2.6 100-FR-3

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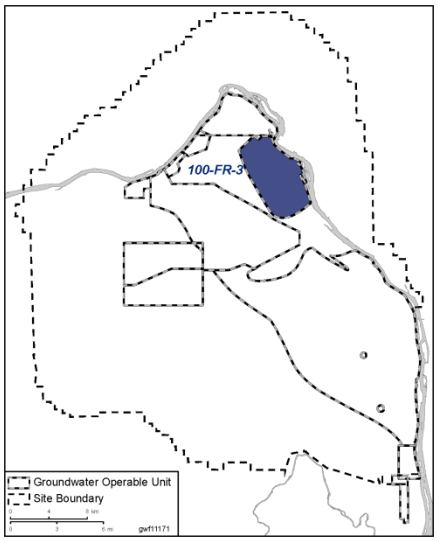
This chapter describes groundwater flow and contaminant distribution in the vicinity of the 100-F Area, which is known as the 100-FR-3 Operable Unit. Figure 2.6-1 shows facilities, wells, and shoreline monitoring sites in 100-FR-3. Chapters 2 and 3 of DOE/RL-2008-46-ADD4 provide additional information on 100-F history, waste sites, and hydrogeology.



Groundwater monitoring for the AEA is integrated fully with CERCLA monitoring. No active waste disposal facilities or RCRA sites are in 100-FR-3. Previous assessments have not resulted in any interim remedial measures for groundwater. Most of the waste sites in the 100-F have been remediated or are classified as not requiring remediation. The area is currently undergoing a CERCLA RI, which will provide data to support final cleanup decisions.

The vadose zone and the unconfined aquifer in 100-FR-3 comprise Hanford formation sand and gravel. Ringold Formation unit E is largely absent in this region, limited to isolated remnants. The bottom of the aquifer is the Ringold upper mud unit. The aquifer ranges from 1 to 8 meters thick. Most of the monitoring wells are screened across all, or nearly all, of the aquifer.

Near the Columbia River, the direction of groundwater flow beneath 100-FR-3 varies with the Columbia River stage. Figure 2.6-2 shows the water table in March 2011, when the river was at a moderate level. The map indicates a flow direction toward the east-northeast (toward the river) in the western portion of 100-FR-3 and toward the southeast (approximately parallel to the river) in the eastern portion. Figure 2.1-3 in Section 2.1 illustrates the regional water table in this area. Southeast of 100-F, the water table slopes very gently at elevations ranging from 111 to 112 meters. This is approximately the same elevation as the Columbia River at this location. Consequently, the average direction of groundwater flow in this region is approximately parallel to the river.
The shoreline topography in this area is low and flat, and the shore is submerged during the high river stage (spring and early summer).

100-FR-3 at a Glance

F Reactor Operations: 1945–1965

Biological Experiments: 1945–1976

2011 Groundwater Monitoring

Contaminant	Drinking Water Standard	Maximum Concentration	Plume Area[a] (km^2)	Shoreline Impact (m)
Nitrate	45 mg/L	201	10.6	0
Hexavalent Chromium	10/48[b] µg/L	23.5	0.17[c]	100[c]
Strontium-90	8 pCi/L	270	0.07	0
Trichloroethene	5 µg/L	14	0.70	0

Remediation

Waste Sites (interim action): >85% complete[d].

Groundwater (interim action): None.

Final ROD anticipated in 2013.

a. Estimated area above drinking water standard.

b. 10 µg/L aquatic standard; 48 µg/L groundwater cleanup standard.

c. At the 10 µg/L level.

d. Waste sites with status of closed, interim closed, no action, not accepted, or rejected.

Normal seasonal variability in the water table in 100-FR-3 is more than 3 meters in wells near the river and decreases farther inland. During times of high river stage, water levels rise in the aquifer near the river, and a "valley" forms in the water table. Groundwater from east and west converges and moves toward the southeast, approximately parallel to the river. Flow may be influenced by a buried paleochannel of highly transmissive sediments. The changing river stage can affect concentrations in near-river wells temporarily, but the effects are local and short-lived. Spring and fall 2010 plume maps showed little difference (Chapter 8 of DOE/RL-2011-01). Most wells in 100-FR-3 were sampled once in 2011.

100-FR-3 Operable Unit Sampling and Analysis Plan (DOE/RL-2003-49) describes the routine groundwater monitoring requirements. Wells are sampled for the contaminants of concern selected using the data quality objectives process (PNNL-14287) (Appendix A). Most of the wells are sampled once per year or once every other year. Three wells installed in 2010 for the RI/FS have not yet been incorporated formally into the groundwater sampling and analysis plan. They were sampled quarterly during 2011 (Appendix A).

A subset of 100-FR-3 aquifer tubes is scheduled for annual sampling in the fall. All but one of the tubes were sampled in late 2011. Some 100-FR-3 tubes were also sampled in early 2011, delayed from the event scheduled in fall 2010. Appendix D lists sampling dates for the aquifer tubes.

Groundwater contaminants in 100-FR-3 include hexavalent chromium, nitrate, strontium-90, trichloroethene, and tritium. Figure 2.6-3 shows changes in plume sizes since 2003. Some of the apparent changes in plume sizes were the result of new data and not an actual change in size. These changes are discussed in the following sections.

2.6.1 Nitrate

A large nitrate plume from past sources in 100-FR-3 extends southward approximately 5 kilometers, although data are limited south of the 100-F Area (Figure 2.6-4). The size of the plume is stable, within the limits of what can be determined by the monitoring network. Because there are so few monitoring wells defining the large plume, the data are open to various interpretations. Changes in interpretation account for changes in the plume estimates illustrated on Figure 2.6-3.

Figure 2.6-5 shows nitrate trends in the three wells with the highest concentrations. Concentrations have declined since 2002 in well 199-F7-3 in southwestern 100-FR-3. New well 199-F5-54, in eastern 100-FR-3, had variable concentrations since it was installed in 2010, with a 2011 maximum of 145 mg/L. Temporary well 199-F5-56, near the F Reactor building, was sampled for nitrate for the first time in December 2011 and had the highest concentration in 100-FR-3 at 201 mg/L.

Aquifer tubes 62-M (northern 100-FR-3) and 75-D (approximately 2 kilometers downstream) historically have had the highest nitrate concentrations. Concentrations declined in these tubes in 2011 (Figure 2.6-6). The 2011 plume was interpreted to be narrower based on these changes.

2.6.2 Trichloroethene

Trichloroethene concentrations in the unconfined aquifer underlying southwestern 100-FR-3 (Figure 2.6-7) exceed the drinking water standard (5 µg/L), but are declining. 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 west of 100-F Area. Trichloroethene concentrations declined in wells in this region between 2010 and 2011 (Figure 2.6-8). The monitoring wells are screened across the entire aquifer thickness, which is less than 3 meters in this location.

Wells in other portions of the 100-F Area also detect trichloroethene at concentrations that fluctuate around the drinking water standard. Wells sampled in 2011 had concentrations below the standard.

One well in the 600 Area, approximately 6 kilometers west of 100-FR-3, consistently has trichloroethene concentrations above the drinking water standard. Concentrations have ranged from 7 to 11 µg/L in well 699-77-54 between 2005 and 2011. Figure 2.1-4 in Section 2.1 shows the location of this well. This contamination is not connected to the more prominent plume near 100-F Area, and its source has not been determined. It was not investigated during the RI.

2.6.3 Hexavalent Chromium

Sources of hexavalent chromium in 100-FR-3 included cribs near the reactor buildings, trenches, retention basins near the Columbia River, and pipelines from the reactor buildings to these near-river facilities. In 2011, soil contaminated with chromium was found in Waste Site 100-F-57, near the F Reactor building. The site was excavated to remove contaminated soil down to the water table (13 to 14 meters below ground surface) and is being backfilled in 2012. Other hexavalent chromium sources were previously remediated.

Figure 2.6-9 illustrates the portion of the chromium plume with concentrations greater than 10 µg/L in 2011. Wells 199-F5-6 and 199-F5-46 exhibited the highest concentrations in 2011 (~25 µg/L), and concentrations are declining with time (Figure 2.6-10).

Two 100-FR-3 wells are screened in a water-bearing zone of the Ringold upper mud unit, and concentrations of hexavalent chromium are near or below detection limits. Both are located within the footprint of the plume in the unconfined aquifer.

Hexavalent chromium concentrations in groundwater exceed the aquatic water quality standard in a few wells, but concentrations entering the river are below the standard.

Data from aquifer tubes and Columbia River pore water samples indicate that concentrations of hexavalent chromium entering the river are below the ambient water quality standard (10 µg/L). Two aquifer tubes formerly had concentrations slightly above the standard, but levels have declined (Figure 2.6-11). Columbia River pore water samples were collected near the 100-F Area in 2010 and early 2011. Hexavalent chromium concentrations were below detection limits at most locations. A single sample in 2010 exceeded the ambient water quality standard, but the result was questionable because the total chromium concentration was lower than that of the hexavalent; subsequent sampling showed no detectable chromium. All 2011 results were below the ambient water quality standard. Results are described in *Columbia River Pore Water Sampling in 100-F Area, February 2011* (SGW-49575).

2.6.4 Strontium-90

Primary sources of strontium-90 included the 116-F-14 Retention Basins and 116-F-2 Trench in the eastern 100-F Area. Additional sources were present near the reactor building and burial grounds. In eastern 100-FR-3, two wells had concentrations above the 8 pCi/L drinking water standard in 2011 (Figure 2.6-12). Data from aquifer tubes and pore water samples indicate that the plume does not reach the Columbia River at concentrations above the standard.

Two new temporary wells were sampled in December 2011 and had the highest strontium-90 concentrations in 100-FR-3 groundwater. These boreholes were installed in former waste sites to characterize the vadose zone and were completed as monitoring wells to obtain representative groundwater samples. Well 199-F5-55, in the center of the strontium-90 plume at the 116-F-14 retention basins, had a concentration of 270 pCi/L. Although there currently are no other wells adjacent to the retention basins, decommissioned well 199-F5-3 formerly had concentrations comparable to those detected in 199-F5-55 (Figure 2.6-13; see Figure 2.6-1 for well location). The next nearest downgradient well, 199-F5-1, has much lower concentrations.

Two new wells in former waste sites had higher concentrations of strontium-90 than have been seen in other wells in recent years.

Temporary well 199-F5-56, near the F Reactor building, had a concentration of 80 pCi/L in December 2011. This is the only well in this part of 100-FR-3 with strontium-90 concentrations above the drinking water standard. Nearby wells historically had strontium-90 concentrations ranging from less than the detection limit up to approximately 7 pCi/L, and strontium-90 is no longer analyzed at some of these wells. The contamination detected in 199-F5-56 is evidently part of a small, local plume. It is recommended that strontium-90 be added to the constituent lists for wells downgradient of this location, to watch for movement of the plume in the future.

Duplicate groundwater samples from characterization borehole C7971 in the 118-F-1 Burial Ground had strontium-90 concentrations of 7.99 and 8.5 pCi/L in February 2011. Wells 199-F8-3 and 199-F8-7 had lower concentrations (undetected and 5.5 pCi/L, respectively).

Strontium-90 shows vertical stratification in the only shallow/deep well pair in 100-FR-3. Deep well 199-F5-43B, which monitors a water-producing zone in the Ringold Formation upper mud unit, consistently has no detectable strontium-90. Its shallow counterpart screened in the unconfined aquifer, 199-F5-43A, typically has strontium-90 detections of 2 to 4 pCi/L.

2.6.5 Other Contaminants

Tritium concentrations in groundwater beneath 100-FR-3 have not exceeded the drinking water standard (20,000 pCi/L) since 2001. At lower concentrations, a plume extends to the southeast. Historically, tritium concentrations in groundwater samples from 199-F8-3 in southern 100-FR-3 have exceeded the drinking water standard. In the mid-1990s, concentrations at this well were approximately 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 likely caused by plume movement, dispersion, and radioactive decay. In 2011, the tritium concentration in 199-F8-3 was 12,000 pCi/L, an increase from 2010.

Uranium exceeded the drinking water standard in one new, temporary well.

The RI/FS work plan for 100-F (DOE/RL-2008-46-ADD4) did not identify uranium as a contaminant of potential concern for groundwater because uranium concentrations have historically been below the drinking water standard (30 µg/L). However, uranium is monitored in selected wells under the routine groundwater sampling and analysis plan (DOE/RL-2003-49). In 2011, new temporary well 199-F5-56, near the F Reactor building, was sampled for uranium with a result of 35 µg/L. The contamination is of limited extent. Nearby wells had uranium concentrations ranging from 11 to 15 µg/L in 2010 and 2011, which are consistent with Hanford Site background levels (Table ES-1 of DOE/RL-96-61, *Hanford Site Background: Part 3, Groundwater Background*). DOE will continue to monitor this and other 100-FR-3 wells for uranium to track trends.

The 100-F RI work plan identified an extensive list of groundwater contaminants of potential concern (Table 4-3 of DOE/RL-2008-46-ADD4). Evaluation of the RI data concluded that only hexavalent chromium, nitrate, strontium-90, and trichloroethene remain contaminants of concern for groundwater (Section 6.3 of DOE/RL-2010-98, in progress).

2.6.6 CERCLA Groundwater Activities

In 2011, CERCLA activities associated with groundwater continued RI studies and routine groundwater monitoring.

Routine groundwater sampling requirements are defined in the groundwater sampling and analysis plan (DOE/RL-2003-49), as modified by TPA-CN-241, *Change Notice for Modifying Approved Documents/Workplans in Accordance with the Tri-Party Agreement Action Plan, Section 9.0, Documentation and Records, 100-FR-3 Operable Unit Sampling and Analysis Plan, DOE/RL-2003-49, Rev. 1 and TPA-CN-228 (July 14, 2008)*.

Fieldwork related to an RI/FS (DOE/RL-2008-46-ADD4) was performed in 2010 and early 2011. A draft RI/FS report (DOE/RL-2010-98) is being prepared, which will lead to the selection of alternatives for final action site cleanup. The draft report will undergo review by regulatory agencies and the public.

Well sampling occurred as planned in 2011 (Appendix A). The sampling and analysis plan does not yet include new wells installed for the RI/FS and should be updated. The new wells have been sampled quarterly for 1 year and will be sampled once in 2012. Two temporary monitoring wells, originally drilled as vadose zone boreholes under the RI, will also be sampled in 2012.

Figure 2.6-1. Facilities and Groundwater Monitoring Wells in 100-FR-3

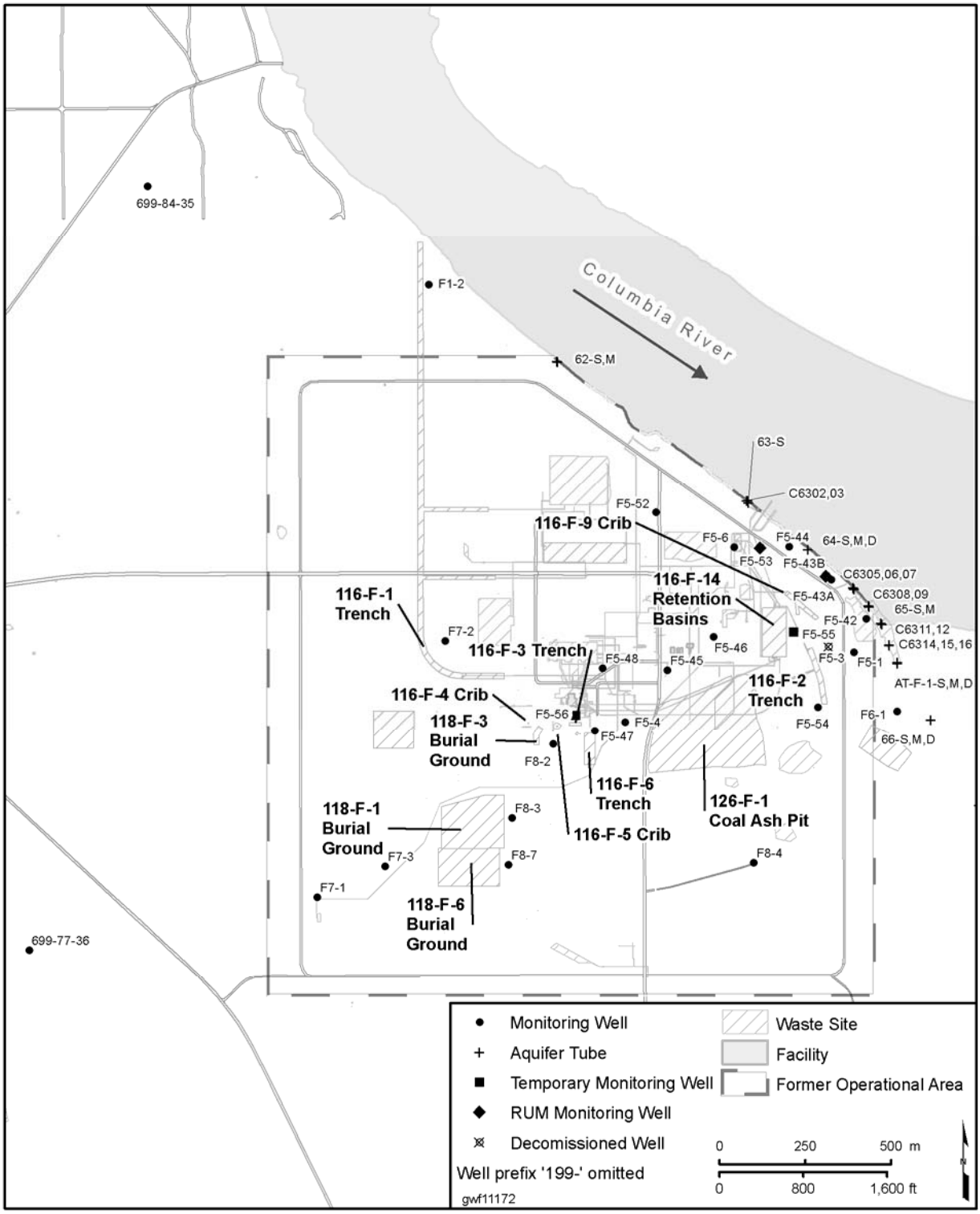


Figure 2.6-2. 100-FR-3 Water Table, March 2011

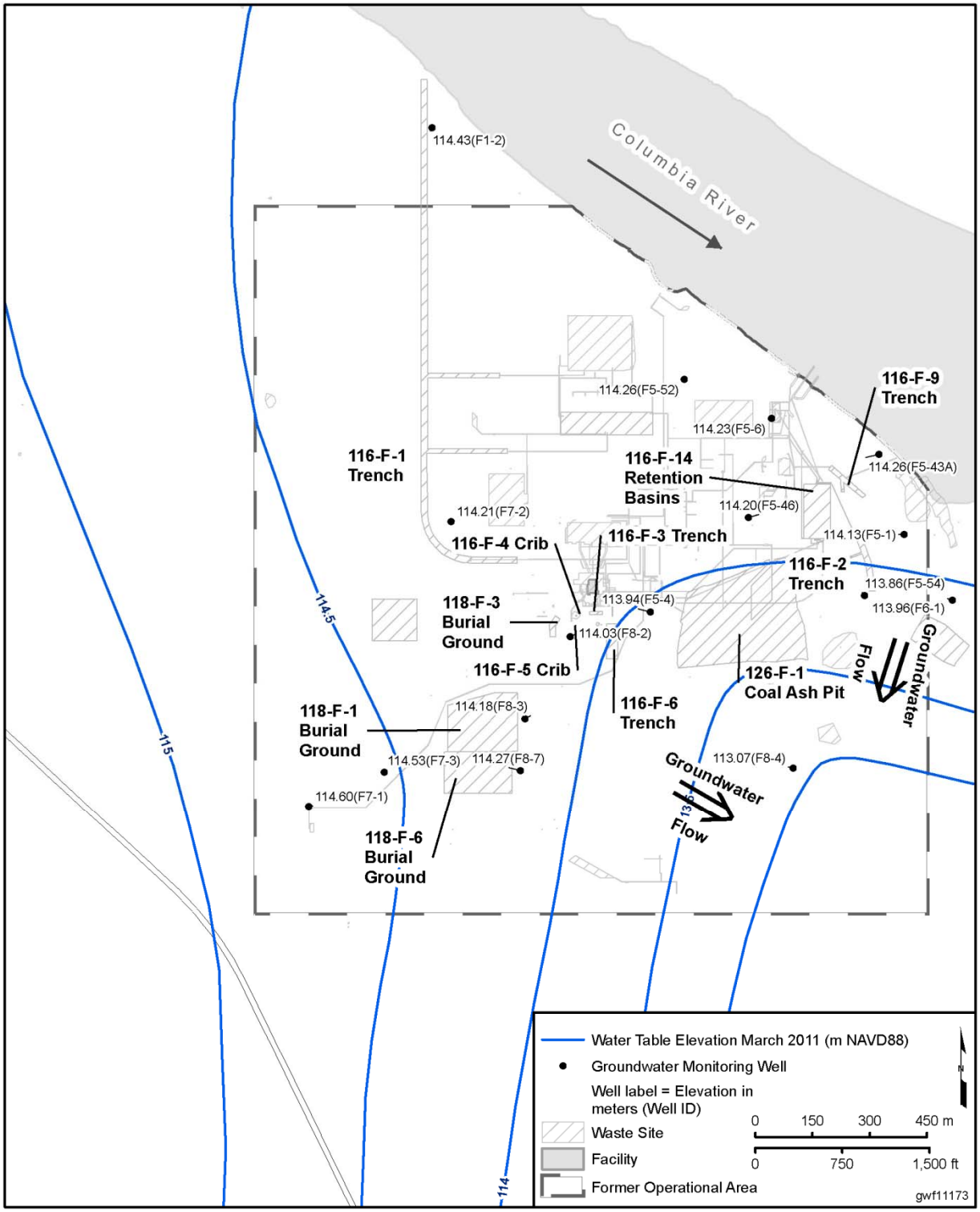


Figure 2.6-3. Changes in 100-FR-3 Plume Areas

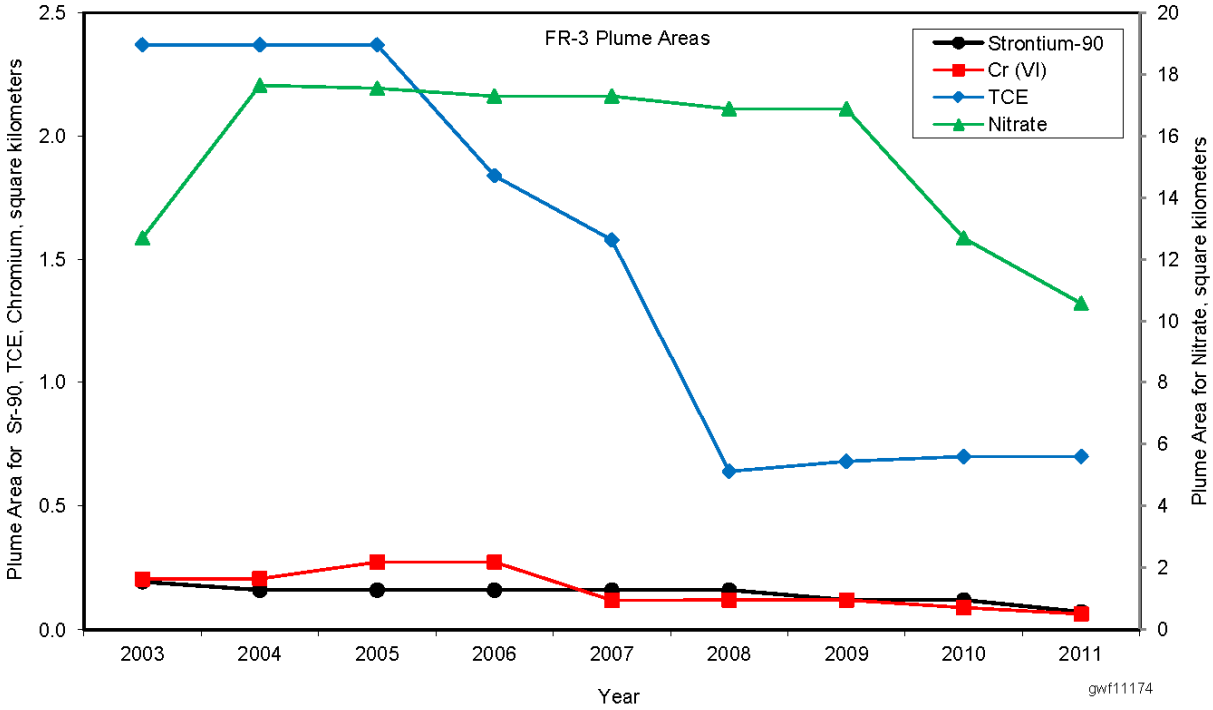


Figure 2.6-4. Average Nitrate Concentrations in 100-FR-3 and Vicinity, Upper Part of Unconfined Aquifer, 2011

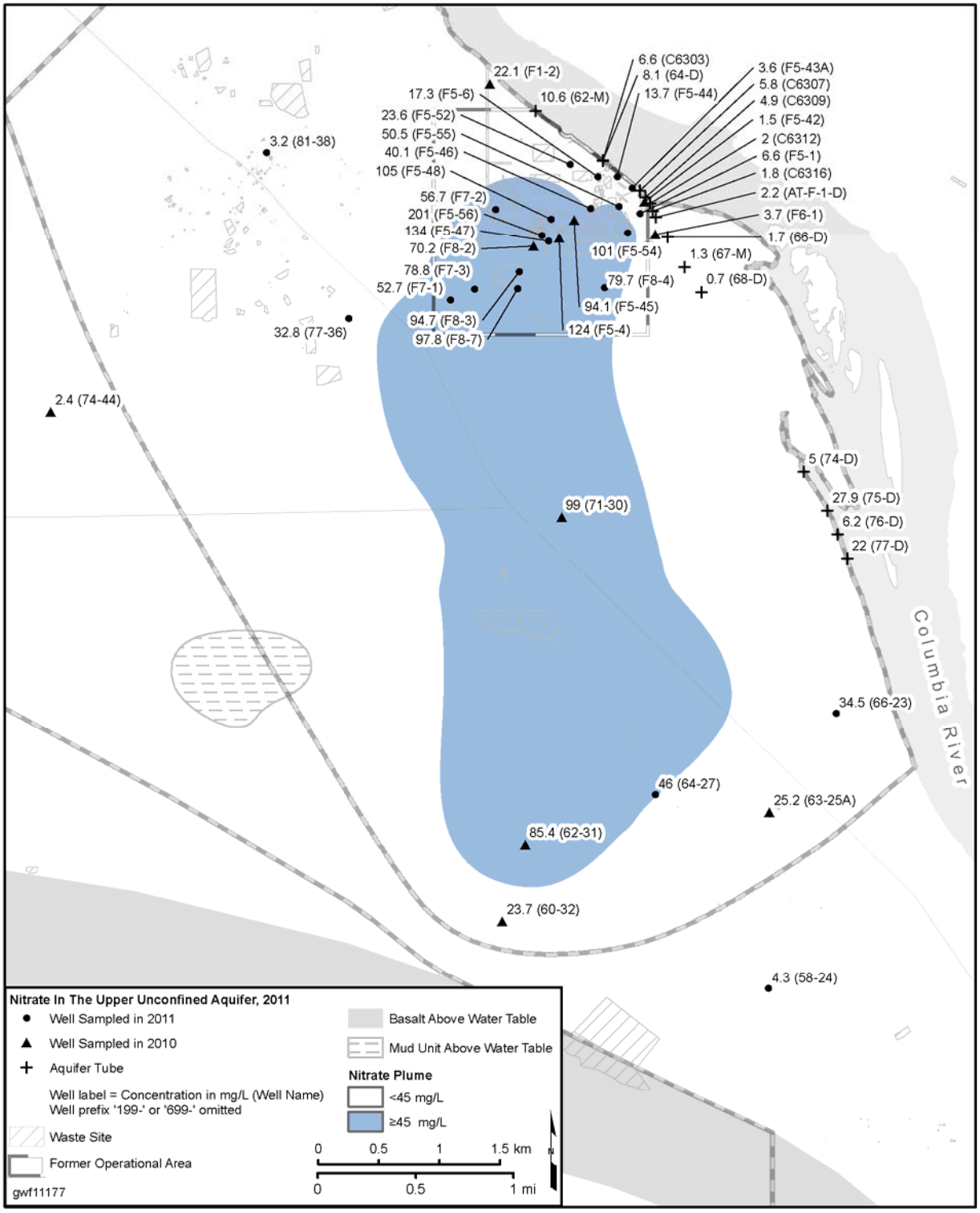


Figure 2.6-5. Nitrate Trends in Wells in 100-FR-3

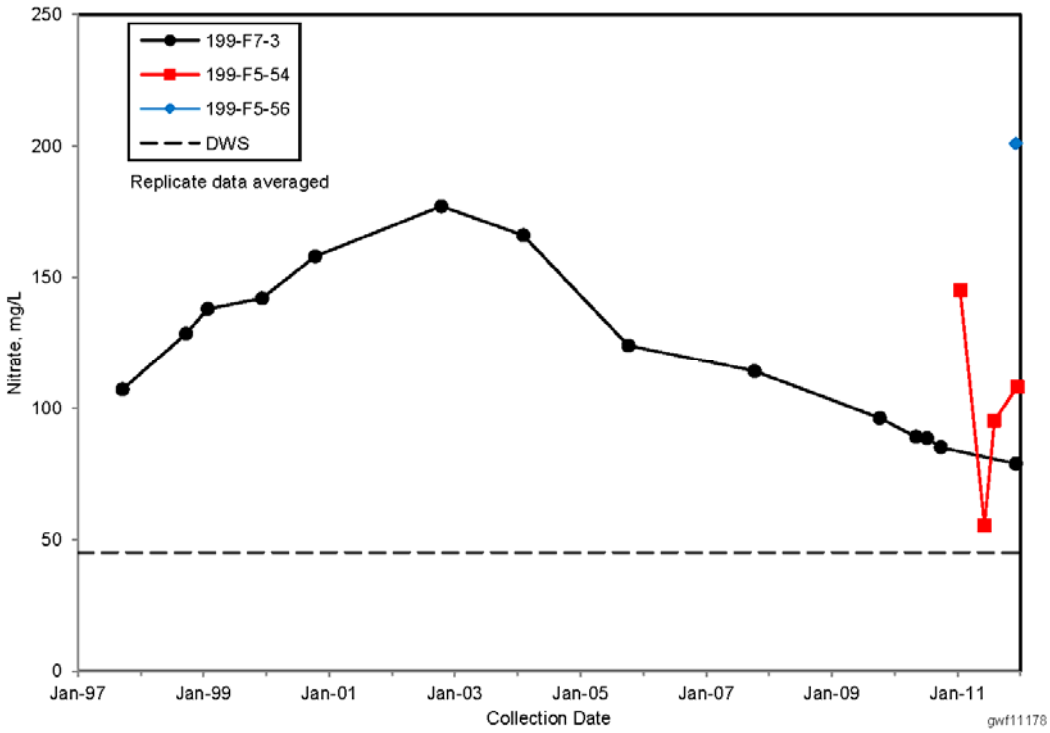


Figure 2.6-6. Nitrate Trends in 100-FR-3 Aquifer Tubes

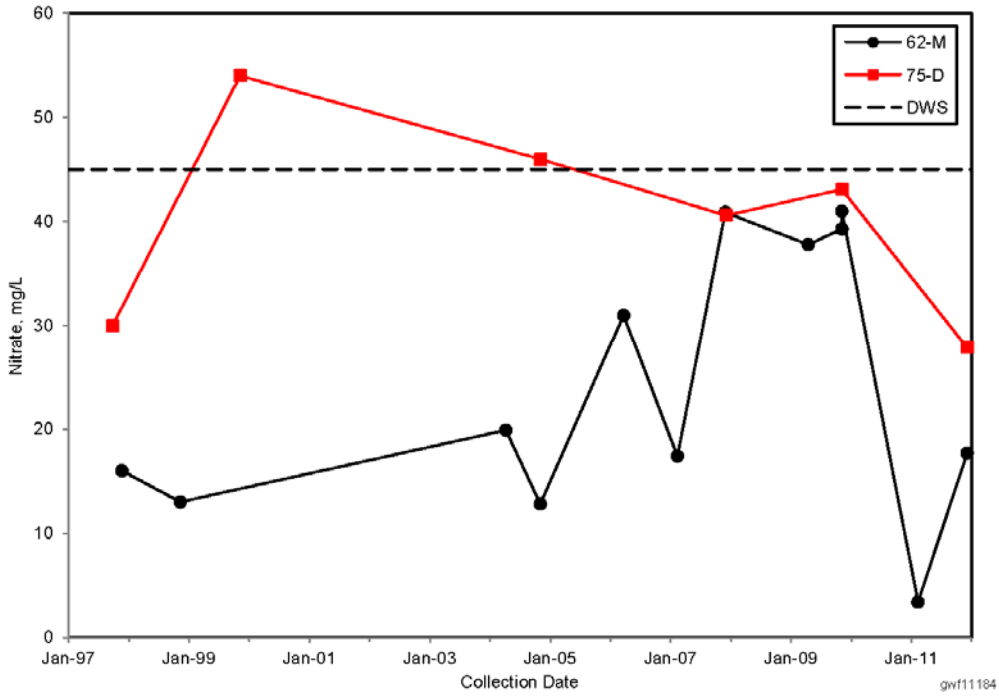


Figure 2.6-7. Average Trichloroethene Concentrations in 100-FR-3, Upper Part of Unconfined Aquifer, 2011

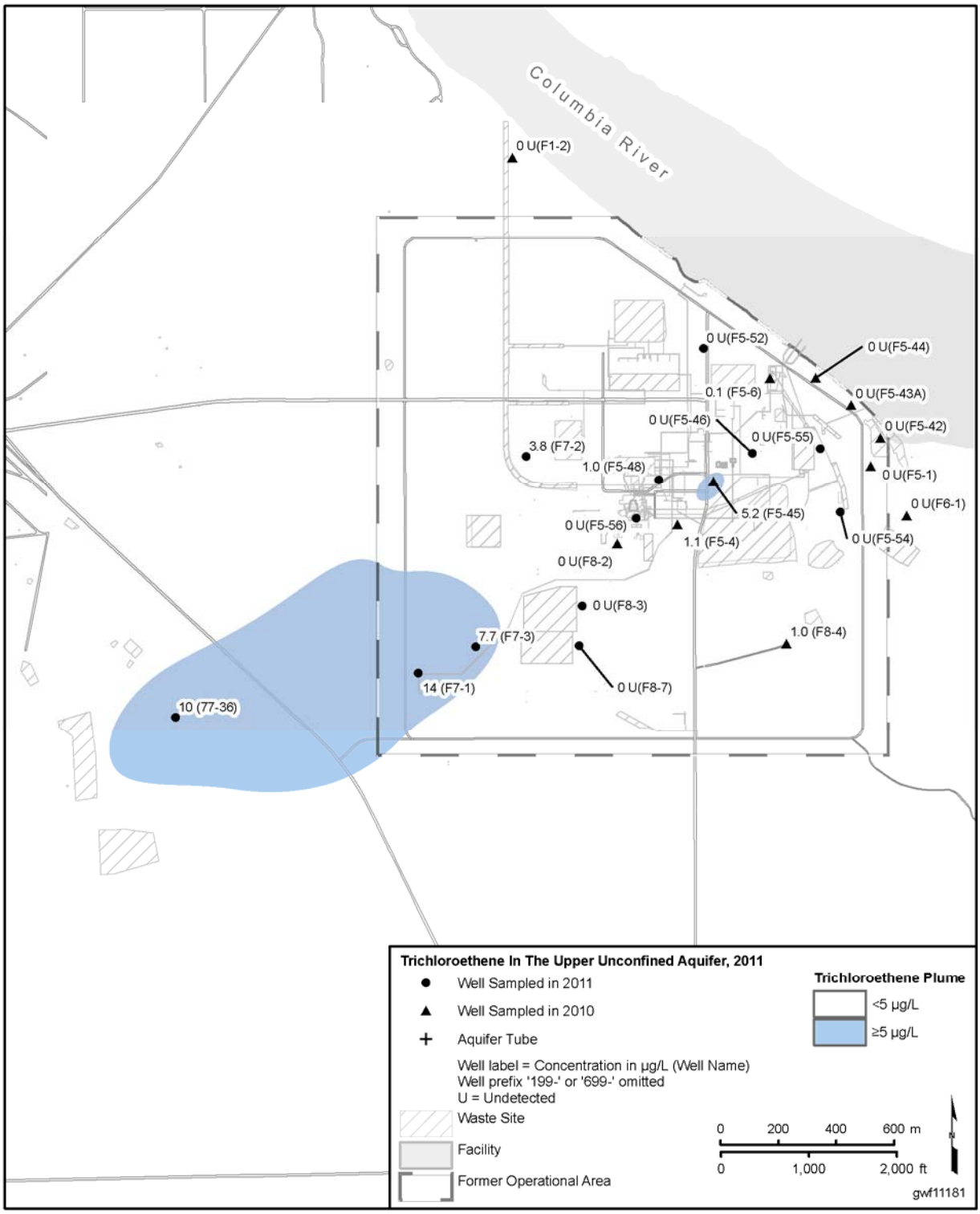


Figure 2.6-8. Trichloroethene Trends in Wells in Western 100-FR-3

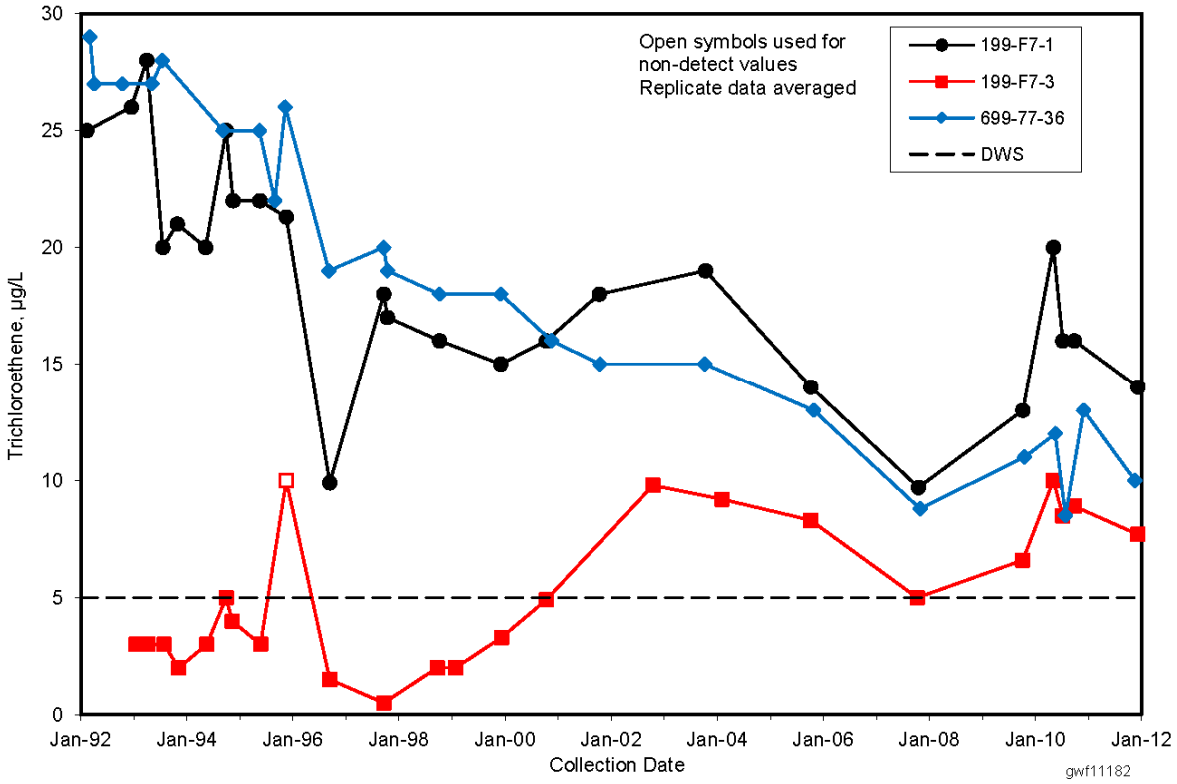


Figure 2.6-9. Average Chromium Concentrations in 100-FR-3, Upper Part of the Unconfined Aquifer, 2011

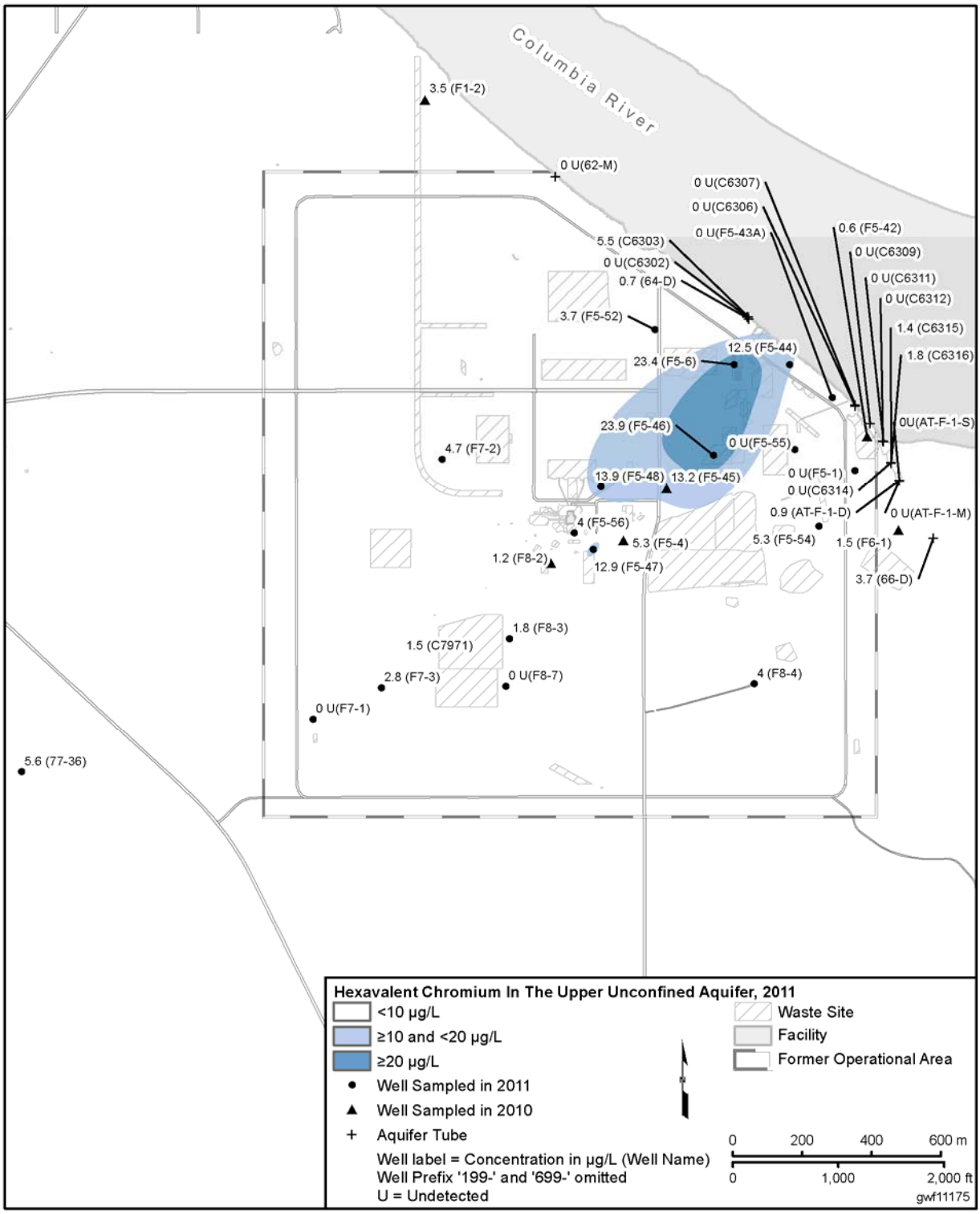


Figure 2.6-10. Dissolved Chromium Trends in Wells in Eastern 100-FR-3

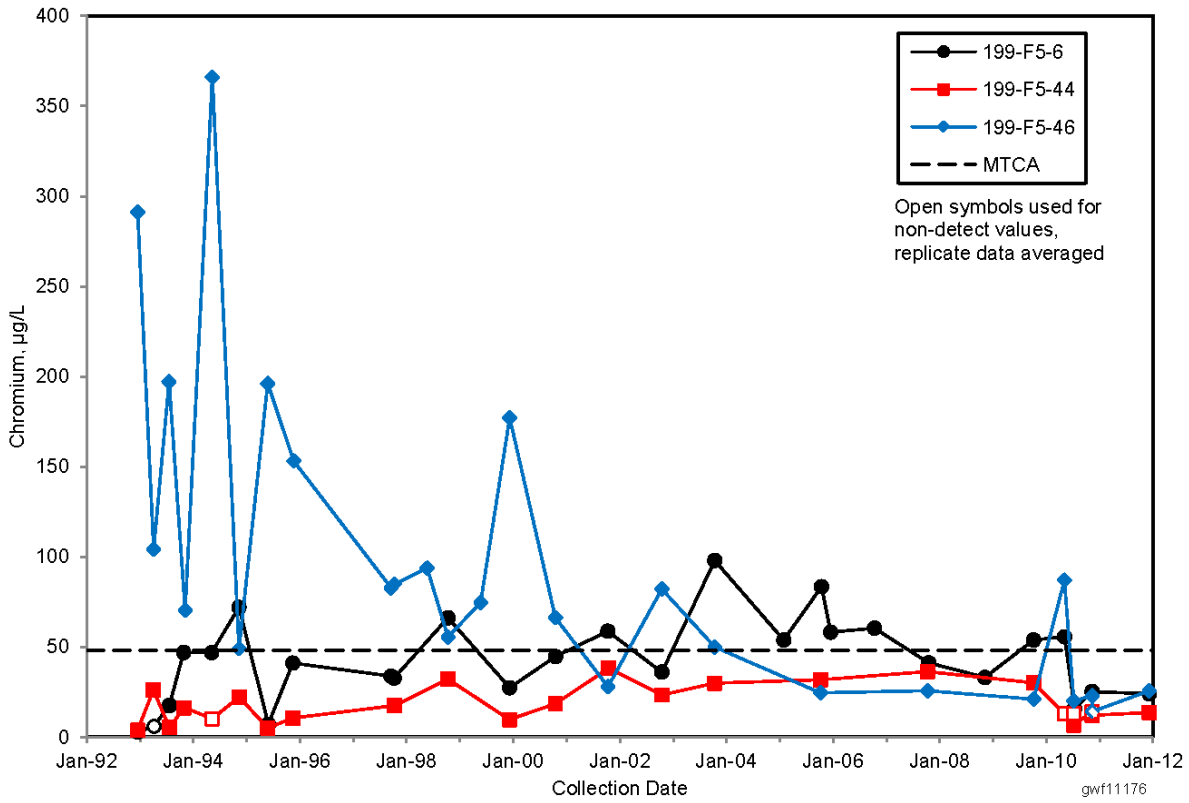


Figure 2.6-11. Hexavalent Chromium Trends in 100-FR-3 Aquifer Tubes

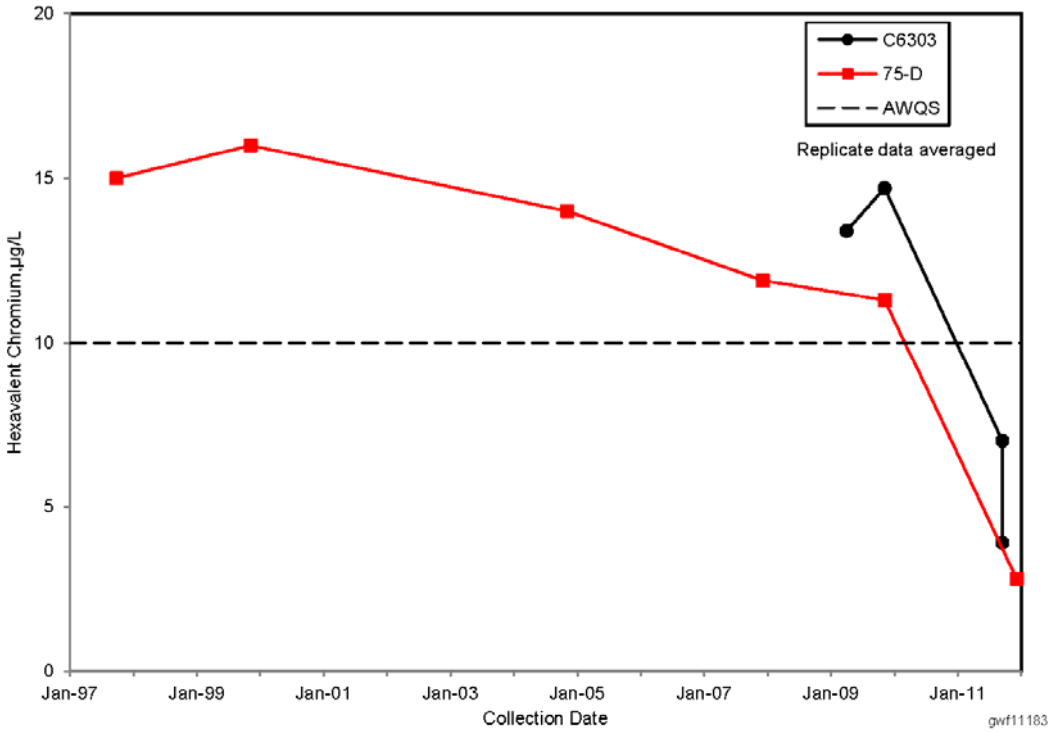


Figure 2.6-12. Average Strontium-90 Concentrations in 100-FR-3, Upper Part of Unconfined Aquifer, 2011

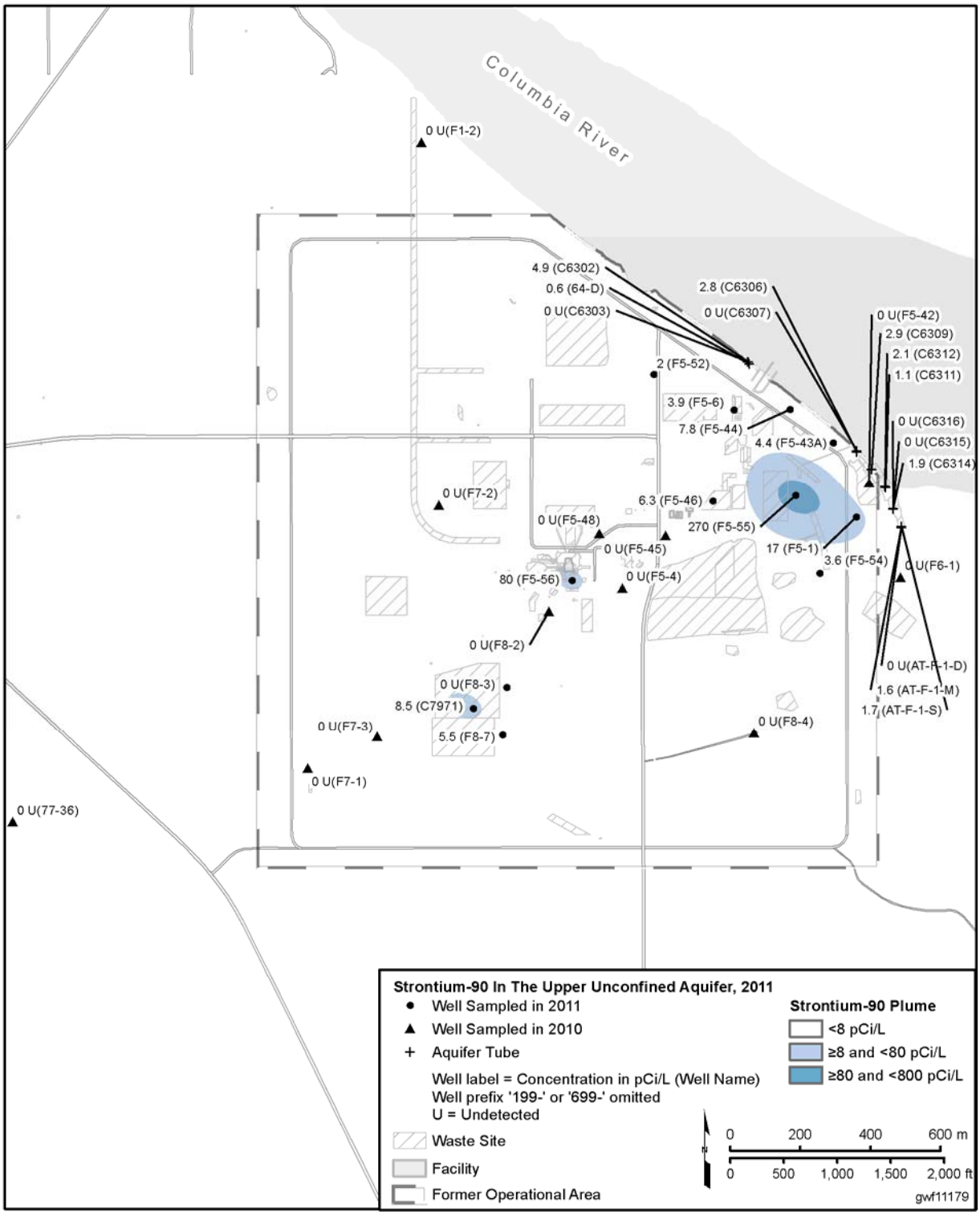
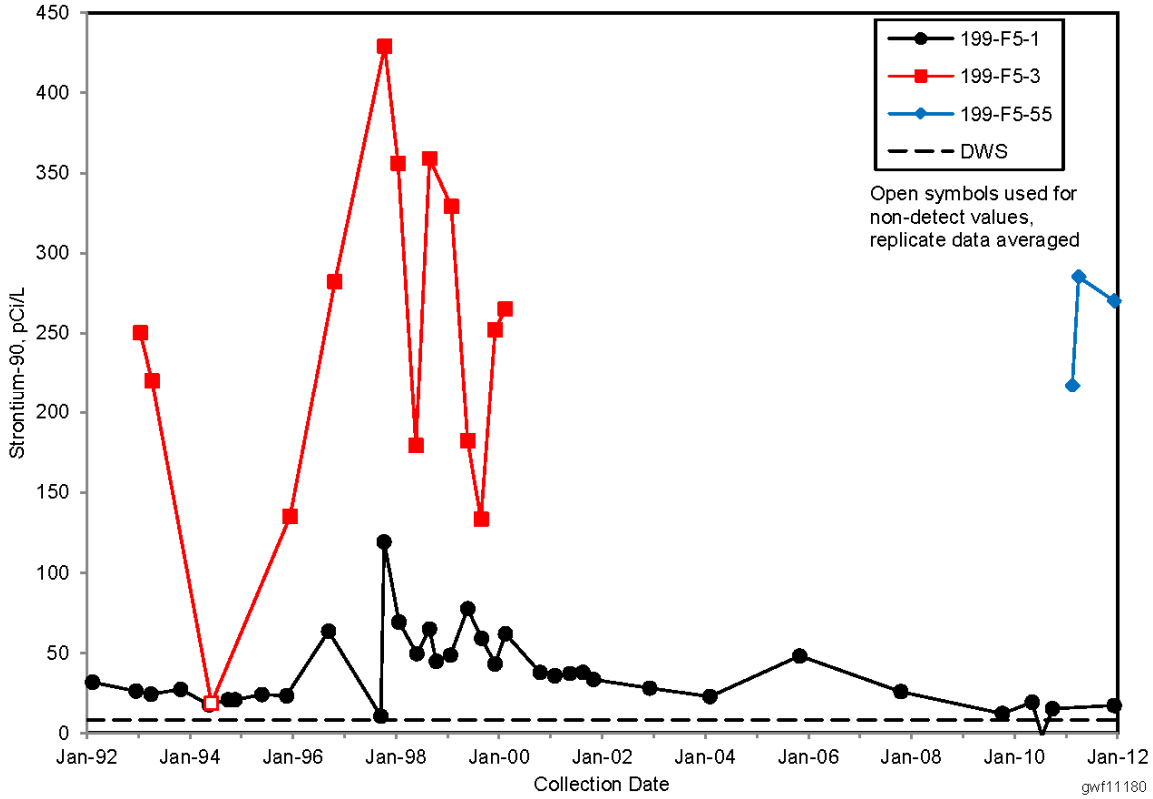



Figure 2.6-13. Strontium-90 Trends in Wells in Eastern 100-FR-3