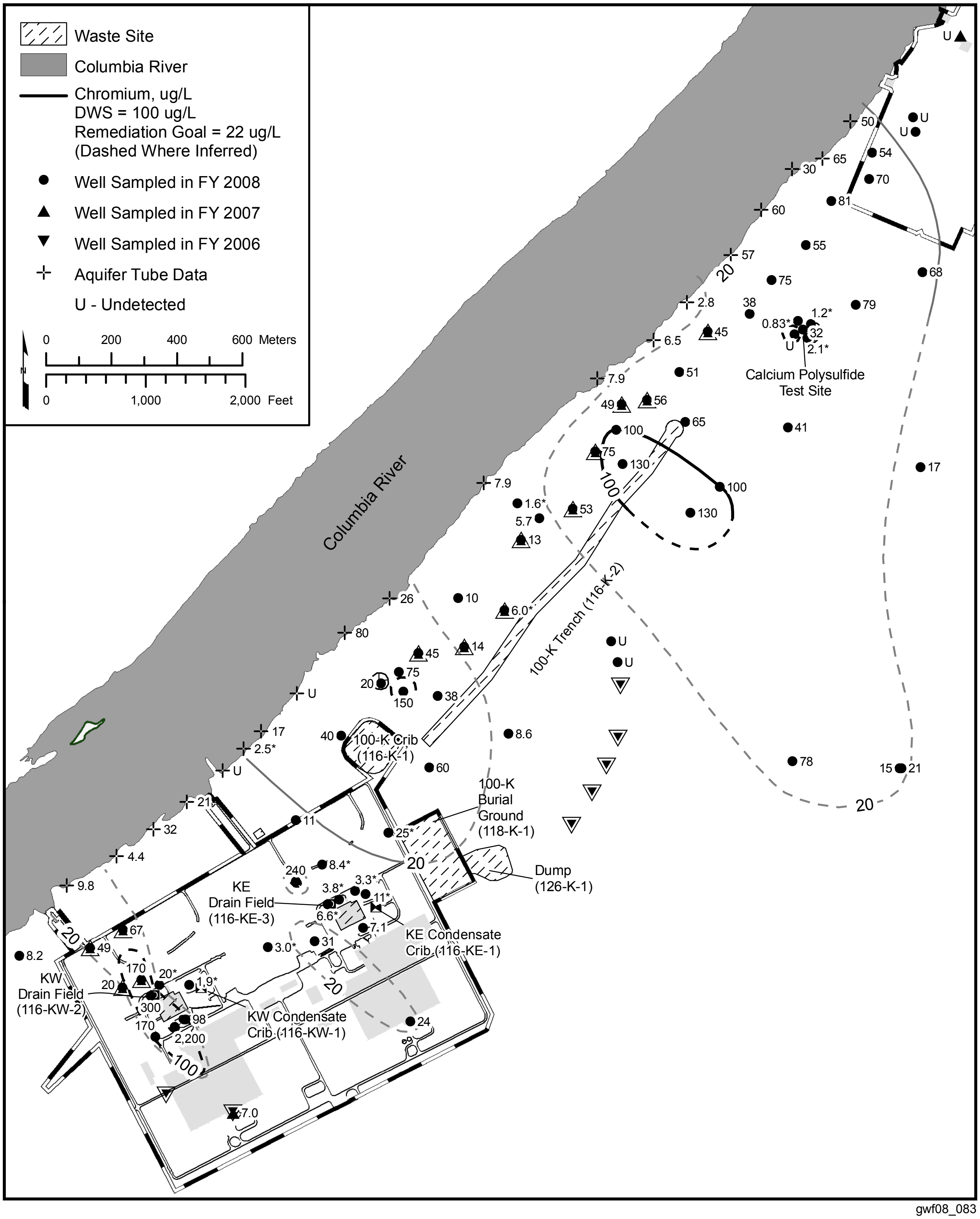
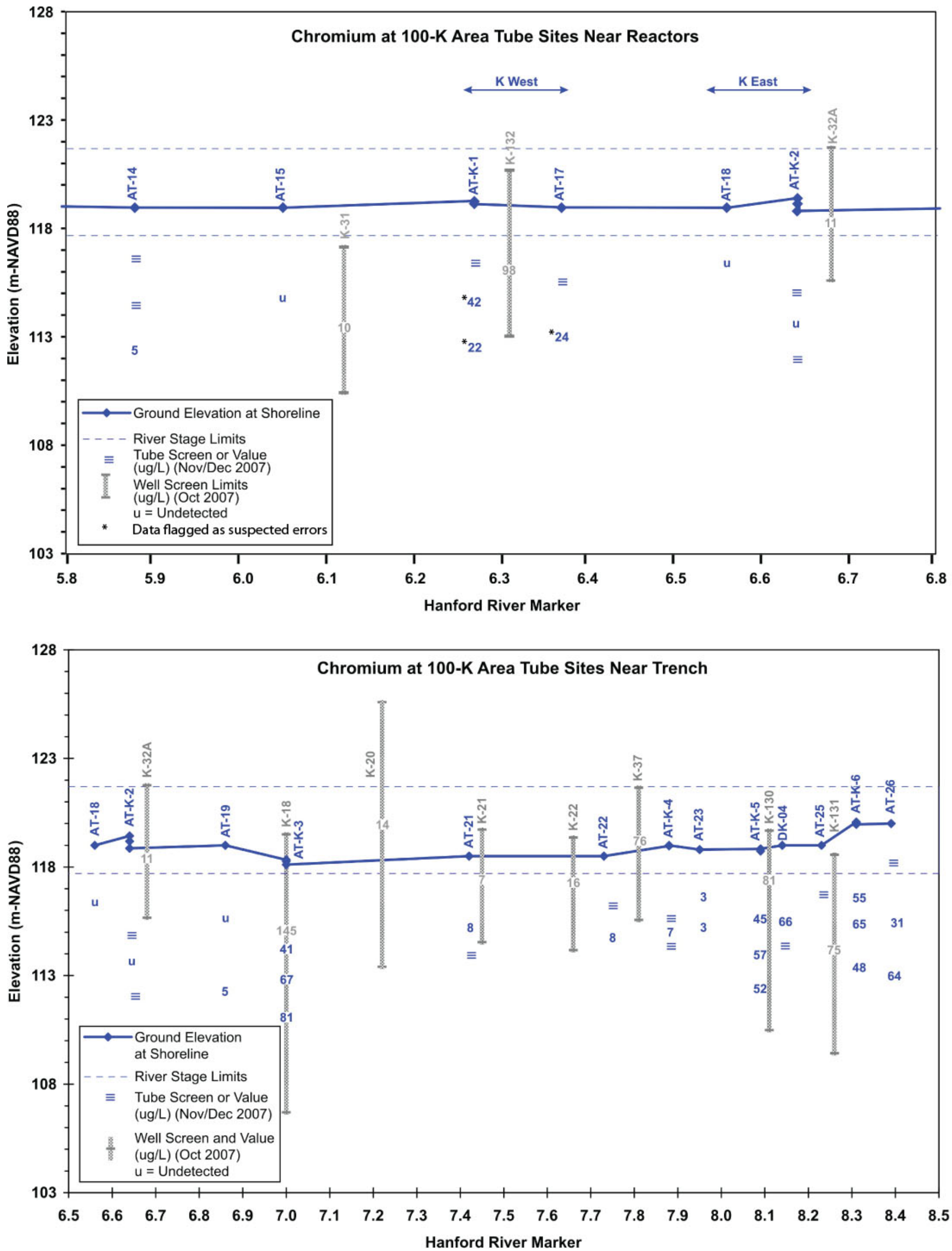


Figure 2.3-4. Cross Section of Chromium Concentrations and Screen Elevations in Wells and Aquifer Tubes in the 100-K Area.



gwf08_084

Figure 2.3-5. Chromium Concentrations in KW Monitoring Wells.

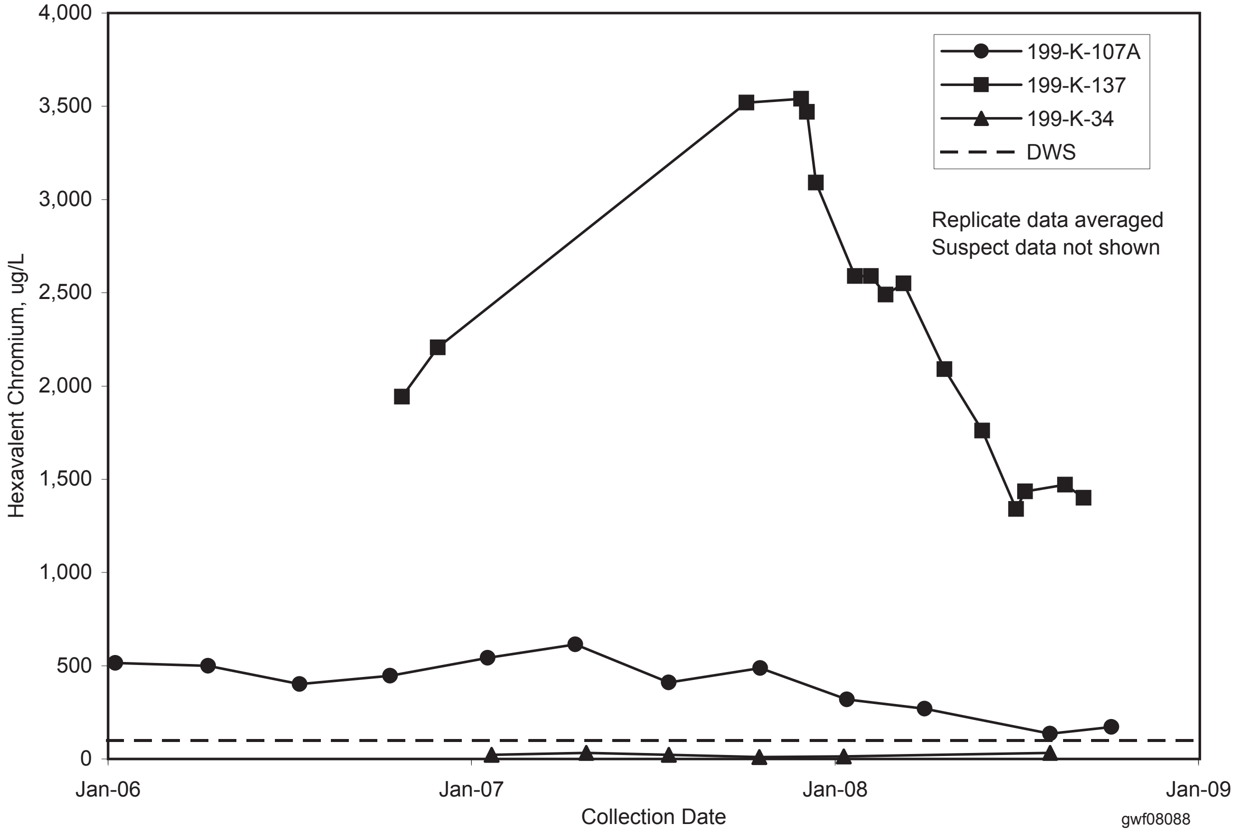


Figure 2.3-6. Chromium Concentrations in KW Extraction Wells.

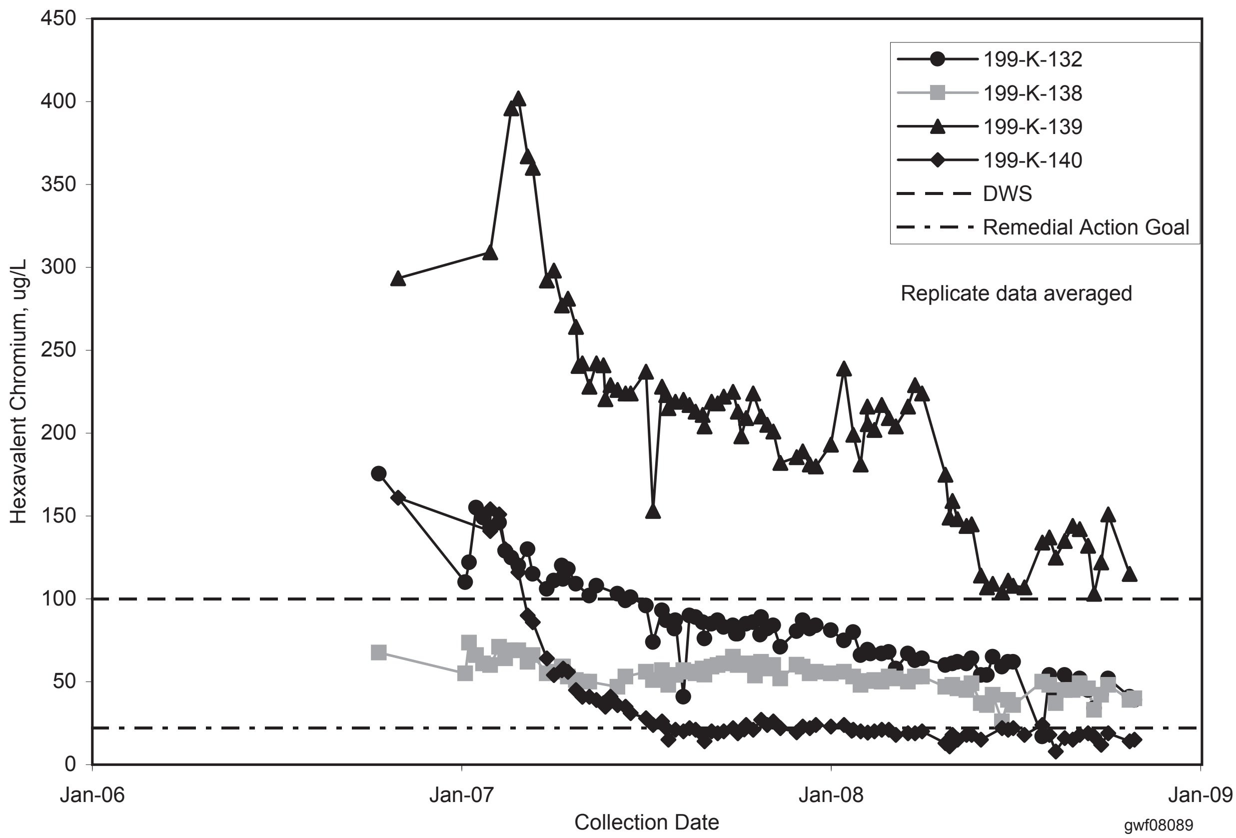
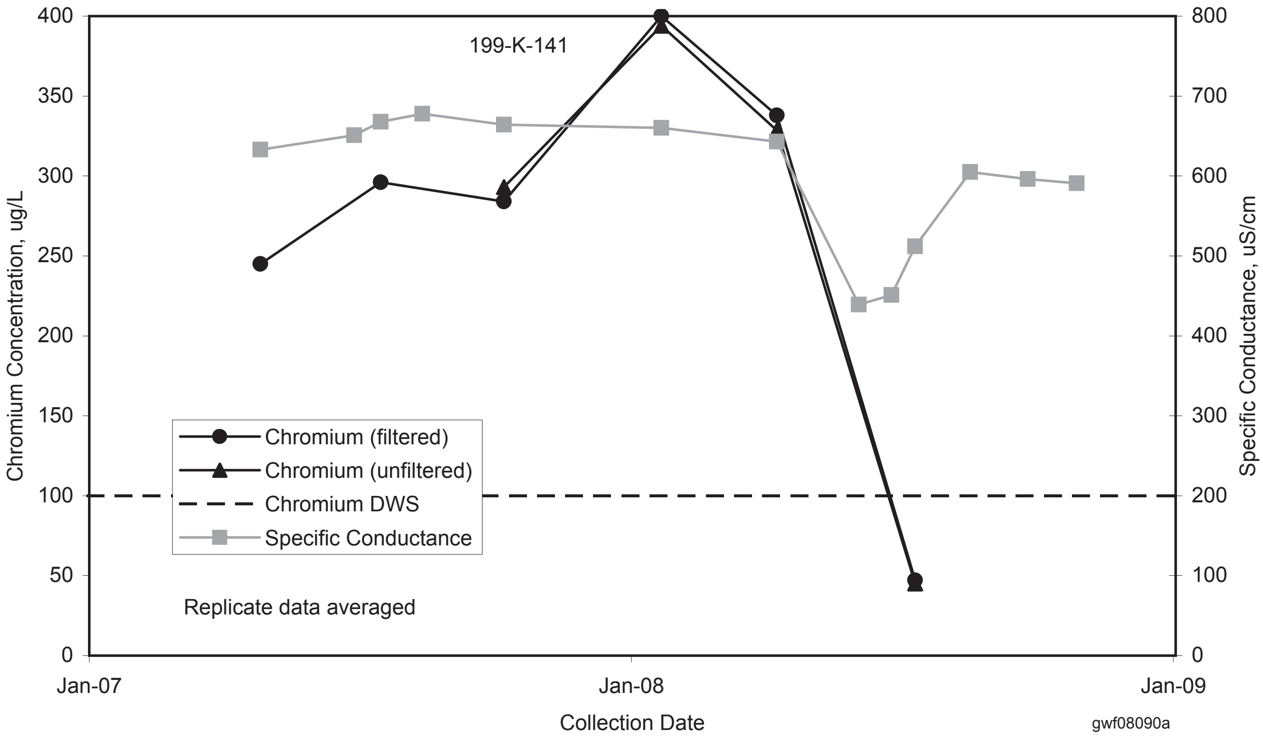
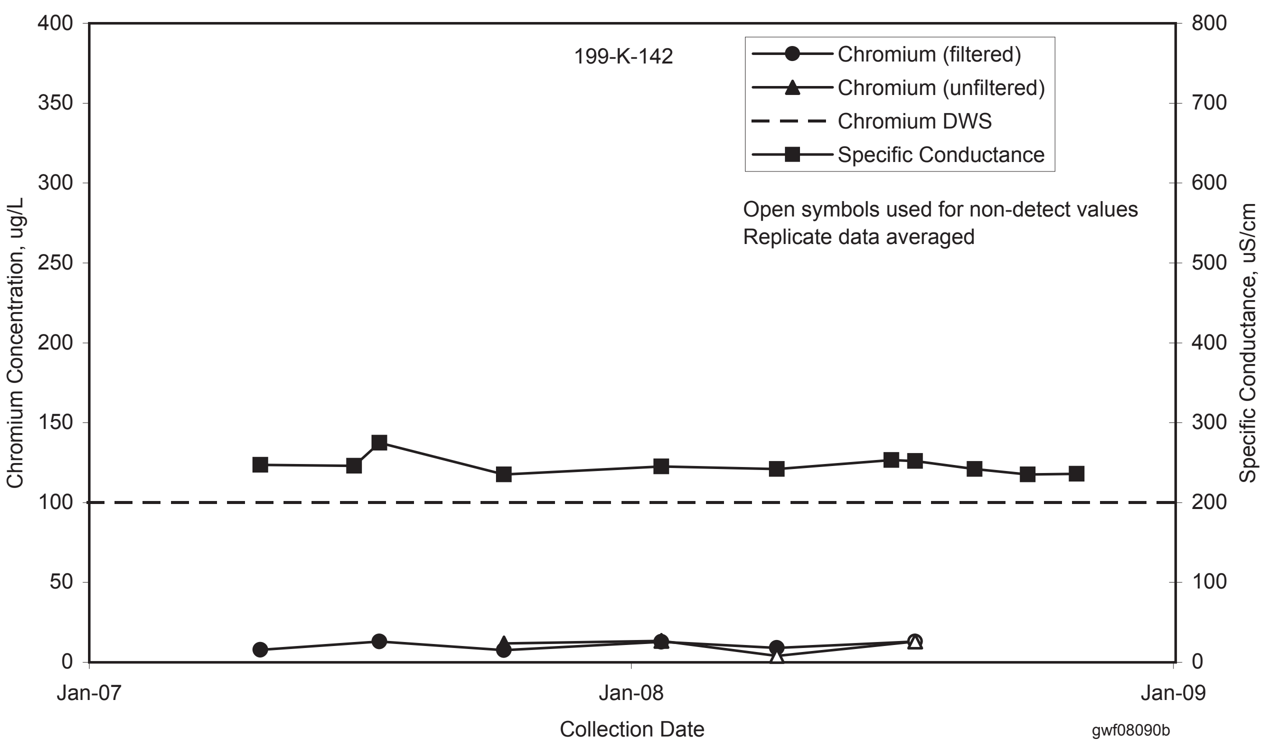


Figure 2.3-7. Chromium and Specific Conductance Downgradient of the KE Reactor.





gwf08090

Figure 2.3-8. Chromium Concentrations in Wells Located at the Southwestern Edge of the 116-K-2 Trench Plume.

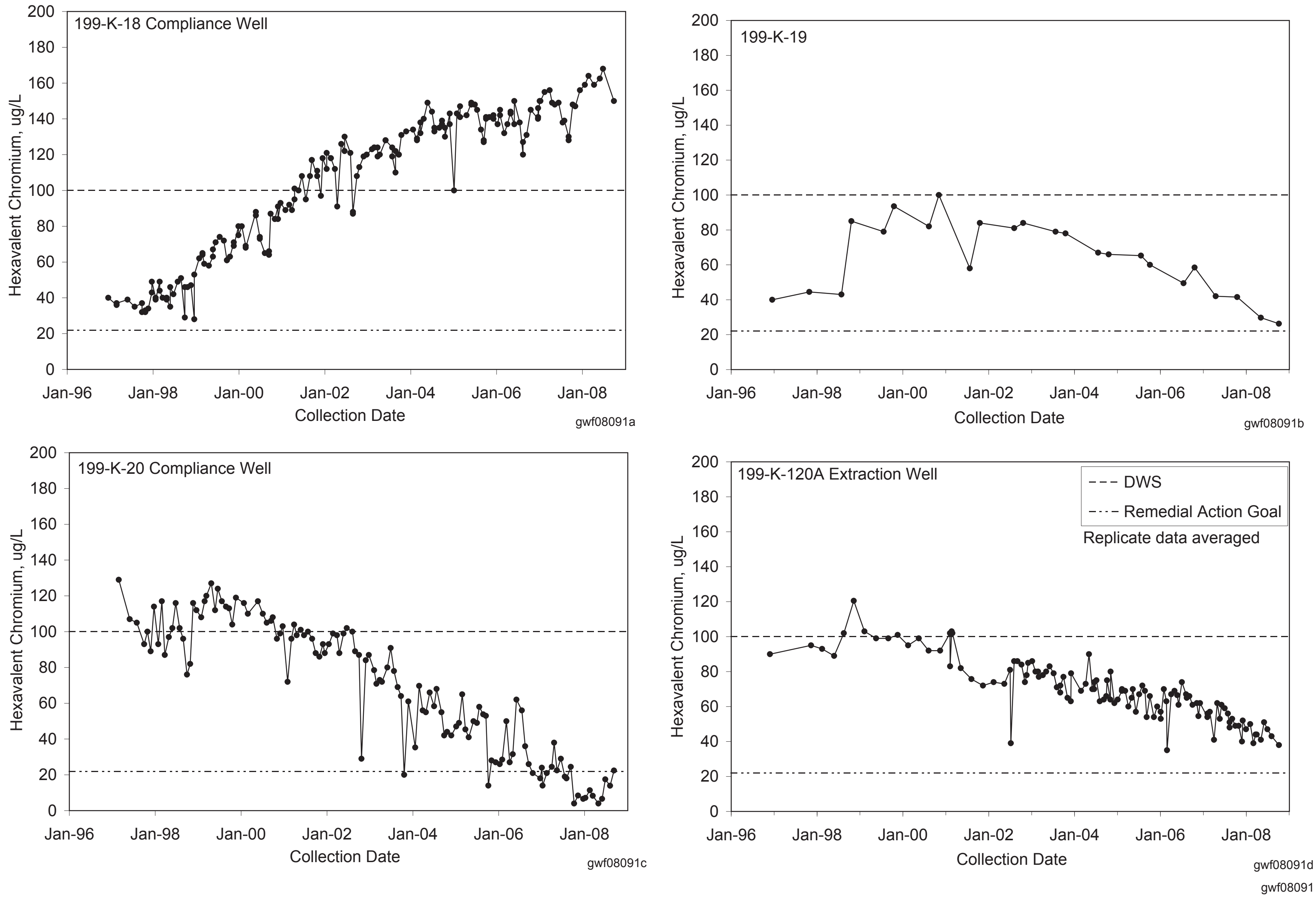


Figure 2.3-9. Chromium Concentrations in Wells Located in Central Portion of the 116-K-2 Trench Plume.

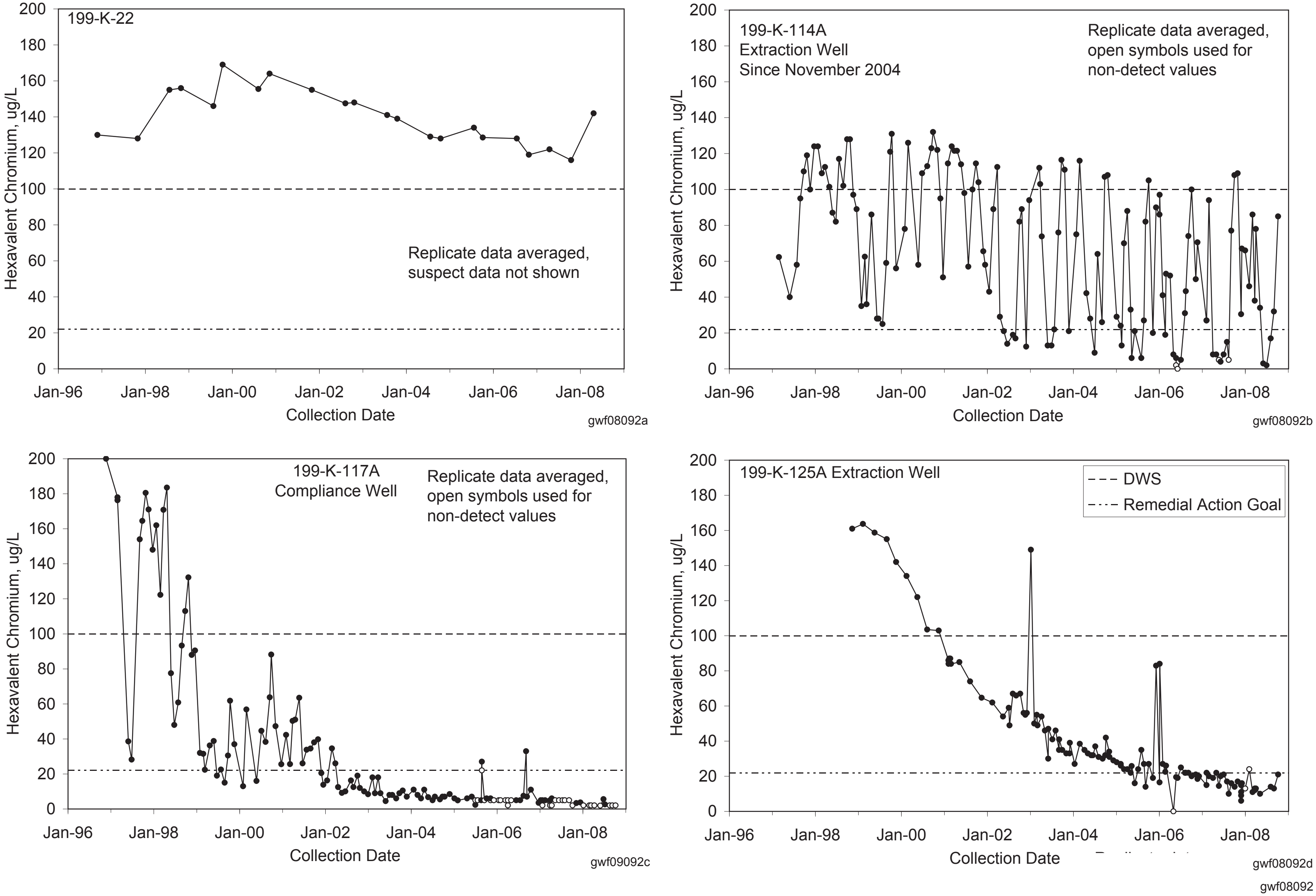


Figure 2.3-10. Chromium Concentrations in Wells Located at the Northeastern Edge of the 116-K-2 Trench Plume.

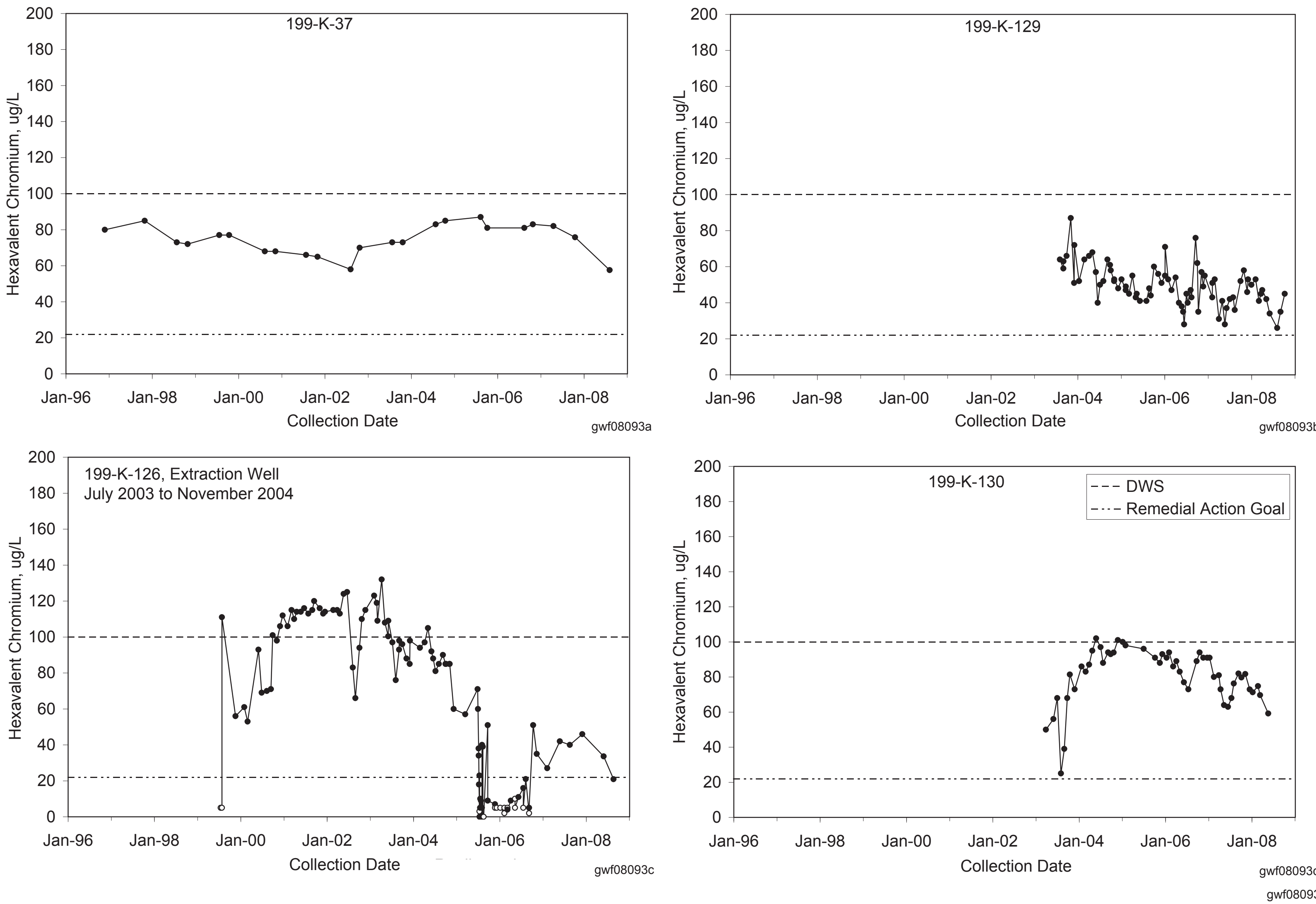


Figure 2.3-11. Chromium Concentrations in Aquifer Tube 26-D near the Northern Portion of the 116-K-2 Trench Plume.

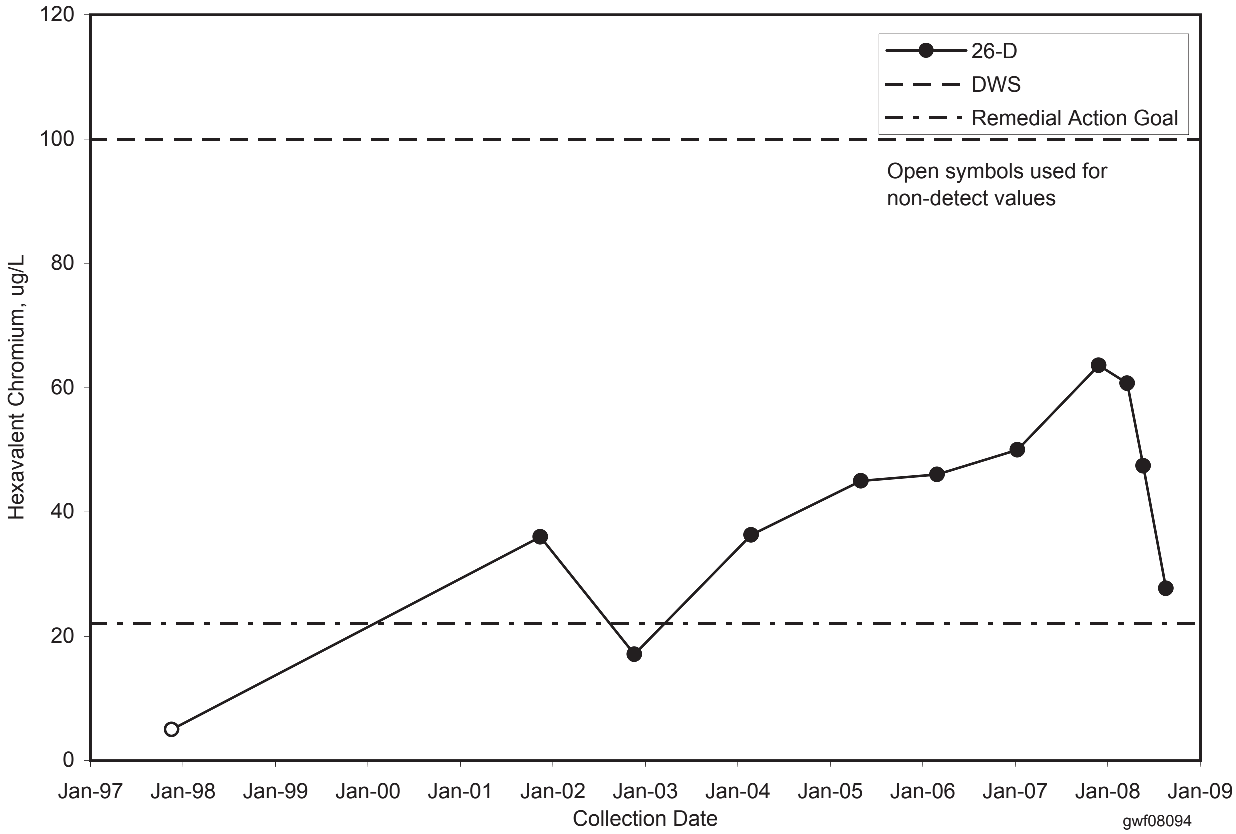


Figure 2.3-12. Average Tritium Concentrations in the 100-K Area, Upper Part of Unconfined Aquifer.

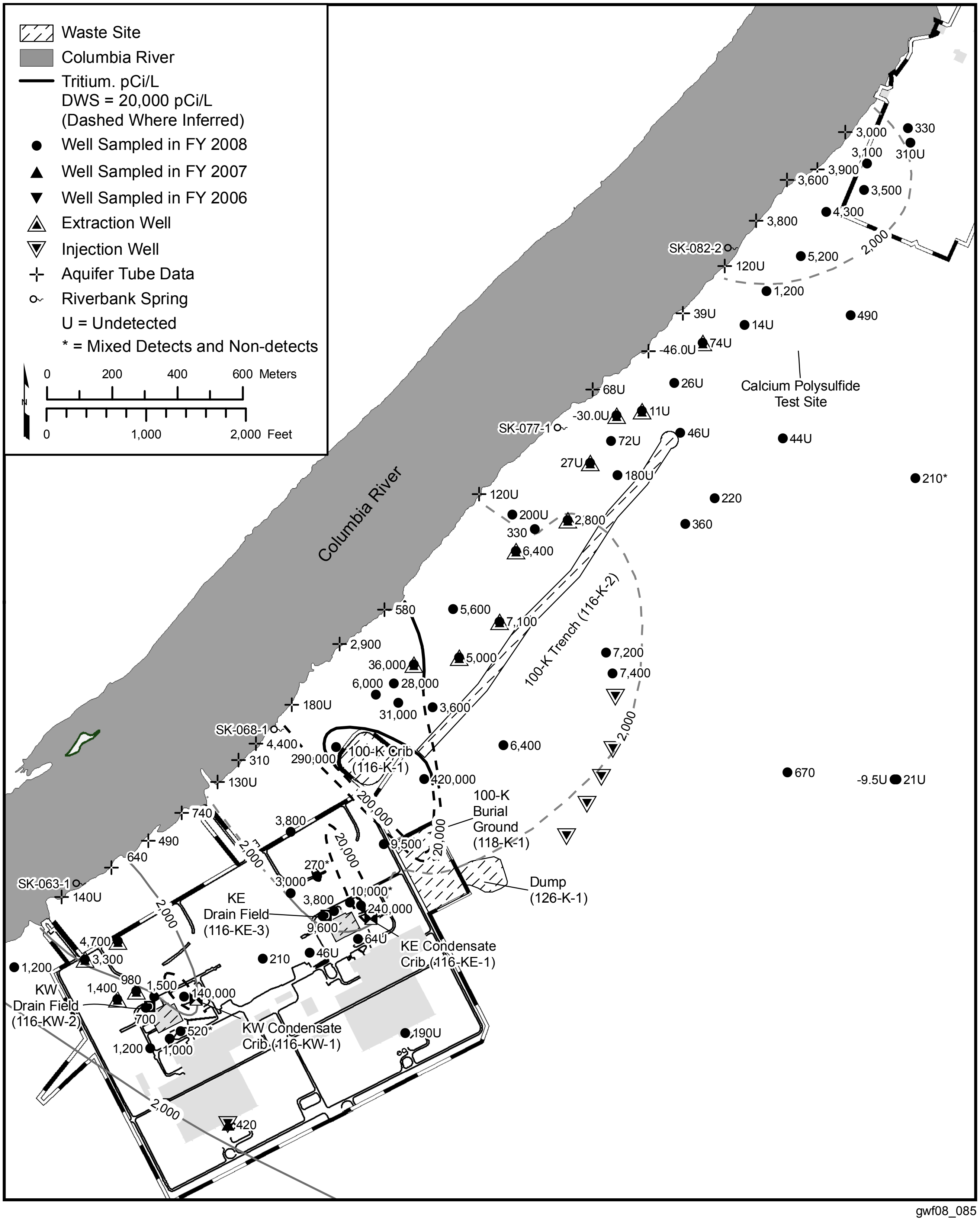


Figure 2.3-13. Tritium and Carbon-14 Concentrations near the Former 116-KW-1 Condensate Crib.

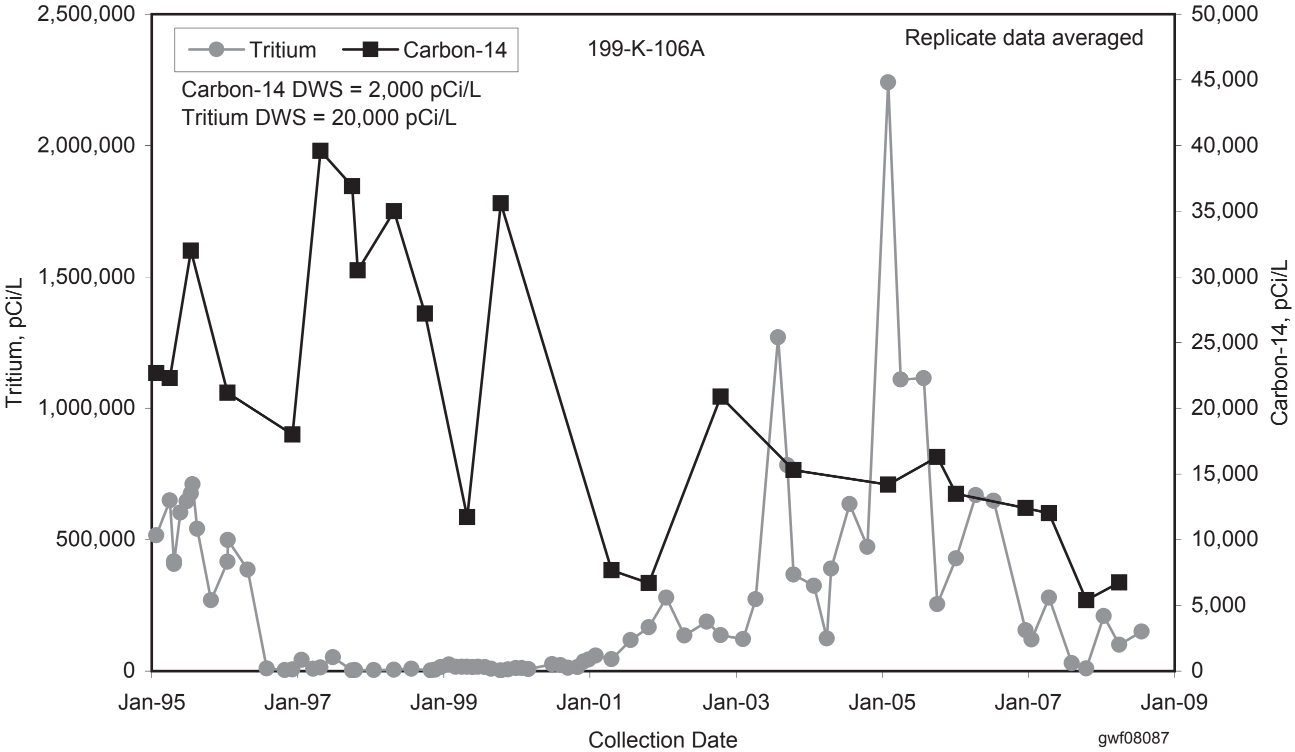


Figure 2.3-14. Tritium and Carbon-14 Concentrations near the Former 116-KE-1 Condensate Crib.

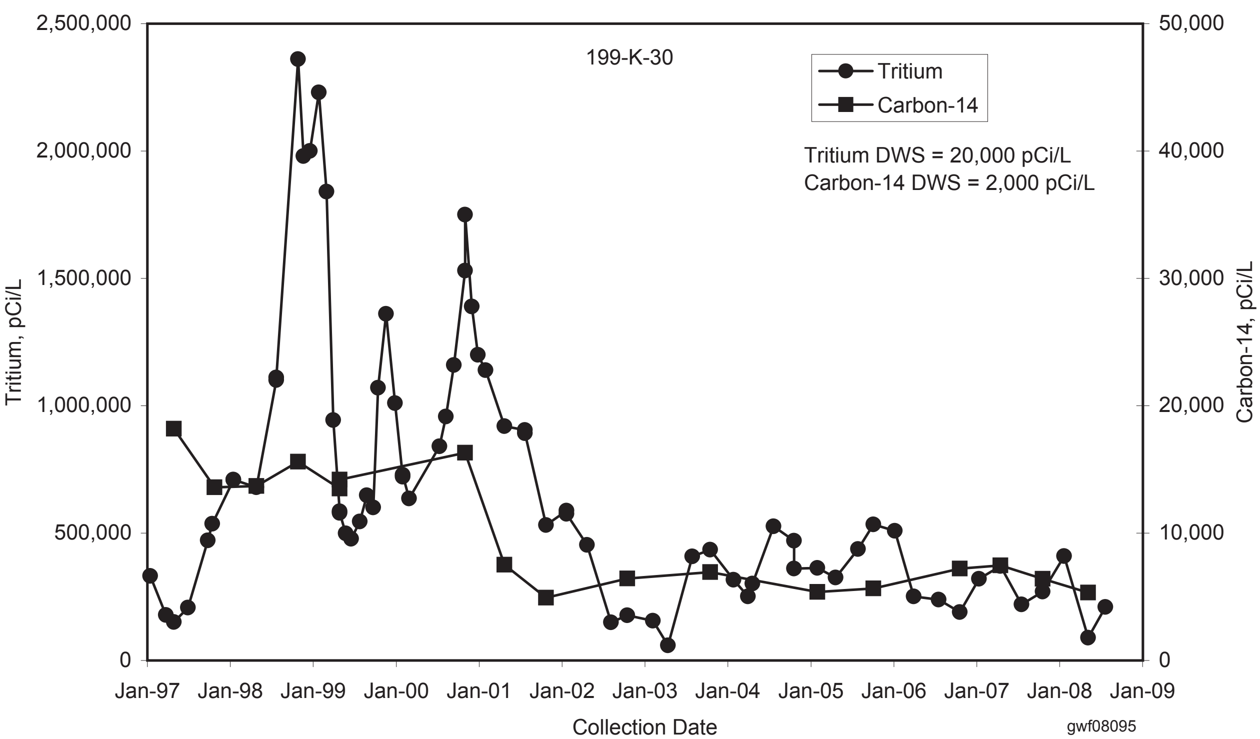


Figure 2.3-15. Tritium Concentrations Downgradient of the Former KE Basin.

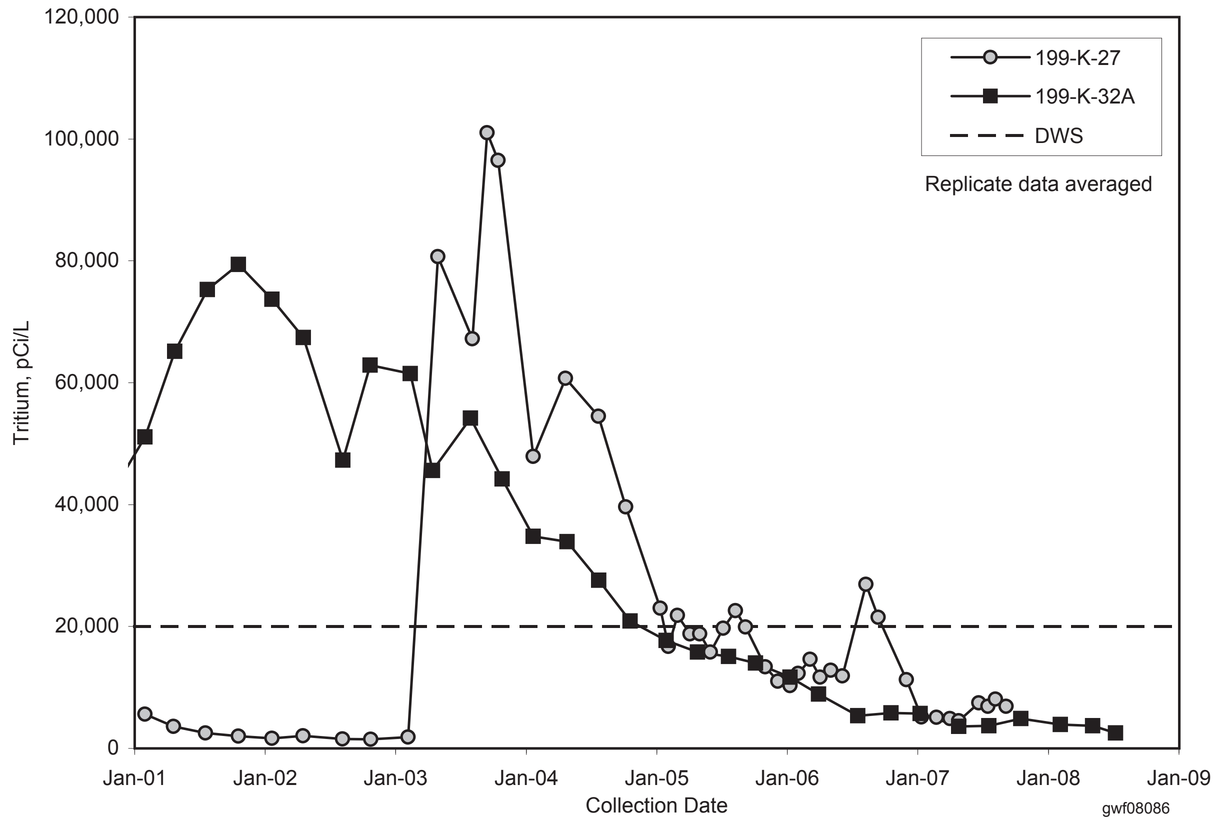


Figure 2.3-16. Carbon-14 Concentrations in KW Downgradient Wells.

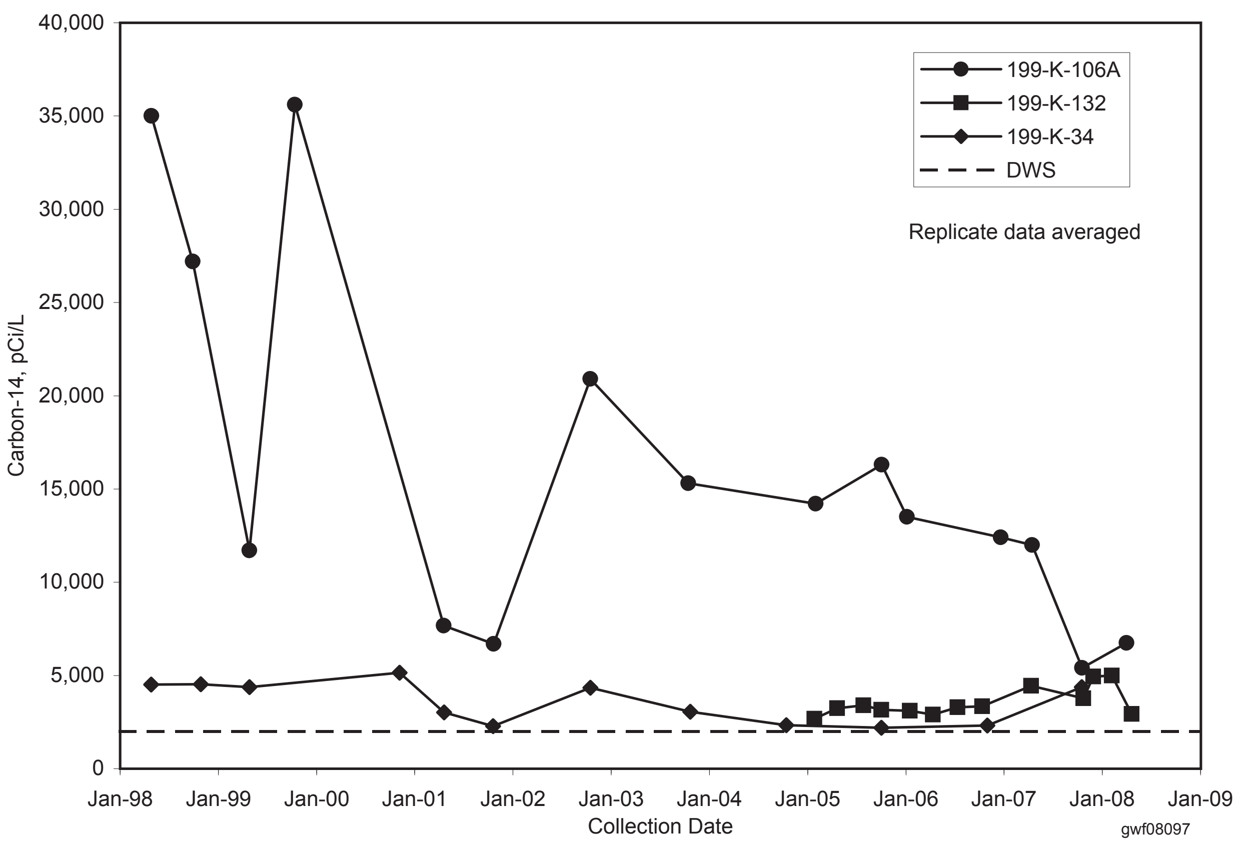


Figure 2.3-17. Carbon-14 Concentrations in KW Upgradient Wells.

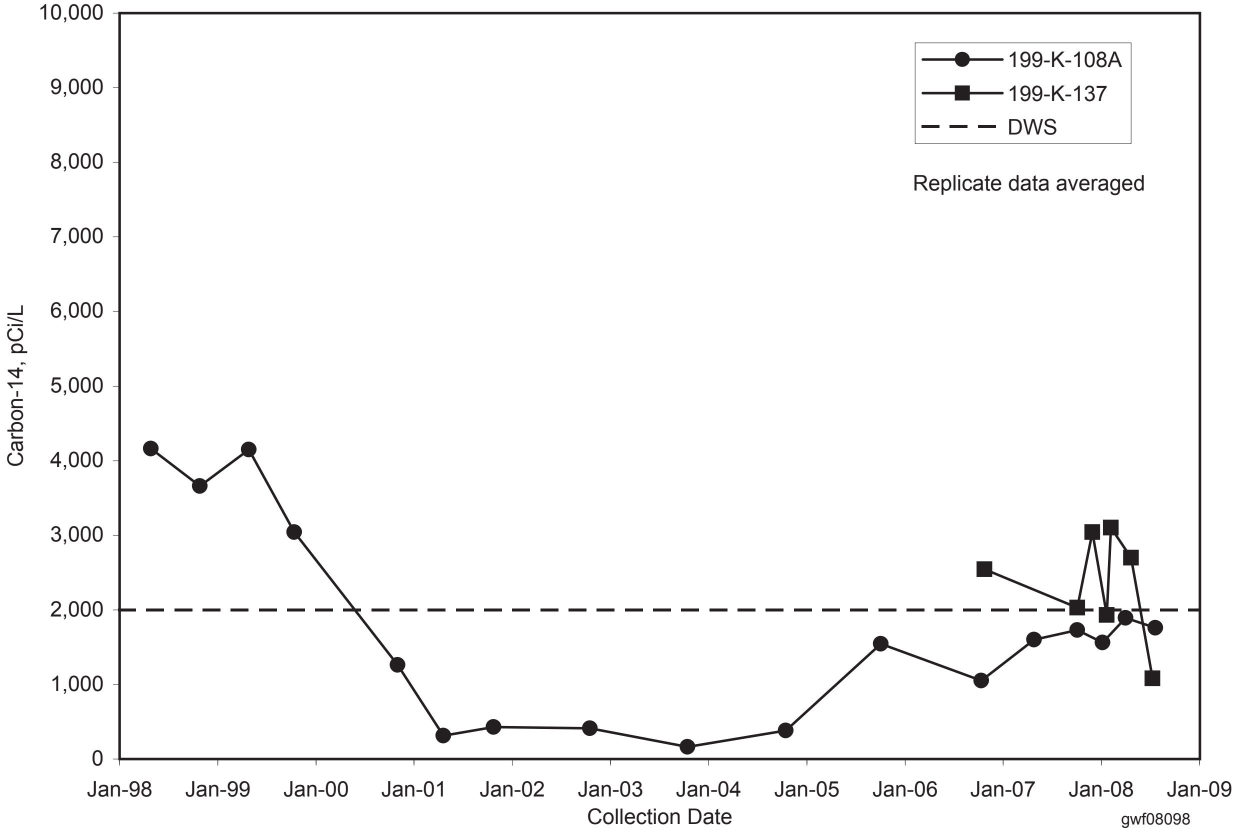


Figure 2.3-18. Tritium Concentrations near the Former KE Basin.