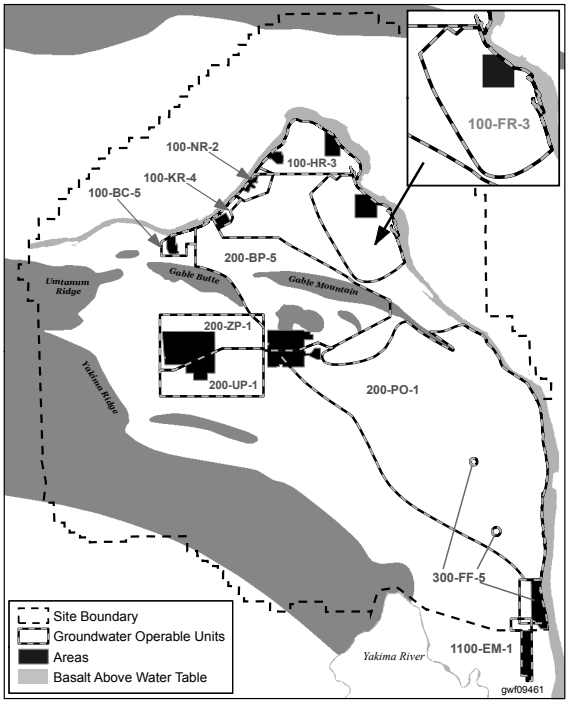
17.0 100-FR-3 Operable Unit

M. J. Hartman

This chapter describes the groundwater flow and contaminant distribution in the 100-FR-3 Operable Unit (OU), which includes the 100-F Area. Figure 17-1 shows the facilities, wells, and shoreline monitoring sites in the 100-F Area.



Groundwater monitoring for the *Atomic Energy Act of 1954* (AEA) is fully integrated with *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) monitoring. Most of the former liquid waste sites in the 100-F Area have been excavated and backfilled. No active waste disposal facilities or *Resource Conservation and Recovery Act of 1976* sites are located in the 100-F Area. Previous assessments have not identified groundwater conditions that warrant interim remedial measures. Final decisions on groundwater cleanup will be reached in the future.

A brief conceptual model for the 100-FR-3 OU is provided in Section 17.1. Section 17.2 discusses the primary groundwater contaminants, and Section 13.3 describes the CERCLA activities for the 100-FR-3 OU. Section 17.4 provides a brief discussion of the conclusions and recommendations for the OU.

Previous annual reports have covered a fiscal year (FY) (October through September). Beginning in 2010, this report covers a calendar year (CY). As a transitional year, this report covers the period from October 1, 2008, through December 31, 2009. As a result of this change, the following date conventions are used throughout this report:

- FY 2009: Refers to the fiscal year named (i.e., October 1, 2008, to September 30, 2009).
- CY 2009: Refers to the calendar year named (i.e., January 1, 2009, to December 31, 2009).
- Reporting period: Refers to the entire 15-month reporting period covered for this report (i.e., October 1, 2008, to December 31 2009).

17.1 Conceptual Model

This section provides a brief summary of the site conceptual model for the 100-FR-3 OU. For additional details, see *Integrated 100 Area Remedial Investigation/ Feasibility Study Work Plan, Addendum 4: 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100 IU 6 Operable Units* (DOE/RL-2008-46-ADD4).

Of more than 100 waste sites identified in the 100-F Area, only fifteen remain to be remediated

The primary sources of contamination in the 100-F Area were the structures and processes associated with the operation of F Reactor from 1945 to 1965. The water-cooled reactor was built to irradiate uranium-enriched fuel rods from which plutonium and other special nuclear materials could be extracted in the 200 Areas. The processes associated with reactor operations generated large quantities of liquid and solid wastes. During operations, effluents were released directly to temporary surface impoundments, cribs, ditches, and the Columbia River. Solid waste was placed in unlined burial grounds. Numerous facilities and systems were

established for biological experiments at the 100-F Area that continued after the plutonium-production mission ended (until 1976), and these activities generated large quantities of contaminated animal and plant wastes (both solid and liquid) that were managed onsite. Wastes released to the environment created secondary sources of contamination beneath ponds, ditches, and cribs, burial grounds, and unplanned release sites, where contaminants were retained in the subsurface (i.e., vadose zone) and released over long periods of time. Over the past decade, the U.S. Department of Energy (DOE) has remediated these liquid waste sites and solid waste burial grounds, usually by excavating contaminated soil and disposing it in a landfill on the Central Plateau, then backfilling and replanting the excavation with native vegetation. Over 100 waste sites have been identified, and only fifteen sites remain to be remediated (DOE/RL-2008-46-ADD4).

In the 100-F Area, the groundwater system comprises several hydrostratigraphic units. From shallowest to deepest, the units are as follows:

- Vadose (unsaturated) zone: Predominantly Hanford formation gravels; up to 13 meters thick beneath the 100-F Area.
- Unconfined aquifer: Hanford gravels; 3 to 13 meters thick.
- Uppermost aquitard: Ringold upper mud unit (clay and silt).
- Series of confined and semiconfined aquifers in the Ringold Formation separated by fine-grained, overbank and paleosol deposits.
- Basalt aquitard and basalt-confined aquifers (shallowest is the Rattlesnake Ridge interbed).

The groundwater is currently contaminated with hexavalent chromium, nitrate, strontium-90, and trichloroethene at levels above aquatic standards or drinking water standards (DWSs); however, these plumes do not appear to reach the Columbia River at levels above the standards. With few exceptions, near-river wells and aquifer tubes have contaminant concentrations below the standards.

All but one of the monitoring wells in the 100-F Area are screened in the unconfined aquifer. Where the aquifer is thin (e.g., 5 meters or less), wells are screened across the entire aquifer thickness. One deeper well is screened in a confined aquifer in the Ringold upper mud unit, ~36 meters below the water table; this well has not detected contamination.

Near the Columbia River, the direction of groundwater flow beneath the 100-F Area varies with Columbia River stage. Figure 17-2 shows the water table in March 2009, when the river was at a moderate level. The map indicates a flow direction toward the east-northeast (toward the river) in the northern portion of the 100-F Area and toward the east-southeast (approximately parallel to the river) in the southern portion. Figure 2-2 in Chapter 2.0 illustrates the water table in this region. The shoreline topography in this area is low and flat, and the shore is under water during part of the year. During periods of high river stage (spring and early summer), the gradient in 100-F Area can reverse, and river water flows into the aquifer.

Plume areas (square kilometers) in the 100-FR-3 Operable Unit:

Chromium, 20 µg/L — 0.12

Nitrate, 45 mg/L — 16.88

Strontium-90, 8 pCi/L — 0.12

Trichloroethene, 5 µg/L — 0.68

17.2 Groundwater Contaminants

Wells in the 100-FR-3 OU are sampled for the contaminants of concern included in *100-FR-3 Operable Unit Sampling and Analysis Plan* (DOE/RL-2003-49): nitrate, strontium-90, tritium, trichloroethene,

uranium, gross alpha, and hexavalent chromium. DOE/RL-2008-46-ADD4 identified additional contaminants of potential concern to be evaluated.

Waste sites that received high volumes of effluent included cribs and pipelines near the former reactor building (e.g., 116-F-5 Crib) and the major retention basins, trenches, and cribs near the Columbia River (e.g., 116-F-14 retention basins, 116-F-2 Trench, and 116-F-9 Trench) (Figure 17-1). Most of the groundwater contamination is associated with these facilities.

Contaminant distribution maps presented in this section show the CY 2009 average concentrations for each well. Many of the 100-F Area wells were sampled twice during the reporting period (October 2008 and October 2009; see Appendix A, Table A-10). Some wells are sampled every other year; if data were not available for CY 2009, earlier data are posted on the maps with a distinct symbol.

17.2.1 Nitrate

A large nitrate plume extends southward ~5 kilometers from the 100-F Area, although data are sparse south of the 100-F Area (Figure 17-3). The plume did not change significantly between FY 2008 and CY 2009.

In CY 2009, wells in the main 100-F Area continued to show levels of nitrate that exceeded the DWS (45 mg/L). The highest concentration was 126 mg/L in well 199-F5-47, located in the central 100-F Area. Concentrations have increased in this well since 2007 (Figure 17-4). Overall concentrations within the nitrate plume (e.g., well 199-F7-3) are steady or declining.

Nitrate concentrations in 100-F Area aquifer tubes were below the DWS in CY 2009 but were above background. The concentration increased to 41 mg/L in aquifer tube 62-M (north of the 100-F Area), which was the highest concentration observed at that location to date. Located upstream from this tube, monitoring well 199-F1-2 has nitrate concentrations at ~30 mg/L. Aquifer tube 75-D, located south of the 100-F Area, has historically had nitrate levels just above the DWS. The October 2009 result was slightly below the DWS at 43 mg/L.

17.2.2 Strontium-90

A strontium-90 plume with concentrations above the 8 pCi/L DWS is present in the eastern 100-F Area (Figure 17-5). In CY 2009, strontium-90 concentrations continued to exceed the DWS in well 199-F5-1, located near the 116-F-2 Trench (Figure 17-6). Concentrations declined below the DWS for the first time in well 199-F5-46. A few other wells had detectable strontium-90, but concentrations were below the DWS.

Strontium-90 concentrations exceed the DWS in one 100-F Area well, but concentrations in the aquifer tubes are lower than the DWS.

Strontium-90 is detected at concentrations below the DWS in a new well in the southwestern 100-F Area. Well 199-F8-7 was installed adjacent to the 118-F-6 Burial Ground in FY 2008 because a grab sample of groundwater during waste site excavation contained strontium-90 at a concentration of hundreds of picocuries per liter. This grab sample was thought to be unrepresentative of groundwater conditions because it was potentially affected by surface contamination from the waste site. During the reporting period, strontium-90 concentrations in well 199-F8-7 ranged from below detection limits to 6.4 pCi/L.

Strontium-90 shows vertical stratification in the only shallow/deep well pair in the 100-F Area. Deep well 199-F5-43B, which monitored a water-producing zone in the Ringold upper mud unit, consistently has not had detectable strontium-90. Its shallow counterpart, well 199-F5-43A, has typically had strontium-90 detections of 2 to 4 pCi/L. In CY 2009, strontium-90 was not detected in either well.

Strontium-90 concentrations tend to be higher in shallow aquifer tubes than deeper aquifer tubes, but all results for CY 2009 were below the 8 pCi/L DWS. The maximum concentration was 5.4 pCi/L in aquifer tubes AT-F-1-M and C6302. The deep tubes at these locations had no detectable strontium-90. Appendix D includes a cross-section showing relative depths of aquifer tube screens and near-river wells in the 100-F Area and the region downstream.

17.2.3 Tritium

Tritium concentrations beneath the 100-F Area have not exceeded the DWS (20,000 pCi/L) in recent years. At lower concentrations, a plume extends to the southeast from the southern 100-F Area.

Historically, only well 199-F8-3 (in the southern 100-F Area) has exceeded the tritium DWS. In the mid-1990s, concentrations at this well were ~180,000 pCi/L, and concentrations began to decline in the late 1990s. Because the decline began before most of the waste sites were remediated, the decline was probably caused by plume movement, dispersion, and radioactive decay. In October 2009, the tritium concentration in well 199-F8-3 was 3,200 pCi/L.

17.2.4 Trichloroethene

Trichloroethene concentrations in the southwestern 100-F Area exceed the DWS (5 µg/L) but are declining overall. The plume appears to be centered west of the 100-F Area (Figure 17-7). A soil vapor investigation (DOE/RL-95-99, *100-FR-3 Groundwater/Soil Gas Supplemental Limited Field Investigation Report*) helped to define the area of contamination but did not identify the contamination source. In CY 2009, trichloroethene concentrations increased slightly in the only wells exceeding the DWS (Figure 17-8). These wells are screened across the entire aquifer thickness (less than 3 meters in this location). The highest concentration was 13 µg/L in well 199-F7-1.

17.2.5 Uranium and Gross Alpha

Uranium concentrations in 100-F Area groundwater remained below the DWS (30 µg/L). Seven wells were sampled for uranium during the reporting period, and the maximum concentration was 17.9 µg/L in well 199-F8-4 (in the southeastern 100-F Area).

Gross alpha was analyzed in most of the 100-F Area wells sampled during the reporting period. Well 199-F8-3 had the highest concentration (12 pCi/L). The DWS for gross alpha is 15 pCi/L.

17.2.6 Chromium

Hexavalent chromium concentrations in groundwater exceed the aquatic standard, but most concentrations in aquifer tubes were below the aquatic standard.

Hexavalent chromium is of potential concern to salmon and other aquatic life. The aquatic standard for hexavalent chromium is 10 µg/L. Three wells located near the 116-F-14 retention basins and the 116-F-9 Trench had levels above 20 µg/L[1] in recent data (Figure 17-9). The highest chromium concentrations in the 100-F Area were in well 199-F5-6 (56.0 µg/L for unfiltered and 53.7 µg/L for filtered samples). Figure 17-10 shows the chromium trends in the three wells with the highest concentrations.

Chromium levels are low in 100-F Area aquifer tubes. The only aquifer tubes with concentrations above 10 µg/L were tube C6303 (near the known groundwater plume) at 14.7 µg/L and tube 75-D (~2 kilometers downstream) at 11.3 µg/L. There

1 20 µg/L is an interim cleanup level for the 100-KR-4 and 100-HR-3 OUs, based on ambient surface water quality criteria with 1:1 dilution applied (EPA/ROD/R10-96/134, *Declaration of the Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units*).

are no known chromium sources near aquifer tube 75-D, so it is likely that the contamination moved southward from the 100-F Area.

17.2.7 Additional Contaminants of Potential Concern

Table 17-1 lists contaminants of potential concern for groundwater that were identified in DOE/RL-2008-46-ADD4. The table lists the maximum concentrations detected in groundwater in CY 2009; these data are provided for information only. Not all of the constituents were analyzed under the routine groundwater sampling and analysis plan, and the proposed well list in the addendum is not the same as that in the routine groundwater sampling and analysis plan. Under the new work plan addendum, monitoring wells will be sampled for the contaminants of potential concern three times in CY 2010 (see Section 17.3).

17.3 CERCLA Groundwater Activities

Groundwater sampling requirements are defined in the groundwater sampling and analysis plan (DOE/RL-2003-49) and a *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989) change notice (TPA-CN-228). All of the wells scheduled for sampling during the reporting period were sampled successfully (Appendix A, Table A-10). Two seeps could not be sampled; seep sampling depends on field conditions and is not always possible.

In CY 2009, a draft remedial investigation/feasibility study work plan addendum (DOE/RL-2008-46-ADD4) and draft sampling and analysis plan (DOE/RL-2009-43, *Sampling and Analysis Plan for the 100-F/IU-2/IU-6 Decision Unit Remedial Investigation/Feasibility Study*) were released for review by the U.S. Environmental Protection Agency (EPA). The documents are related to the *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan* (DOE/RL-2008-46) and describe data to be collected to support selection of final remedies under CERCLA. The approach integrates the data needs for waste sites and groundwater. The draft work plan addendum and sampling and analysis plan for the 100-F Area were revised in response to EPA's comments and were approved in early 2010. The data and results will be reported in a remedial investigation/feasibility study report, which will lead to selection of alternatives for final remedial action decisions. Three new groundwater monitoring wells will be installed for the remedial investigation/feasibility study:

- A well to define the chromium plume west of well 199-F5-6
- A well to define the strontium-90 plume south of the 116-F-14 retention basins
- A well screened in the Ringold upper mud unit.

As part of a study of groundwater upwelling in the river channel (see Chapter 21.0), porewater samples were collected from depths of ~0.3 meter in the river bottom at 27 locations along the 100-F Area segment of shoreline. Only one sample contained a detectable level of hexavalent chromium (8 µg/L), which is below the aquatic standard. The DOE is continuing the upwelling study in 2010 and will publish a report of the results.

Chromium concentrations in porewater from the Columbia River bed were below the aquatic standard.

17.4 Conclusions and Recommendations

Groundwater beneath the 100-F Area is contaminated with chromium, nitrate, strontium-90, and trichloroethene at levels above the DWSs or aquatic standards. The contaminant plumes are present at the top of the aquifer. Their vertical extent is unknown because no wells are monitoring at depth in the unconfined aquifer.

Three new wells are proposed as part of CERCLA investigations (DOE/RL-2008-46-ADD4). Two wells will be drilled to the bottom of the unconfined aquifer and screened at the depth with the highest levels of contamination in water samples (or at the top of the aquifer if no significant vertical variability is found). One well will be drilled ~15 meters into the Ringold upper mud unit and screened in a water-bearing zone. Geologic and groundwater chemistry data from the new wells will be used to help characterize the hydrogeology and contaminant distribution.

Additional data are needed to support the final CERCLA remedy for the 100-F Area. The remedial investigation/feasibility study work plan addendum will be implemented in CY 2010 so the necessary data can be gathered.

During the reporting period, 39 wells were sampled as scheduled for the objectives of CERCLA and the AEA (Appendix A, Table A-10). Only one of three seeps could be sampled. Routine groundwater monitoring will continue in CY 2010 and will be coordinated with remedial investigation/feasibility study sampling.

Table 17-1. Contaminants of Potential Concern for 100-F Area Groundwater.

Contaminant	Maximum Concentration in CY 2009 (Filtered/Unfiltered)	Number of Analyses	Comment
1,1-Dichloroethene	ND	11	--
Antimony	ND/38.4 µg/L	52	--
Arsenic	--	0	Not analyzed
Beryllium	ND	52	--
Cadmium	ND	52	--
Carbon tetrachloride	ND	11	--
Chloroform	ND	11	--
Chromium (hexavalent)	ND/ND	7	Only analyzed in well 199-F8-7
Chromium (total)	53.7/56 µg/L	52	--
Cobalt	ND	52	--
Copper	5.1/5.6 µg/L	52	--
Fluoride	694 µg/L	26	--
Lead	--	0	Not analyzed
Manganese	37.4/48 µg/L	52	--
Mercury	--	0	Not analyzed
Nickel	19.2/20.7 µg/L	52	--
Nitrate	126 mg/L	26	--
Selenium	--	0	Not analyzed
Styrene	--	0	Not analyzed
Strontium-90	12 pCi/L	12	--
Sulfate	180 mg/L	26	--
Tetrachloroethene	3.59 µg/L	11	Flagged "J" (estimated value, near detection limit)
Thallium	--	0	Not analyzed
Trichloroethene	13 µg/L	11	--
Tritium	3,200 pCi/L	17	--
Vinyl chloride	ND	11	--
Zinc	4,980/5,100 µg/L ND/14.3[a]	52	--
Additional radionuclides[b]	--	0	Not analyzed

Notes:

Contaminants of potential concern are from *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 4: 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100 IU 6 Operable Units* (DOE/RL200846ADD4). Sampling under that addendum had not yet begun in 2009. Wells are those listed in the routine groundwater sampling and analysis plan (DOE/RL-2003-49, *100-FR-3 Operable Unit Sampling and Analysis Plan*, as modified by Tri-Party Agreement change notice TPA-CN-228).

a. Second set of data excludes 600 Area wells.

b. Americium-241, carbon-14, cesium-137, cobalt-60, europium-154, iodine-129, plutonium-238, plutonium239/240, and thorium-230.

CY = calendar year

ND = not detected

Tri-Party Agreement = *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989)

Figure 17-1. Facilities and Groundwater Monitoring Wells in the 100-F Area.

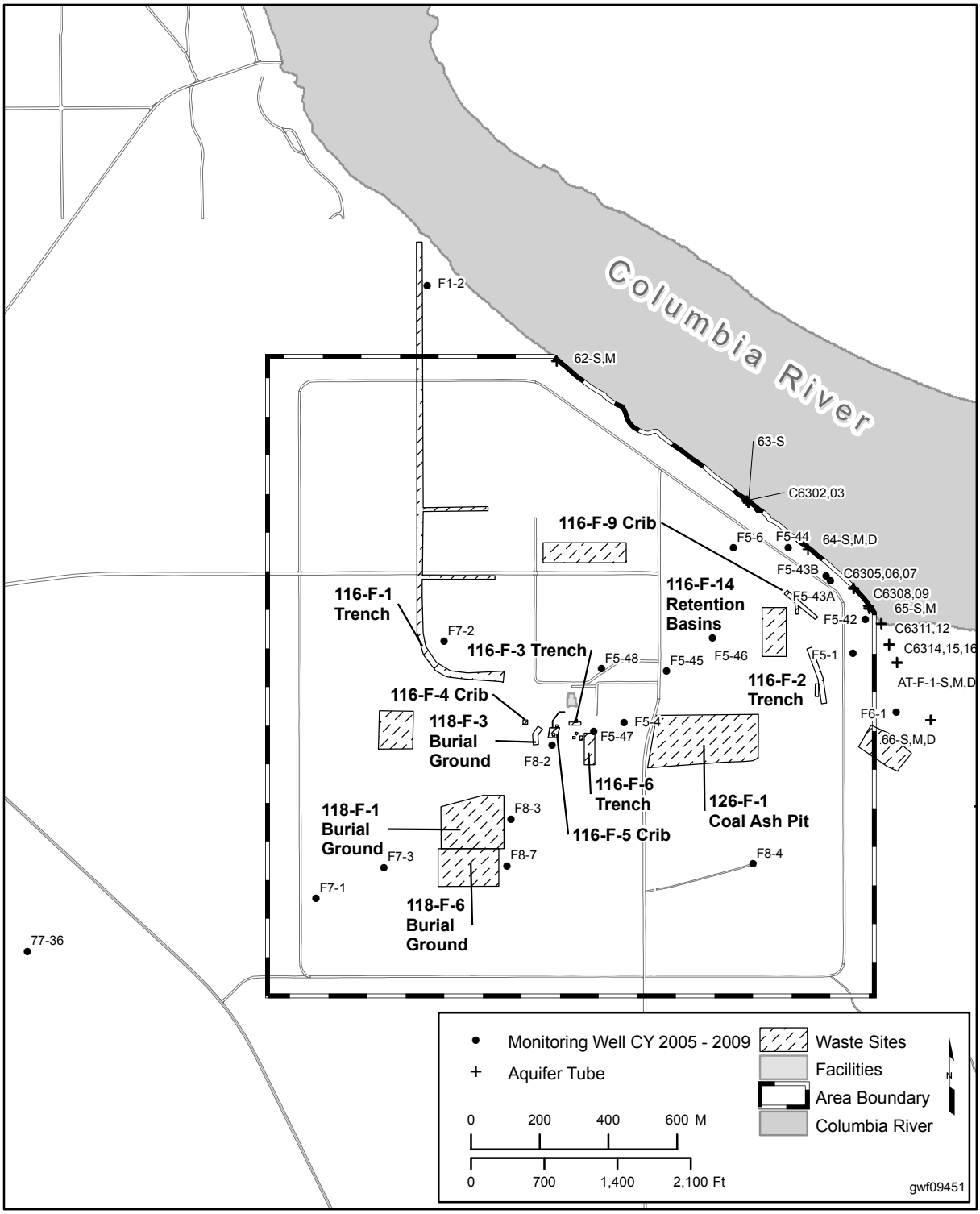


Figure 17-2. 100-F Area Water Table Map, March 2009.

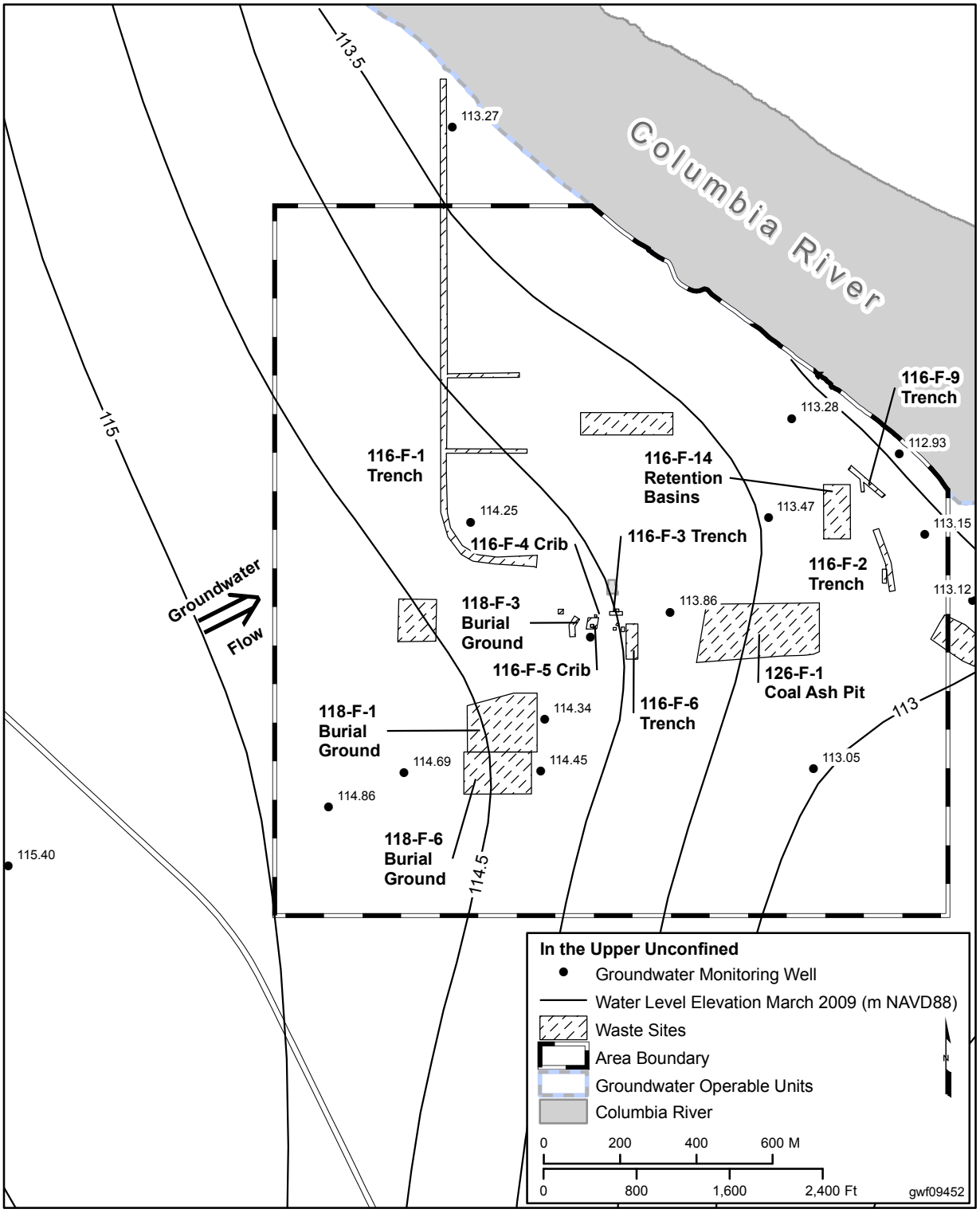


Figure 17-3. Average Nitrate Concentrations in the 100-F Area Vicinity, Upper Portion of Unconfined Aquifer.

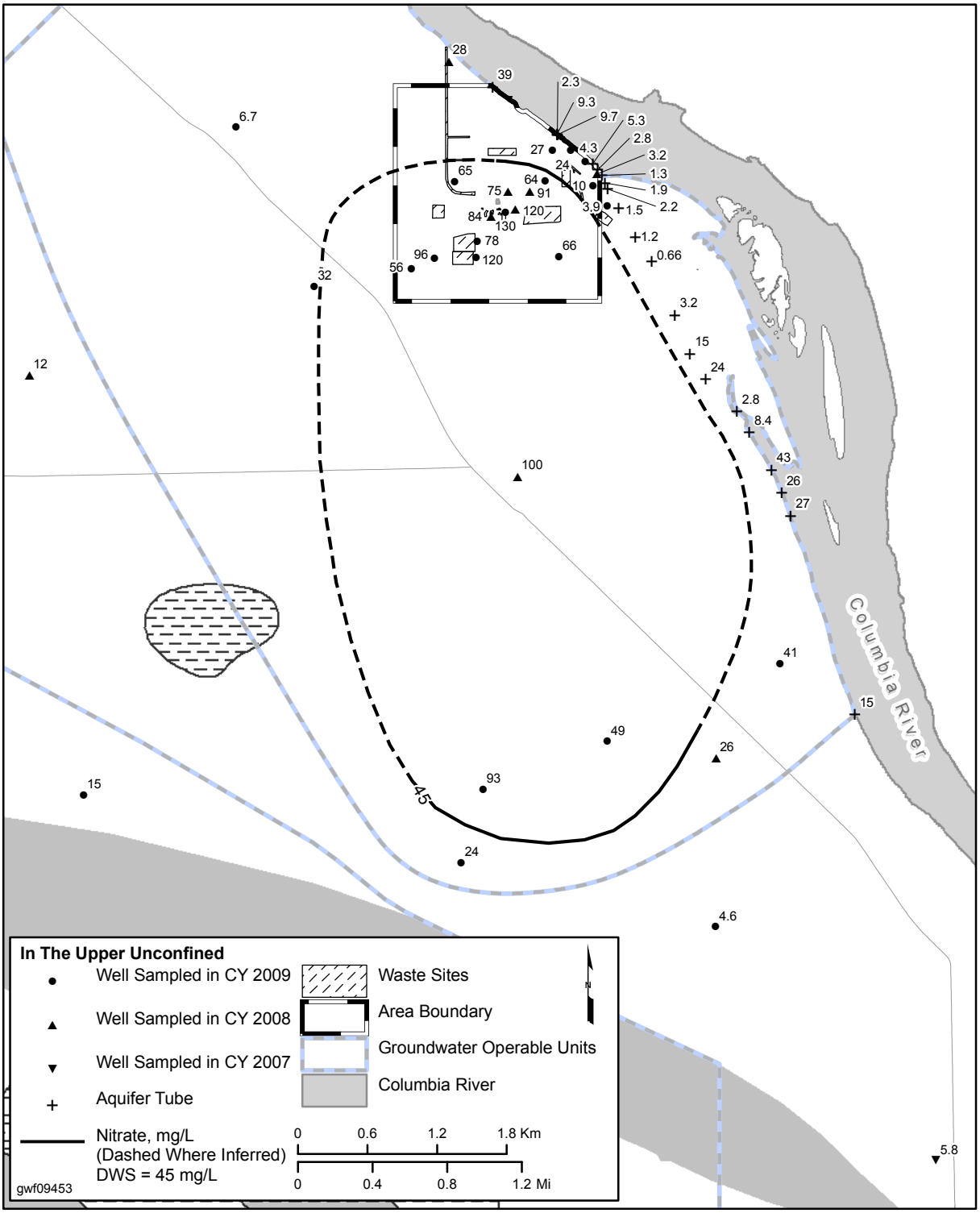


Figure 17-4. Nitrate Concentrations in Central (199-F5-47) and Southwestern (199-F7-3) 100-F Area.

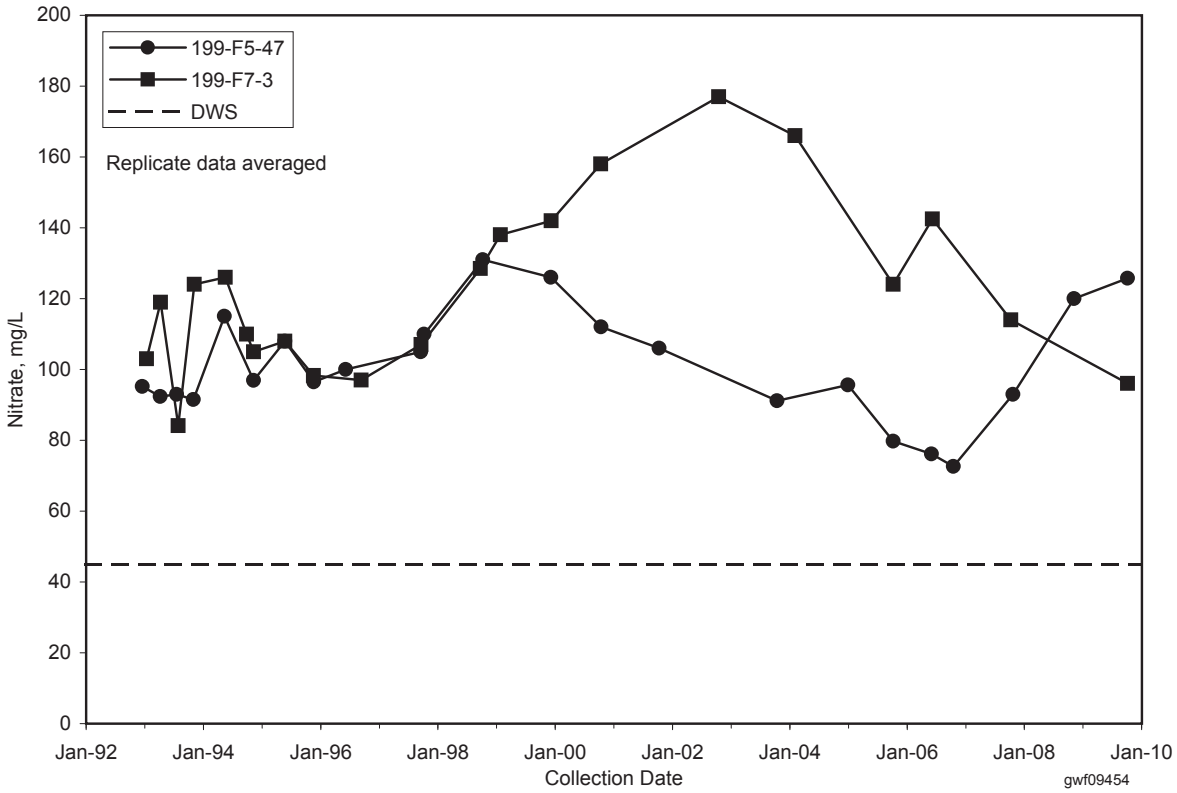


Figure 17-5. Average Strontium-90 Concentrations in the 100-F Area, Upper Portion of Unconfined Aquifer.

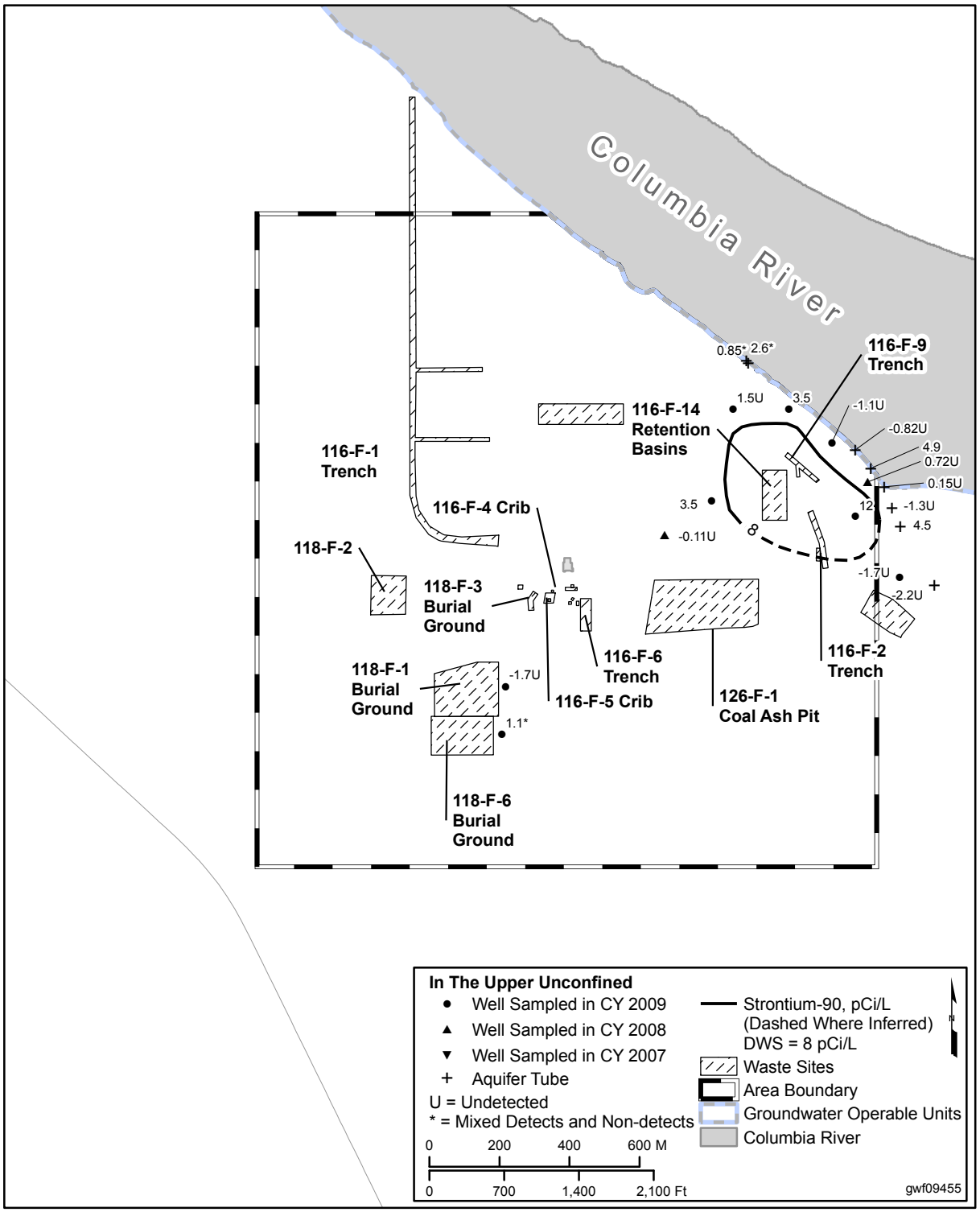


Figure 17-6. Strontium-90 Concentrations in Wells Monitoring the Eastern 100-F Area.

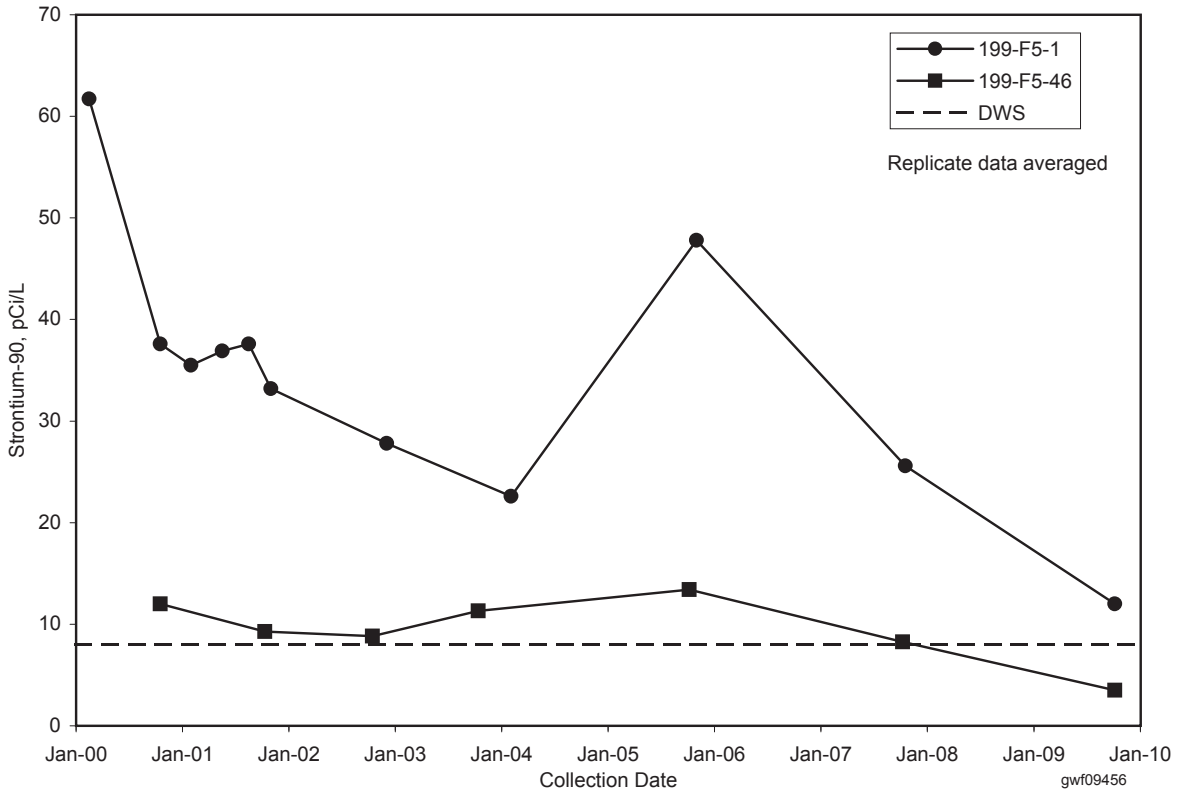


Figure 17-7. Average Trichloroethene Concentrations in the 100-F Area, Upper Portion of Unconfined Aquifer.

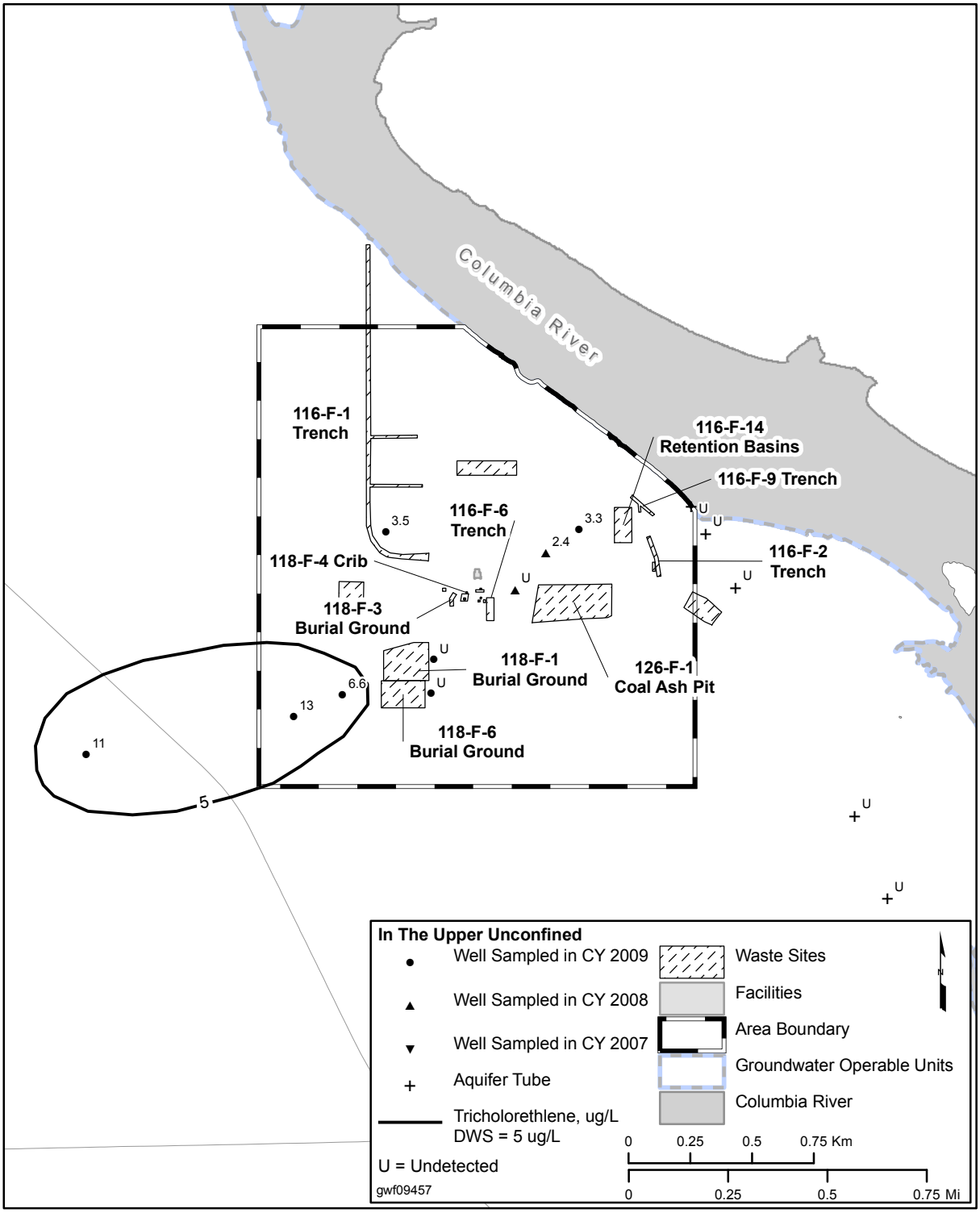


Figure 17-8. Trichloroethene Concentrations in Wells Monitoring the Southwestern 100-F Area.

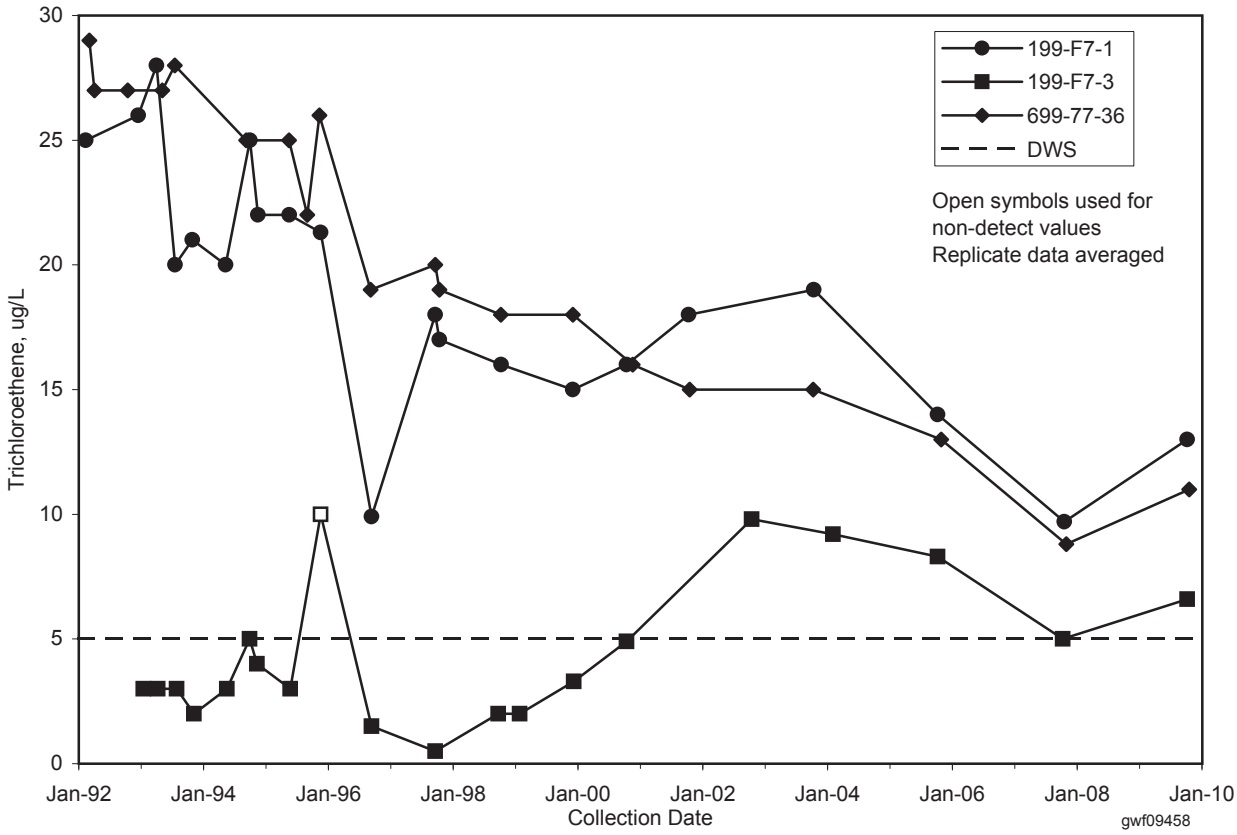


Figure 17-9. Average Chromium Concentrations in the 100-F Area, Upper Portion of Unconfined Aquifer.

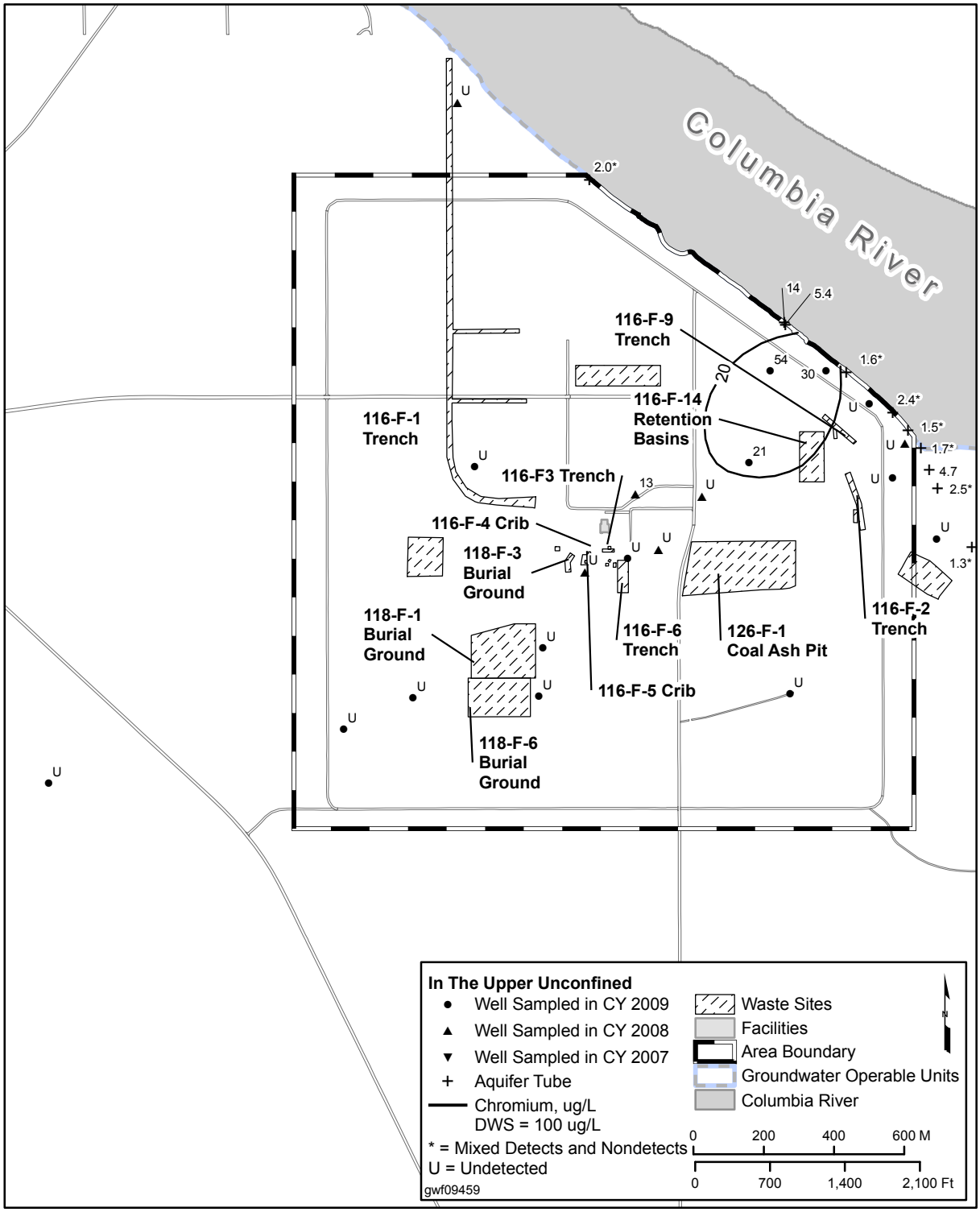
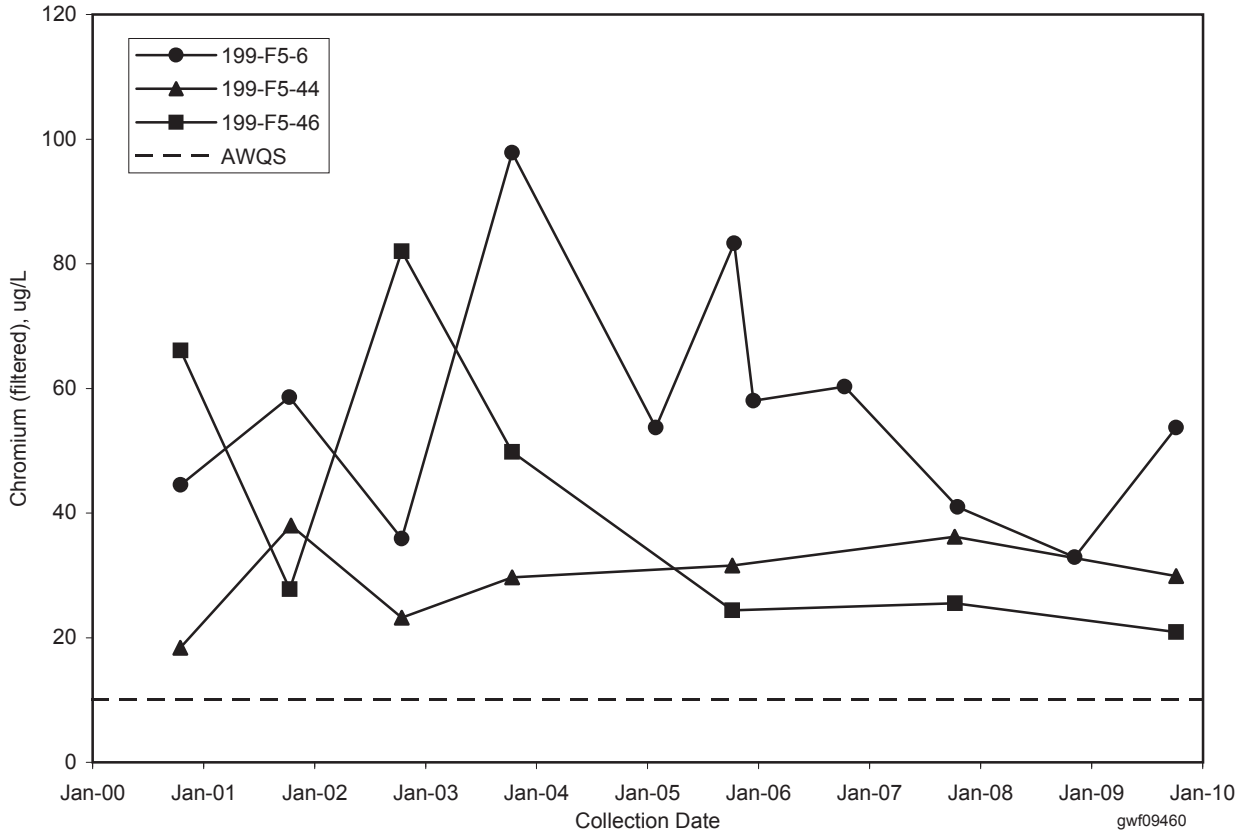


Figure 17-10. Chromium Concentrations in Wells Monitoring the Eastern 100-F Area.



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