

3 100-FR

3.1 Overview

The 100-FR groundwater interest area includes the 100-FR-3 OU and surrounding region. One nuclear reactor operated at 100-FR between 1945 and 1965. Groundwater contamination originated from waste sources related to reactor operations and biological experiments that continued until 1976. Table 3-1 summarizes key facts about 100-FR and additional details about 100-FR history and waste sites are provided in [DOE/RL-2010-98](#). As of 2014, waste site remediation in 100-FR is 100 percent complete (Table 3-1).

DOE monitors 100-FR groundwater to meet CERCLA and AEA requirements. Groundwater COCs are nitrate, TCE, hexavalent chromium, and strontium-90 ([DOE/RL-2010-98](#)). Figures 3-1 and 3-2 show the locations of groundwater monitoring wells and aquifer sampling tubes. Figure 3-3 shows how plume areas have changed over the years. Section 1.3 provides plume mapping details, including descriptions of terms in figure legends (e.g., Type 1 Control Point).

Previous assessments have not resulted in any interim remedial measures for groundwater in 100-FR. EPA signed a final CERCLA ROD in September 2014 (*Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2 and 100-IU-6 Operable Units* [\[EPA et al., 2014\]](#)).

Table 3-1. 100-FR at a Glance

| F Reactor operations: 1945–1965 | | | | |
|---|--|--------------------------|--|----------------------|
| Biological experiments: 1945–1976 | | | | |
| 2014 Groundwater Monitoring | | | | |
| Contaminant | Cleanup Level ^a | Maximum Concentration | Plume Area ^b (km ²) | Shoreline Impact (m) |
| Nitrate | 45 mg/L ^c | 146 mg/L (199-F5-56) | 7.9 | 0 |
| Hexavalent chromium | 48 µg/L ^d / 10 µg/L ^d | 29 µg/L (199-F5-46) | 0/0.58 ^e | 0 |
| Strontium-90 | 8 pCi/L | 144 pCi/L (199-F5-55) | 0.13 | 0 |
| Trichloroethene | 4 µg/L | 15.3 µg/L (199-F7-1) | 1.0 | 0 |
| Remediation | | | | |
| Waste sites in 100-FR-1 and 100-FR-2 OU (interim action): 100 percent complete^f | | | | |
| Final ROD signed in 2014 | | | | |
| MNA for groundwater | | | | |

a. Cleanup levels from [EPA et al. \(2014\)](#)

b. Estimated area at a concentration greater than the listed level.

c. 45 mg/L as NO₃ is equivalent to the drinking water standard of 10 mg/L as N.

d. 48 µg/L in upland groundwater and 10 µg/L where groundwater discharges to surface water.

e. Plume area >10 µg/L in 100-F Area is 0.58 km². Wells in western part of interest area not included because the 10 µg/L standard does not apply to inland areas.

f. Sites with status of closed, interim closed, no action, not accepted, or rejected. Two sites not covered by interim action are proposed as “no further action,” and a third site, the reactor, is considered separately.

COCs = contaminants of concern

DWS = drinking water standard

MNA = monitored natural attenuation

OU = Operable Unit

ROD = Record of Decision

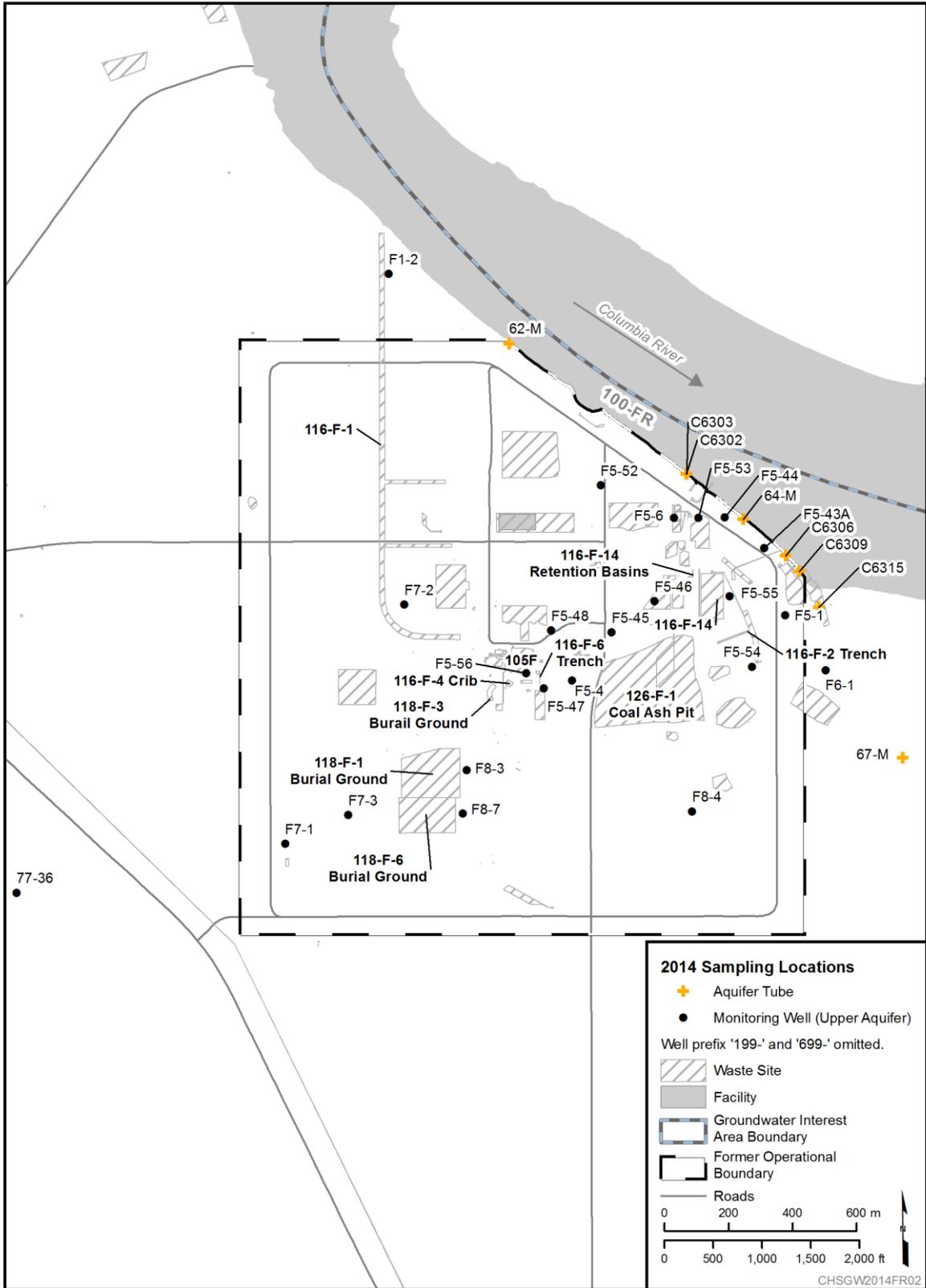


Figure 3-1. 100-FR Sample Locations

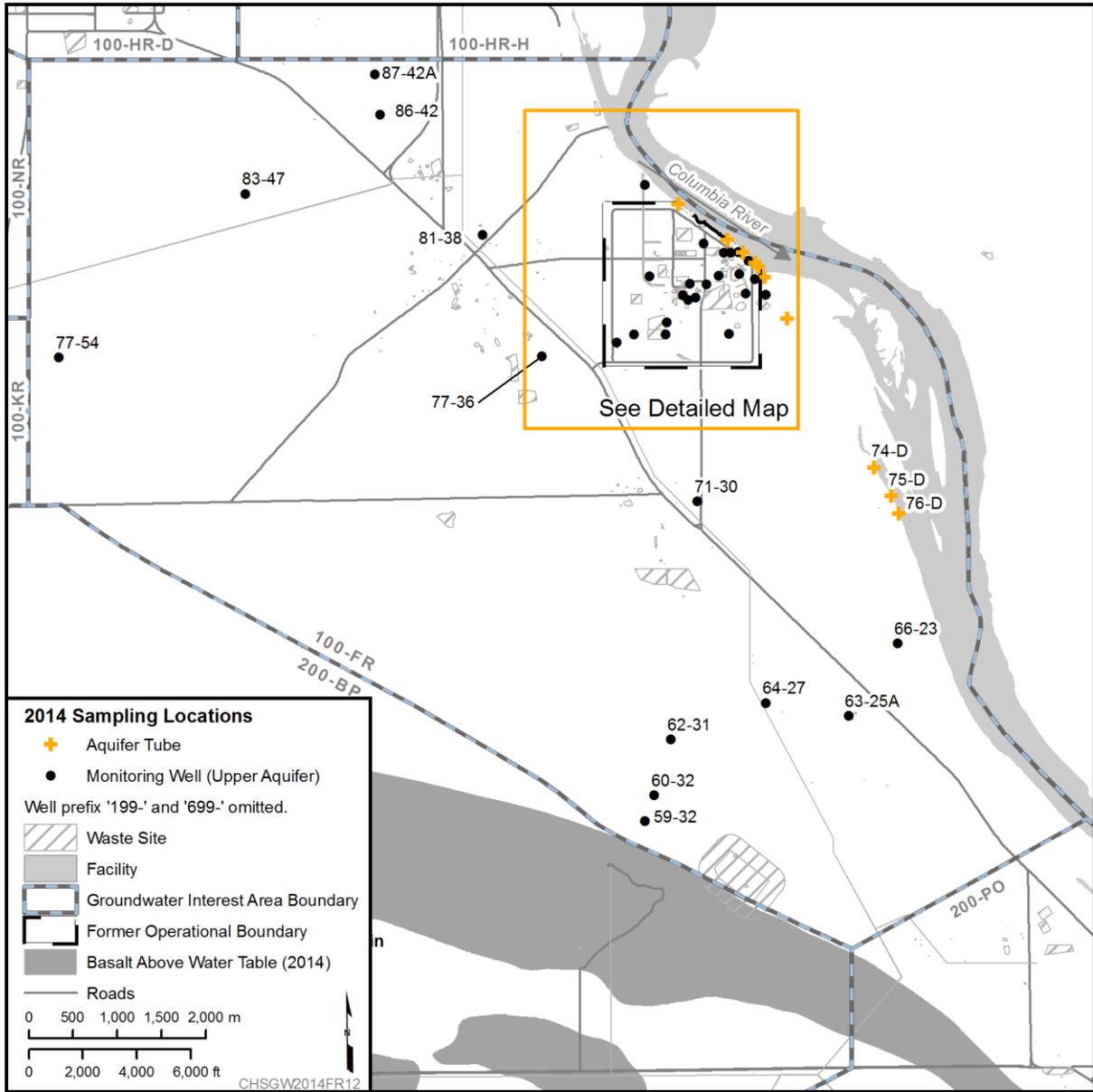


Figure 3-2. 100-FR Sample Locations in Outlying Area

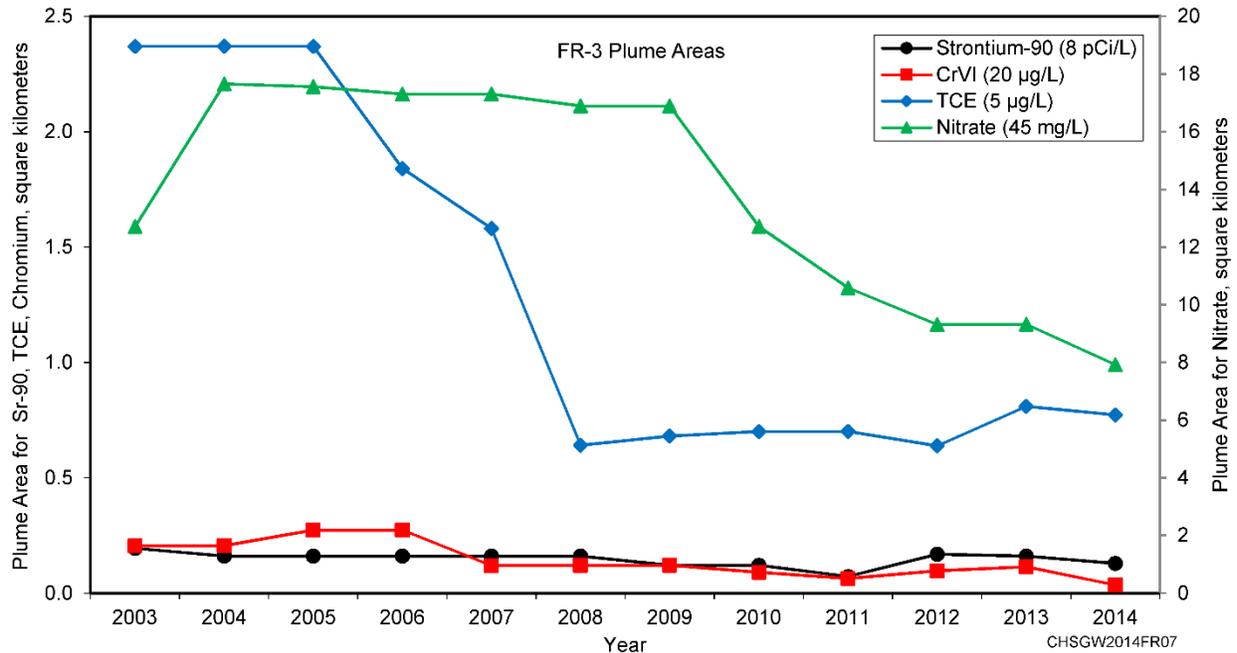


Figure 3-3. 100-FR-3 Plume Areas

Figure 3-4 includes water table contours based on data collected in March 2014. In the northern portion of the 100-F Area, groundwater flow is to the northeast, toward the river. In the southern 100-F Area, groundwater flows primarily to the east and then curves to the southeast. Southeast of the 100-F Area, the water table slopes very gently at elevations ranging from 110 to 112 m (361 to 368 ft). This is approximately the same elevation as the Columbia River at this location. Consequently, the average direction of groundwater flow 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). Normal seasonal variability in the water table in the 100-F Area is more than 3 m (10 ft) in wells near the river and decreases farther inland.

During seasonal periods of high river stage, the hydraulic gradient reverses near the river and surface water can flow into the aquifer. Figure 3-5 shows the water table in June 2014 when river stage had been high for several weeks. The measurements were made during a brief “dip” in river stage in mid-June, creating an extra bend in the water-table contours.

The vadose zone and the unconfined aquifer comprise Hanford formation sand and gravel (Figure 3-6). Ringold Formation unit E is largely absent in this region, but a remnant of Ringold unit E is interpreted to exist in the southwestern 100-F Area and smaller remnants in central and eastern 100-F Area. In two locations, Ringold unit E extends above the water table, comprising the entire aquifer thickness. Geologic maps were updated in 2014 for input to the 100 Areas groundwater model based on revised interpretations of geologic and geophysical logs. The updated maps will be presented in an upcoming SAP later in 2015.

The bottom of the aquifer is the RUM. The thickness of the aquifer ranges from 1 m (3 ft) in the southern 100-F Area to 8 m (26 ft) in the eastern 100-F Area. Most of the monitoring wells are screened across all, or nearly all, of the aquifer. Two wells are screened in water-bearing units of the RUM. No contamination has been detected in those wells.

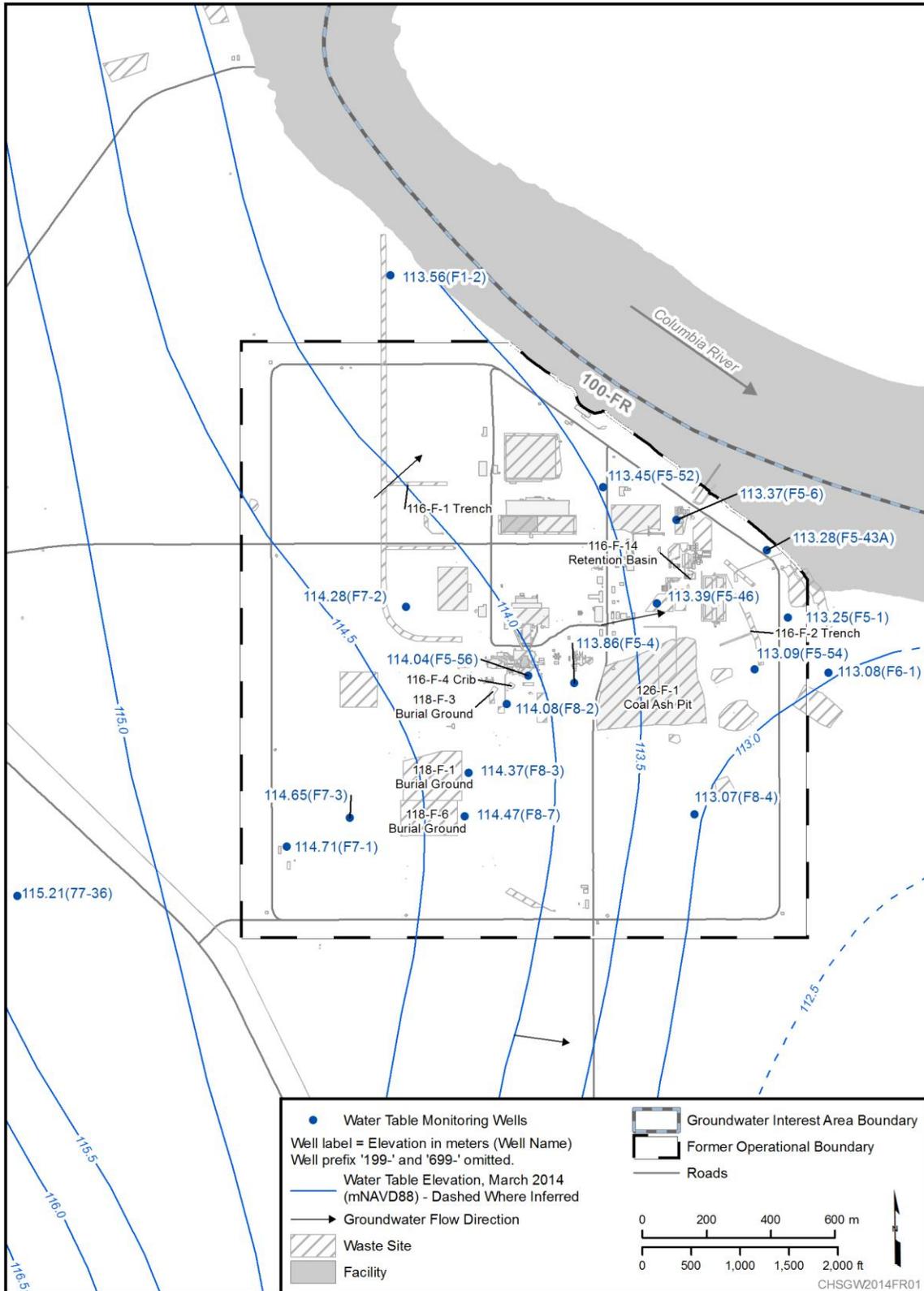


Figure 3-4. 100-FR Water Table, March 2014

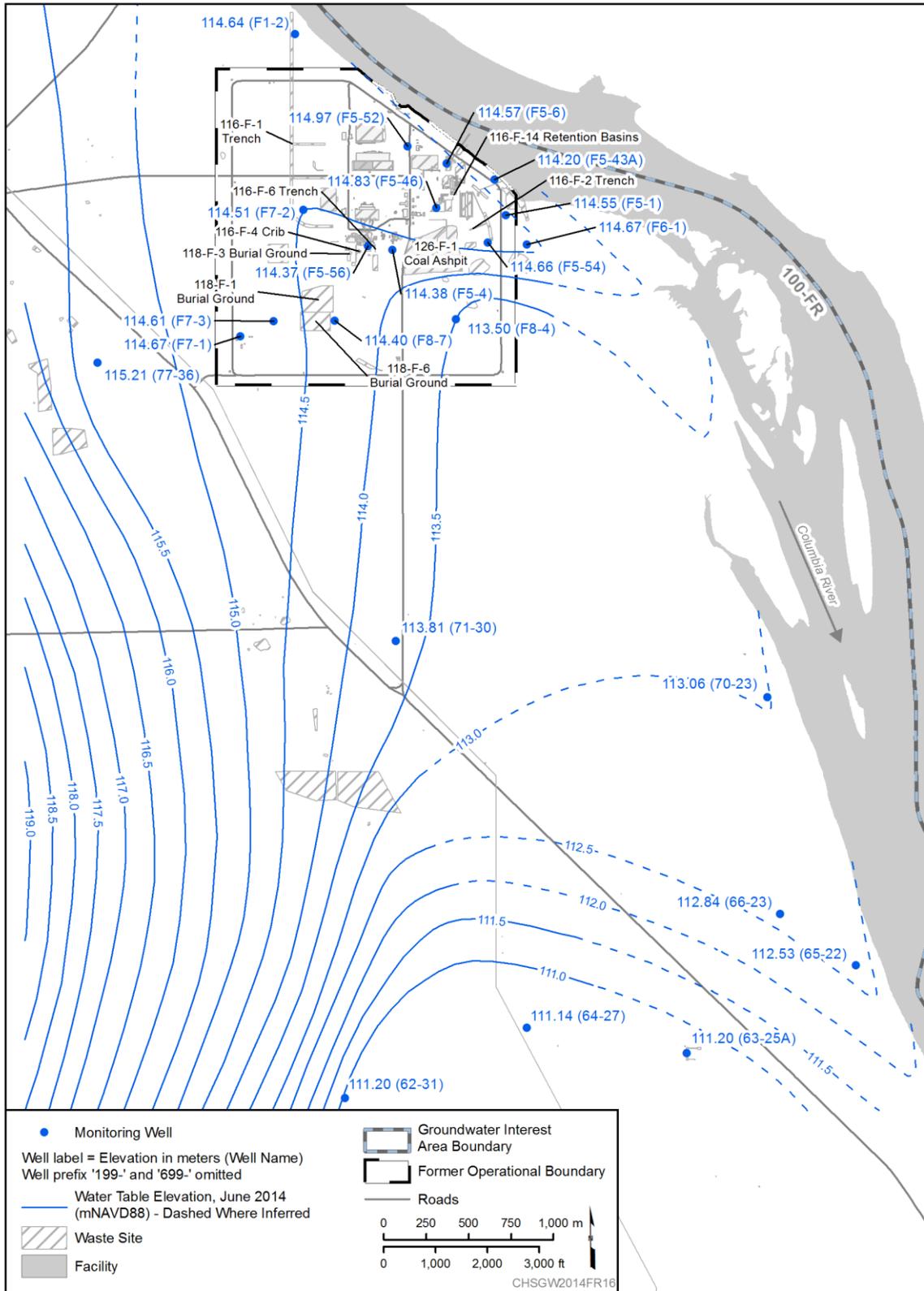
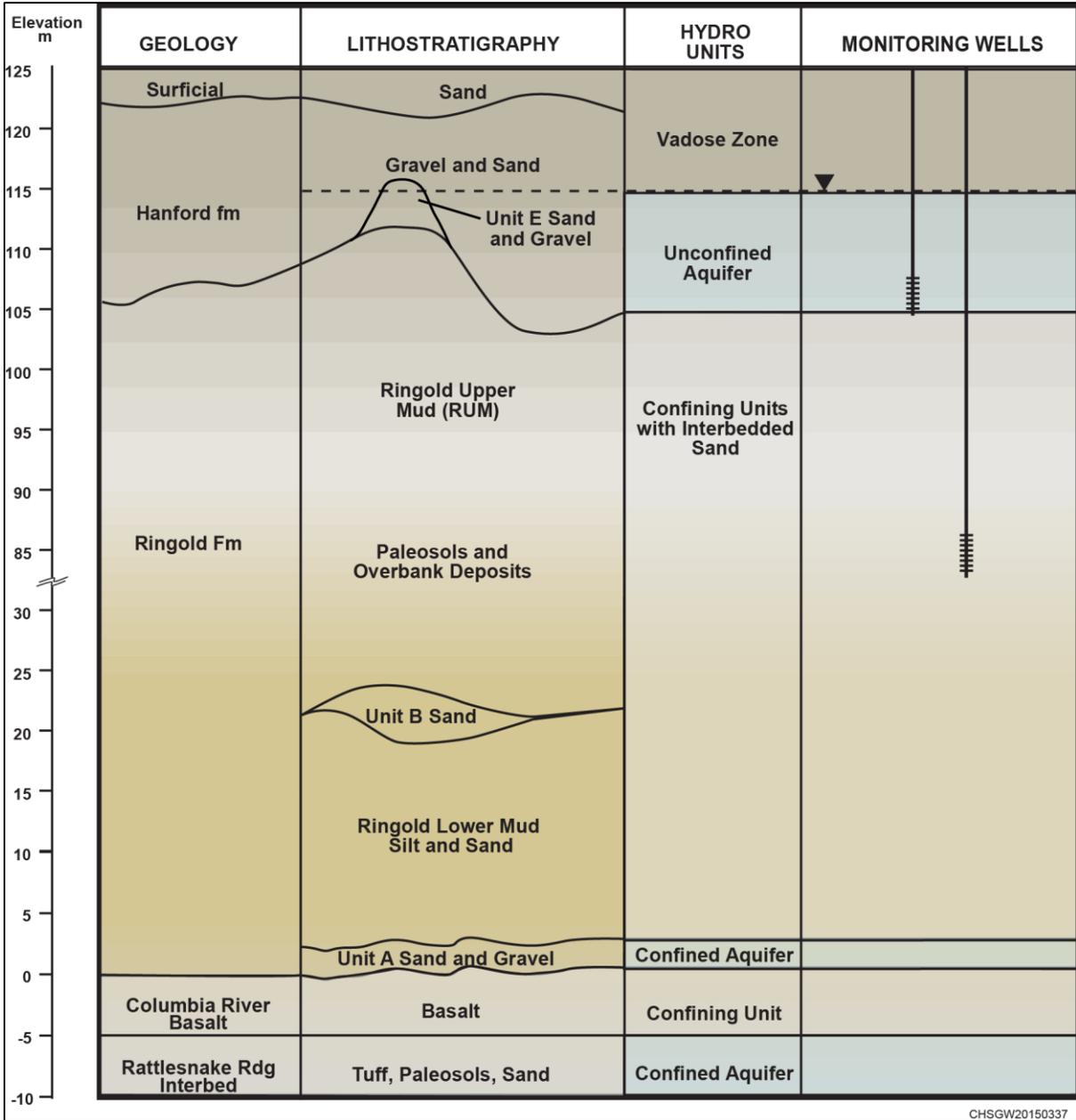


Figure 3-5. 100-FR Water Table, June 2014



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Figure 3-6. 100-FR Geology

3.2 CERCLA Activities

In 2014, CERCLA activities included routine groundwater monitoring, publication of a final RI/FS report and Proposed Plan, and a ROD.

3.2.1 Groundwater Monitoring

Routine groundwater sampling requirements were revised in 2014 under the groundwater SAP ([DOE/RL-2003-49, Rev. 2](#)). The comprehensive annual sampling event occurred in October; a few wells were also sampled in April. Table A-9 of Appendix A lists wells and constituents monitored in 2014. A subset of aquifer tubes was also scheduled for sampling in October 2014, but sampling was delayed until December due to resource limitations (Appendix C).

3.2.2 Remedial Investigation/Feasibility Study

In 2014, DOE released a final RI/FS report ([DOE/RL-2010-98](#)) and a Proposed Plan ([DOE/RL-2012-41](#)). In September 2014, EPA and DOE signed a ROD that includes MNA and ICs as the remedy for the 100-FR-3 Groundwater OU ([EPA et al., 2014](#)). MNA relies on natural processes within the aquifer to reduce the toxicity, mobility, volume, concentration, and/or bioavailability of the contaminants. Groundwater sampling and analysis, data evaluation, and reporting are an important component of this alternative to confirm that natural attenuation is occurring. ICs to protect human health and the environment will be maintained until cleanup levels are achieved.

To implement the remedial actions, DOE is preparing a remedial design/remedial action work plan for soil and groundwater. A groundwater addendum will include a SAP. These documents are planned for publication in 2015.

3.3 Nitrate

Past sources of nitrate contamination included the experimental animal farm (e.g., 116-F-9 Animal Leach Trench and 118-F-6 Burial Ground) and various septic tanks and leach fields located throughout the 100-F Area. These sites have been remediated. Pre-Hanford Site agriculture is another potential source of nitrate contamination.

A large nitrate plume with concentrations above 45 mg/L extends from the 100-F Area approximately 5 km (3.1 mi) to the south (Figure 3-7). The highest concentrations (greater than 120 mg/L) are in the central 100-F Area. Wells near the Columbia River (199-F5-43A, 199-F5-44, 199-F5-1, and 199-F6-1) have low nitrate concentrations. The water in these wells has low specific conductance (160 to 250 $\mu\text{S}/\text{cm}$), indicating the influence of inflowing river water even during periods of low river stage. Thus, the highest nitrate concentrations do not flow directly into the Columbia River adjacent to the 100-F Area.

The fact that the nitrate plume migrated southward is explained by the location of some of the nitrate sources in the southern 100-F Area, where groundwater flow is toward the south and south-southeast. Because there are relatively few monitoring wells to define the western portion of the plume, the western extent of the nitrate contamination above 45 mg/L is uncertain. Under the groundwater remediation alternative, MNA, additional monitoring wells will be installed to monitor the performance of the remedy.

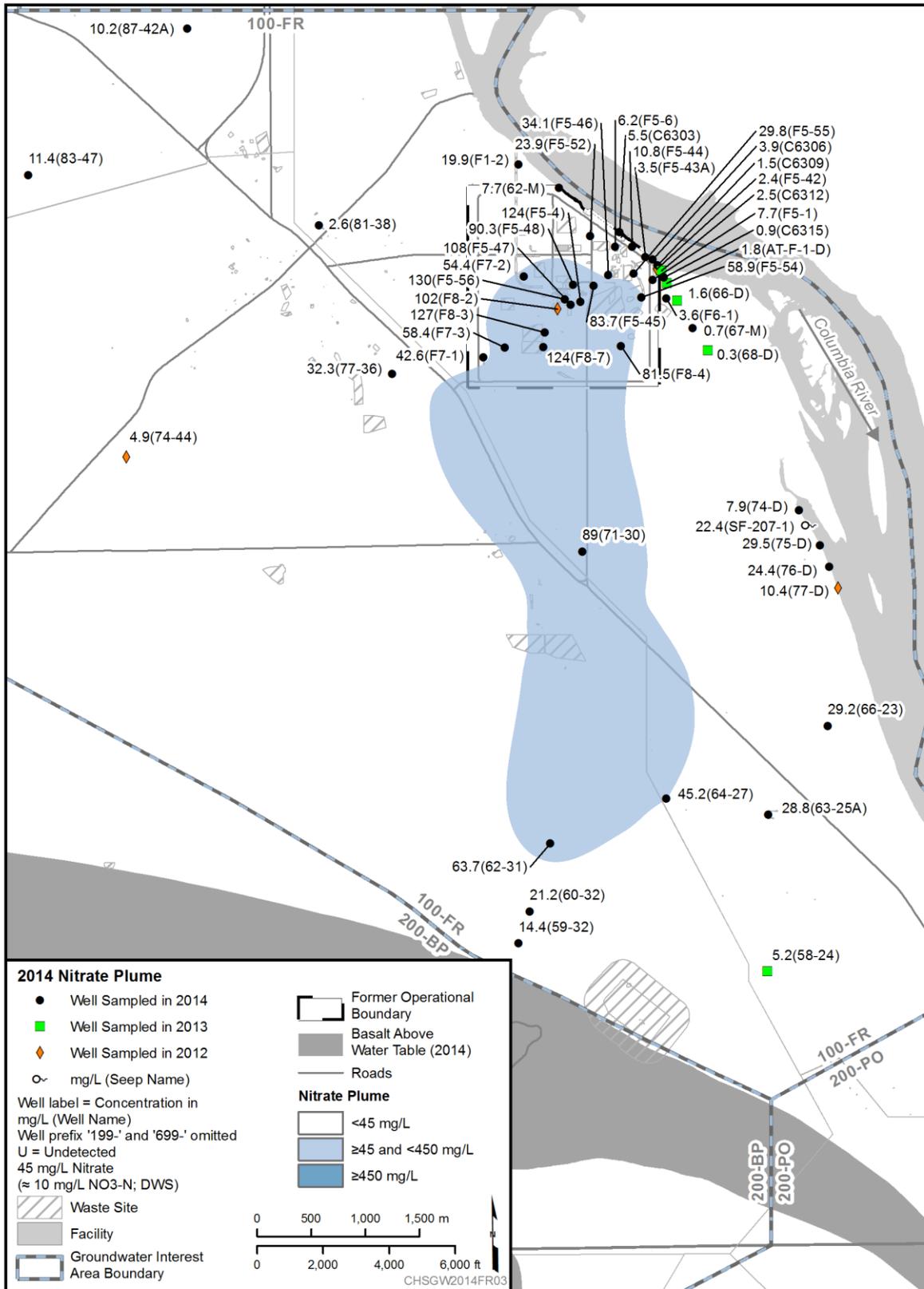


Figure 3-7. 100-FR Nitrate Plume, 2014

Between 2002 and 2014, nitrate concentrations declined in 17 of 30 wells, were stable in 7 wells, and increased in 6 wells. The median concentration decreased from 69 mg/L in 2002 to 45 mg/L in 2014. Concentrations in several wells in the high-concentration heart of the plume increased between 2002 and present (Figure 3-8), but 2014 data suggest the trend may be reversing.

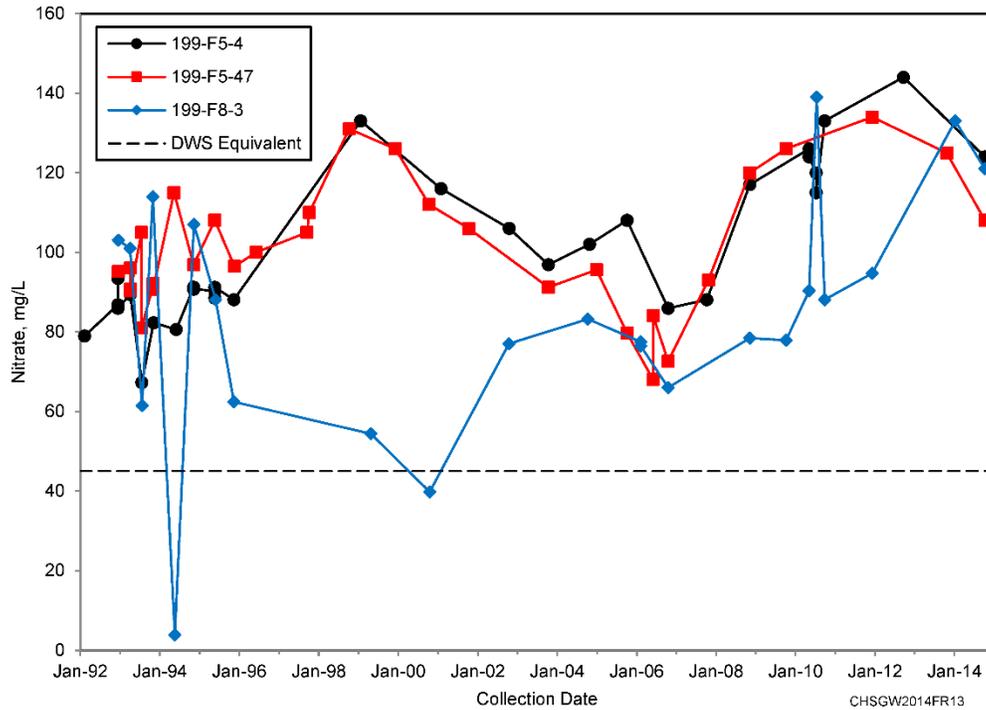


Figure 3-8. 100-FR Nitrate Data for Wells 199-F5-4, 199-F5-47, and 199-F8-3 in Central 100-F Area

Nitrate concentrations continued to decline in wells in the southwestern 100-F Area, dropping below the DWS for the first time in 199-F7-1 (Figure 3-9). Concentrations also are declining or stable in wells in the southern part of the plume (Figure 3-10).

The highest nitrate concentrations in aquifer tubes have historically been detected in 75-D (approximately 2 km [1.2 mi] downstream), exceeding 45 mg/L in 1999 and 2004. Concentrations have declined in this aquifer tube in recent years (25.7 mg/L in December 2014).

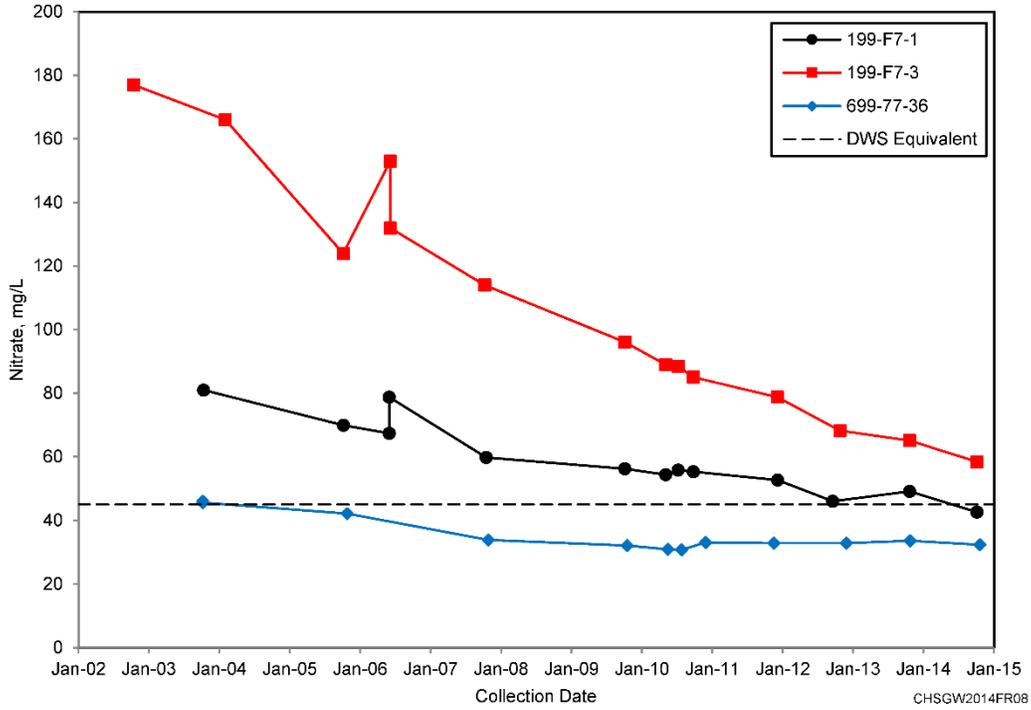


Figure 3-9. 100-FR Nitrate Data for Wells 199-F7-1, 199-F7-3, and 699-77-36 in Southwestern 100-F Area

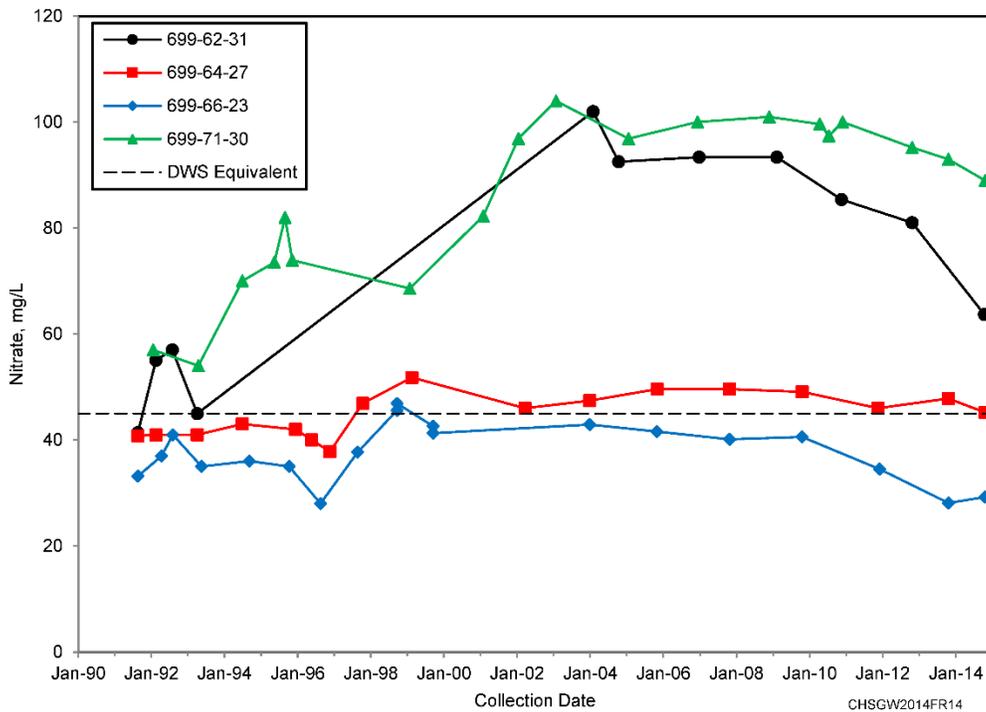


Figure 3-10. 100-FR Nitrate Data for Wells in South Part of Plume

3.4 Trichloroethene

TCE concentrations exceed the 4 µg/L cleanup level specified in the ROD in three wells in the southwestern 100-F Area and sporadically in wells in the central 100-F Area (Figure 3-11). Process knowledge of the former 600-127 waste site, located just west of the 100-F Area, suggests that it may have contributed to the TCE plume. This site was recently remediated. The lack of wells to the south creates uncertainty in the interpretation, and the plume may extend farther south than can be interpreted based on available data. Well 699-71-30, approximately 2 km (1.2 mi) to the south, detected traces of TCE in 2010 and 2014 (maximum 1.7 µg/L). Under the groundwater remediation alternative of MNA, an additional monitoring well will be installed south of the TCE plume.

TCE concentrations have declined since 1992 in 699-77-36 and 199-F7-1 in the southwestern 100-F Area (Figure 3-12). The trend in 199-F7-3 shows the arrival of the plume in the late 1990s and a declining trend since 2002. The monitoring wells in this location are screened across the entire aquifer thickness, which is less than 3 m (10 ft). Wells in other portions of the 100-F Area also detect TCE at concentrations that fluctuate around the cleanup level.

Recently updated interpretations of geologic logs indicate that the aquifer in the southwestern 100-F Area is within a remnant of Ringold unit E rather than in the Hanford formation, as is most of the 100-F aquifer. The presence of less transmissive sediments may explain the persistence of TCE in this region (Figure 3-11). A smaller remnant of Ringold unit E is present in the central 100-F Area where other traces of TCE are found.

Well 699-77-54, located approximately 6 km (3.7 mi) west of the 100-F Area, consistently has TCE concentrations above 5 µg/L, with a 2014 result of 11.8 µg/L. The well, which is located in the western part of the 100-FR groundwater interest area near the 100-KR-4 OU, also has elevated concentrations of chromium (24 µg/L in 2014).

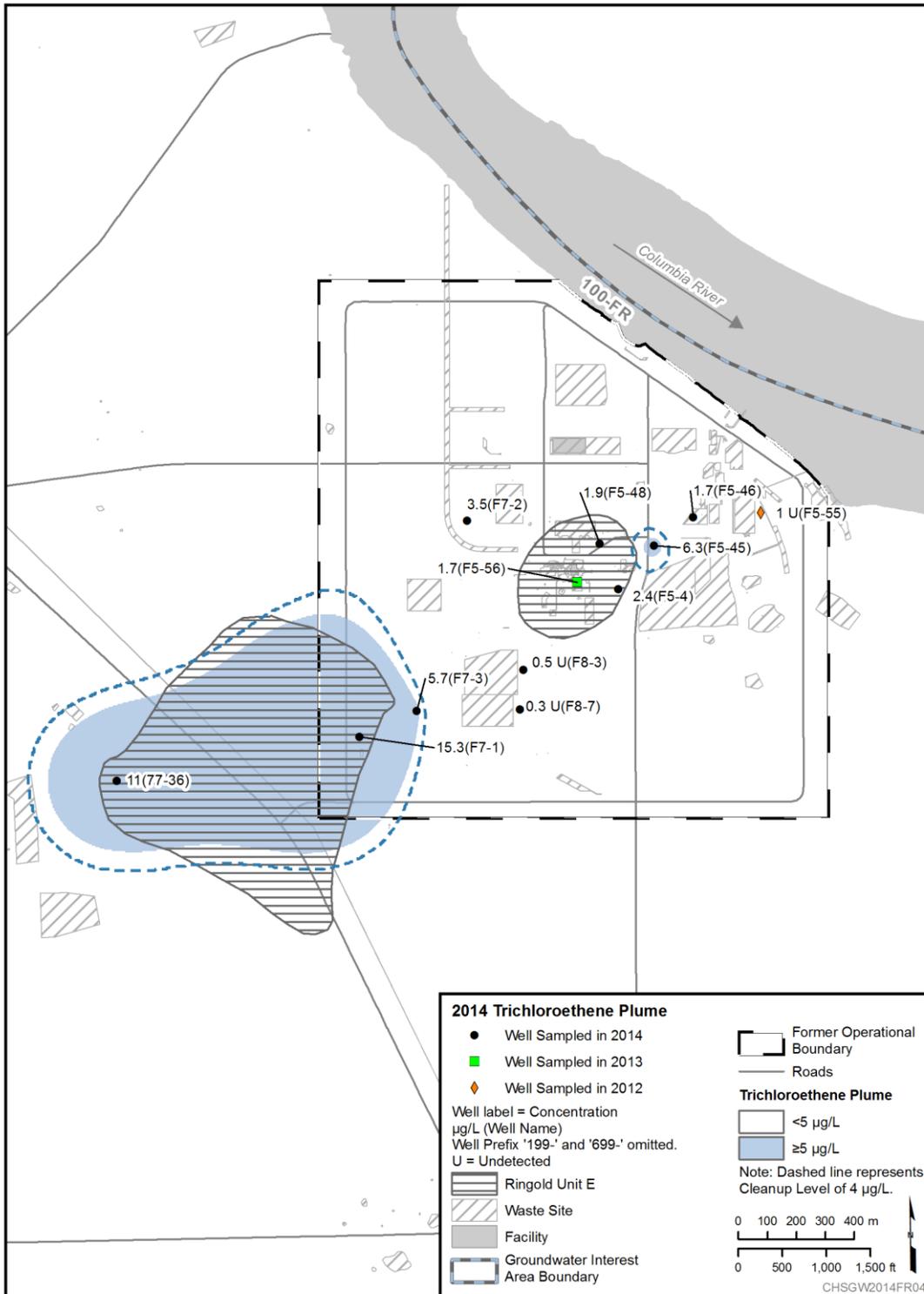


Figure 3-11. 100-FR TCE Plume and Extent of Ringold Unit E Above the Water Table, 2014

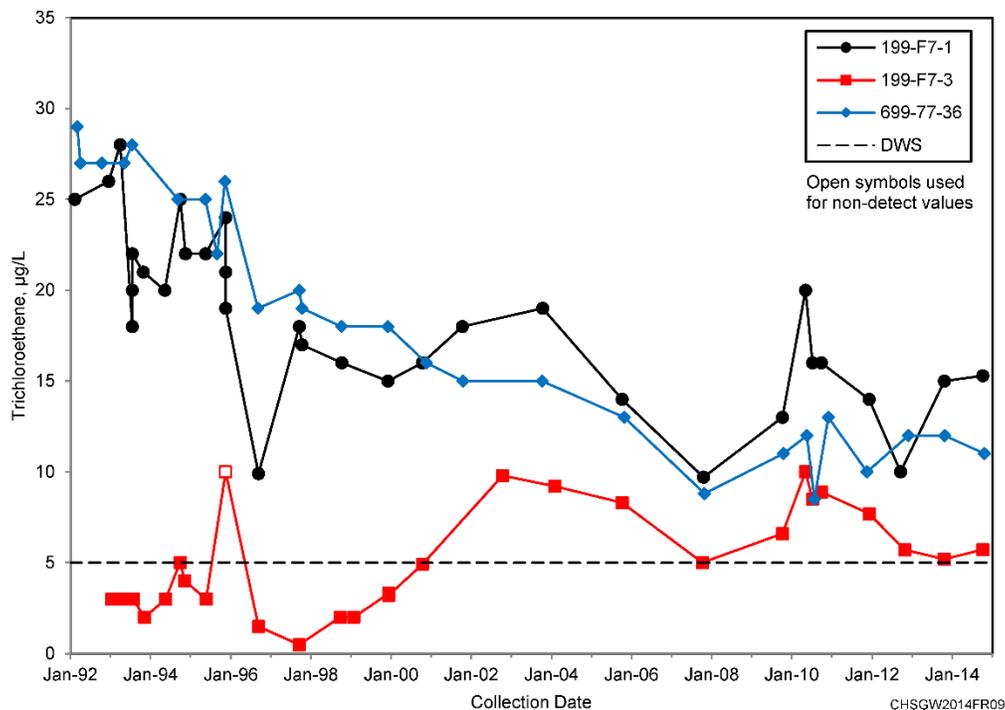


Figure 3-12. 100-FR TCE Data for Wells 199-F7-1, 199-F7-3, and 699-77-36

3.5 Hexavalent Chromium

Former sources of hexavalent chromium in 100-FR included facilities near the reactor building, trenches and retention basins near the Columbia River, and pipelines from the reactor building to these near-river facilities, primarily in the northern and eastern 100-F Area. The waste sites have been remediated, and concentrations in groundwater are expected to continue to decline with time.

Hexavalent chromium in 100-FR is present in a relatively small, low-concentration plume with all concentrations below the 48 µg/L cleanup level (Figure 3-13). Historically, the highest concentrations were in 199-F5-46, where levels have declined from greater than 300 µg/L in the early 1990s to 29 µg/L in 2014 (Figure 3-14). The plume extends toward the river where the concentration in 199-F5-44 continued to exceed the 10 µg/L aquatic standard in 2014. The concentration in 199-F5-6 was 8 µg/L, dropping below the standard for the first time since 1995. Concentrations in aquifer tubes in this region also were below the aquatic standard except C6303, which had a concentration of 10.3 µg/L in December 2014. Filtered total chromium was 6.6 µg/L.

Two wells in the central 100-F Area, 199-F5-47 and 199-F5-56, had increasing concentrations of chromium, 20 to 22 µg/L in 2014 (Figure 3-15). The trends may be related to waste site remediation in the area several years ago, and concentrations are expected to decline in the future. The wells are sampled annually.

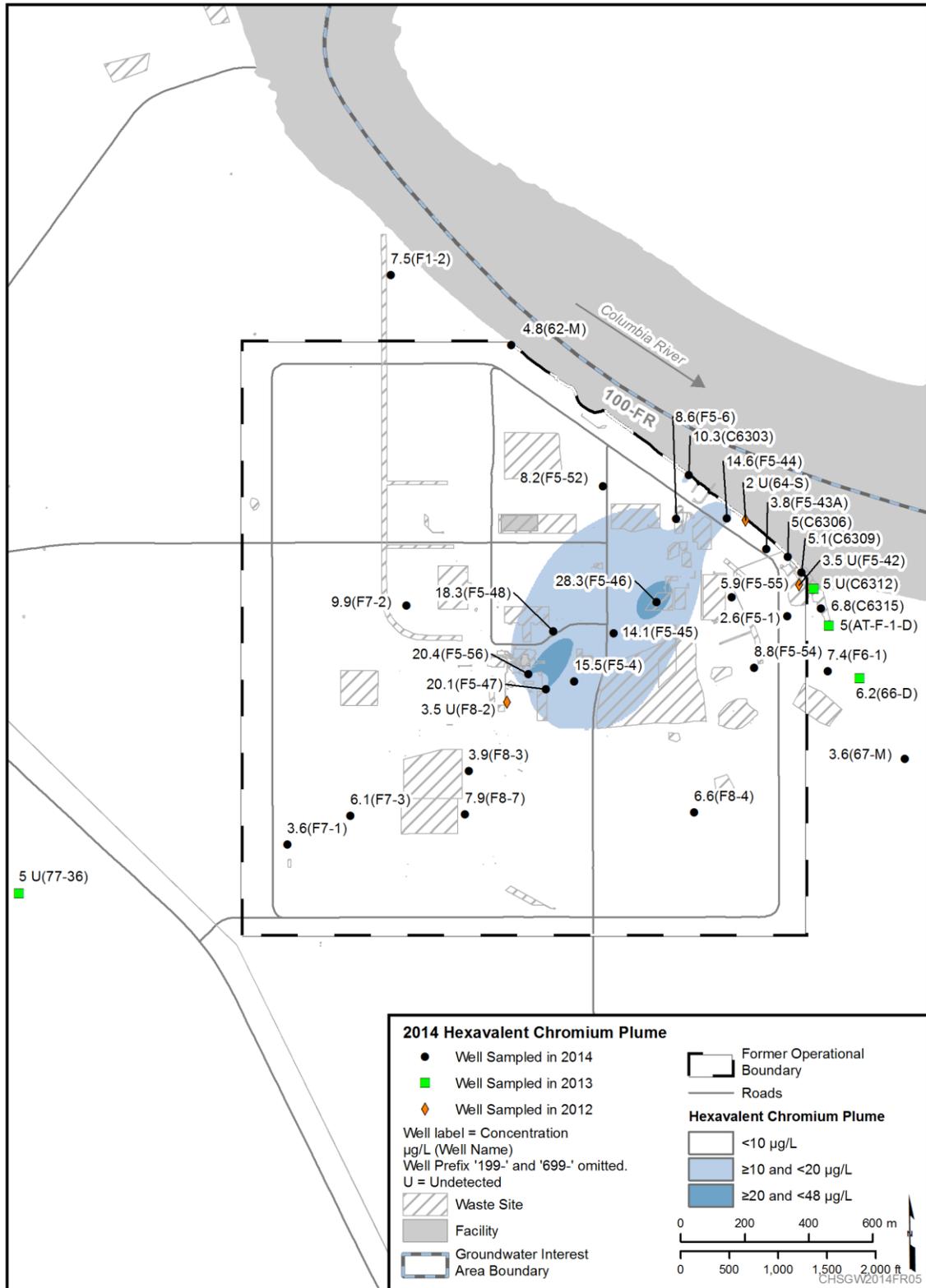


Figure 3-13. 100-FR Hexavalent Chromium Plume, 2014

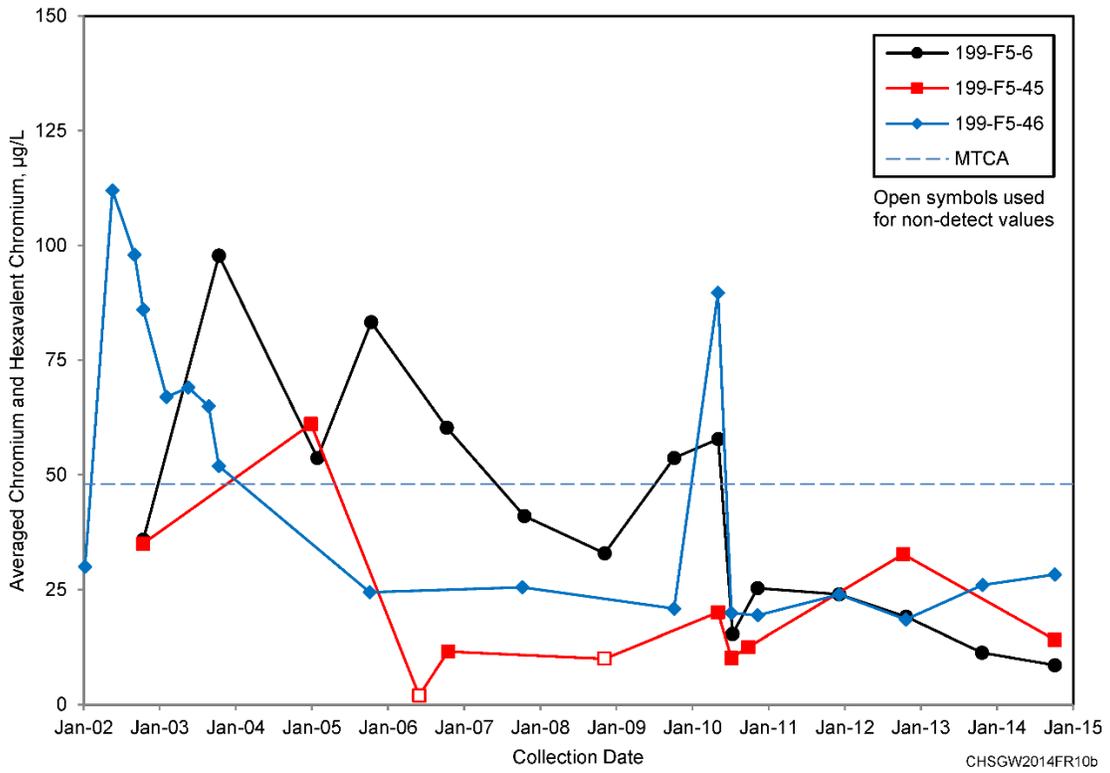
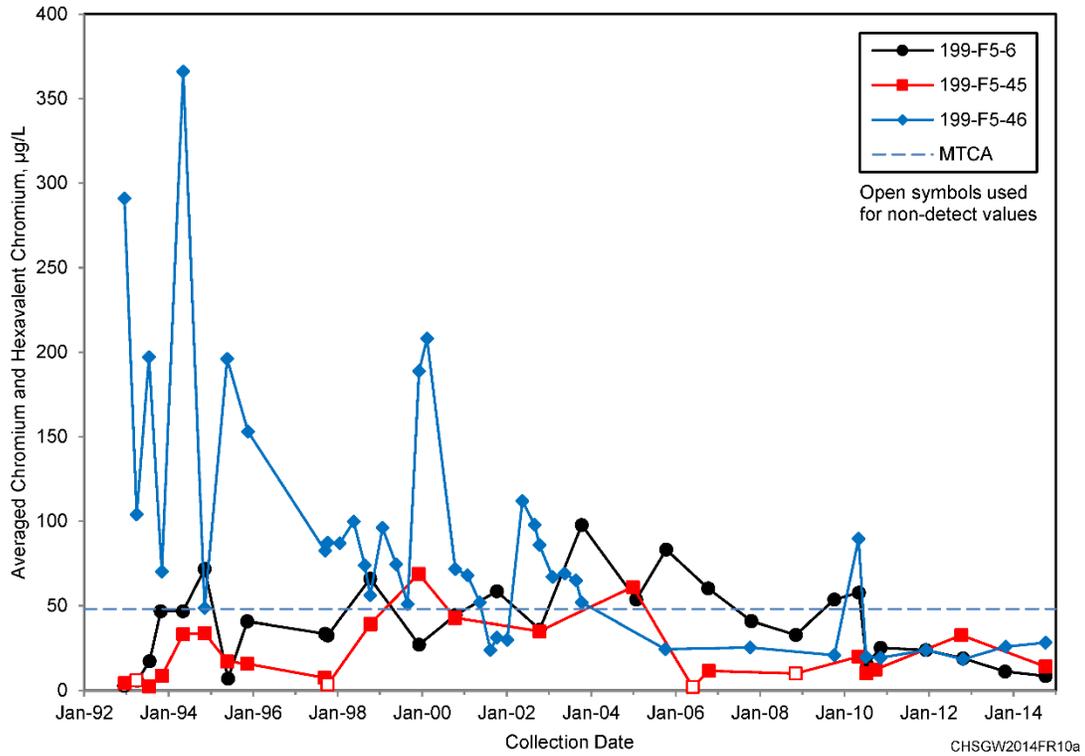


Figure 3-14. 100-FR Hexavalent Chromium Data for Wells 199-F5-6, 199-F5-45, and 199-F5-46 for 1992 to Present (top panel) and 2002 to Present (bottom panel)

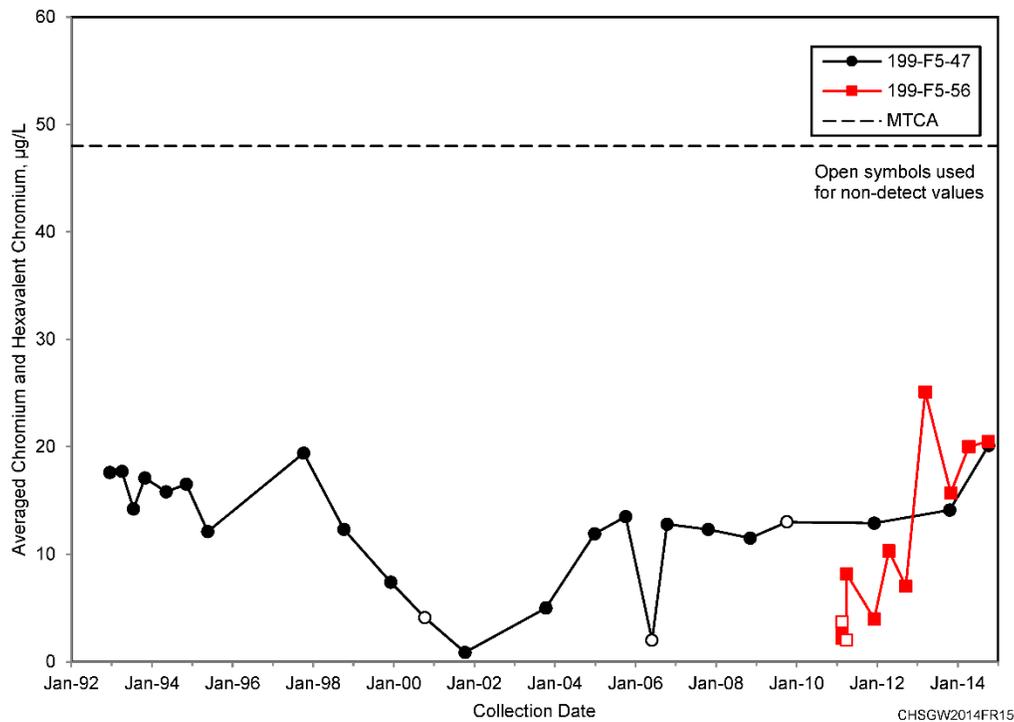


Figure 3-15. 100-FR Dissolved Chromium Concentrations for Wells 199-F5-47 and 199-F5-56 in Central 100-F Area

3.6 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 of strontium-90 were present near the reactor building and burial grounds.

In the eastern 100-F Area, two wells (199-F5-55 and 199-F5-1) continued to have strontium-90 concentrations above the 8 pCi/L DWS in 2014 (Figure 3-16). Well 199-F5-55 had the highest strontium-90 concentrations in 2014, with a maximum of 144 pCi/L (Figure 3-17). This borehole was installed in the former 116-F-14 Retention Basin to characterize the vadose zone and was completed as a monitoring well to obtain representative groundwater samples. Strontium-90 concentrations have declined since 2011 and are inversely related to water levels. This inverse correlation indicates that there is not a vadose zone source of strontium-90 in the vicinity of the well that is mobilized by a higher water table. The contamination is localized and the next nearest downgradient well (199-F5-1) has much lower concentrations.

Strontium-90 concentrations in Well 199-F5-56, near the F Reactor building, also exceeded the DWS with a maximum of 28 pCi/L in 2014, a decline from 2013. This borehole was drilled to characterize a waste site and completed as a well to obtain representative groundwater samples. It was the only well in the central 100-F Area with detectable strontium-90.

Strontium-90 concentrations in aquifer tubes have been below the DWS except in a single sample collected in 2012 from C6306 at 9.6 (± 2.55) pCi/L. Concentrations were lower in 2013 (2.7 [± 0.95] pCi/L) and 2014 (1.86 [± 1.04] pCi/L). Previous studies indicate that strontium-90 concentrations in Columbia River pore water are below the DWS ([DOE/RL-2010-98](#)).

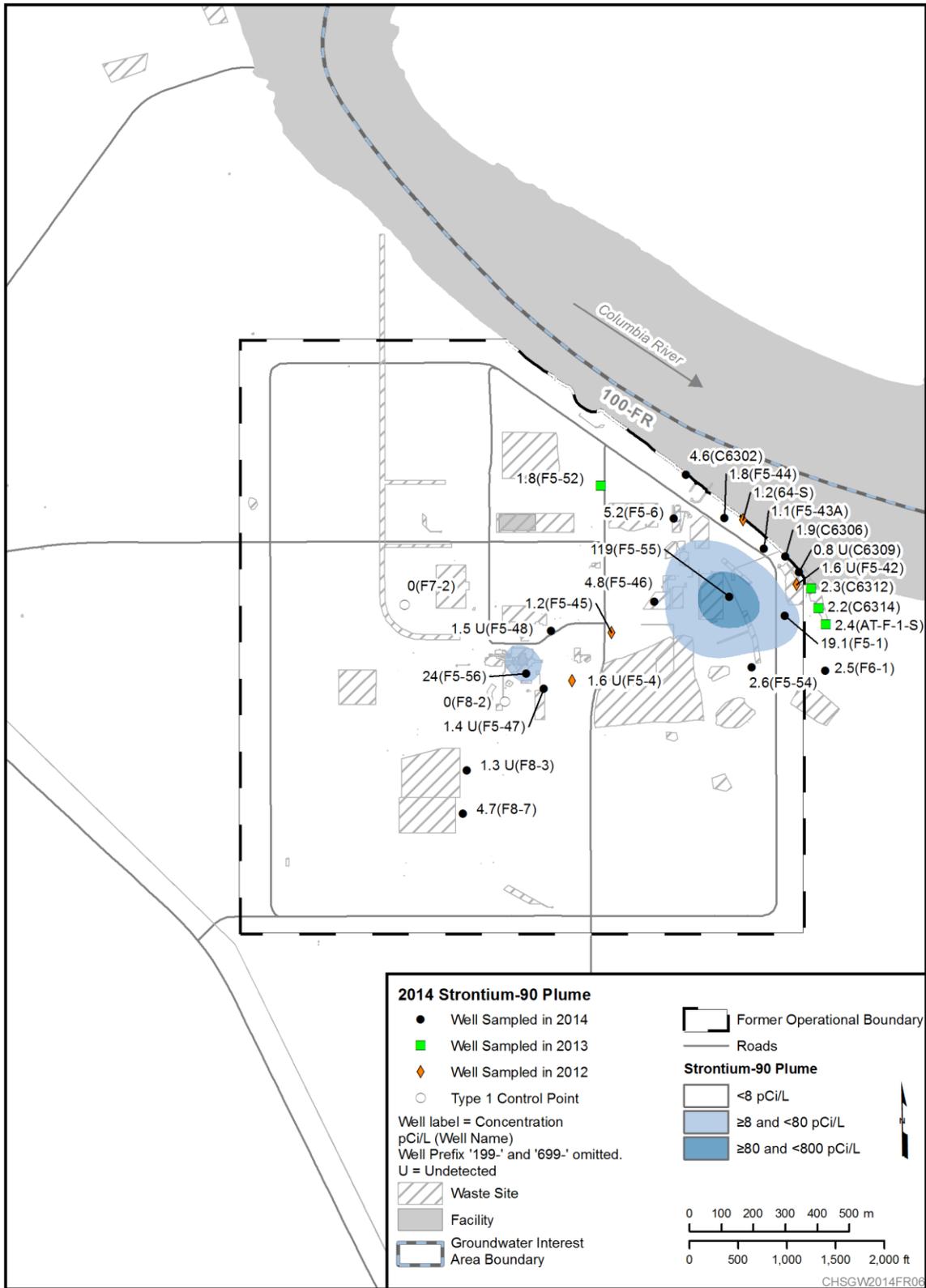


Figure 3-16. 100-FR Strontium-90 Plume, 2014

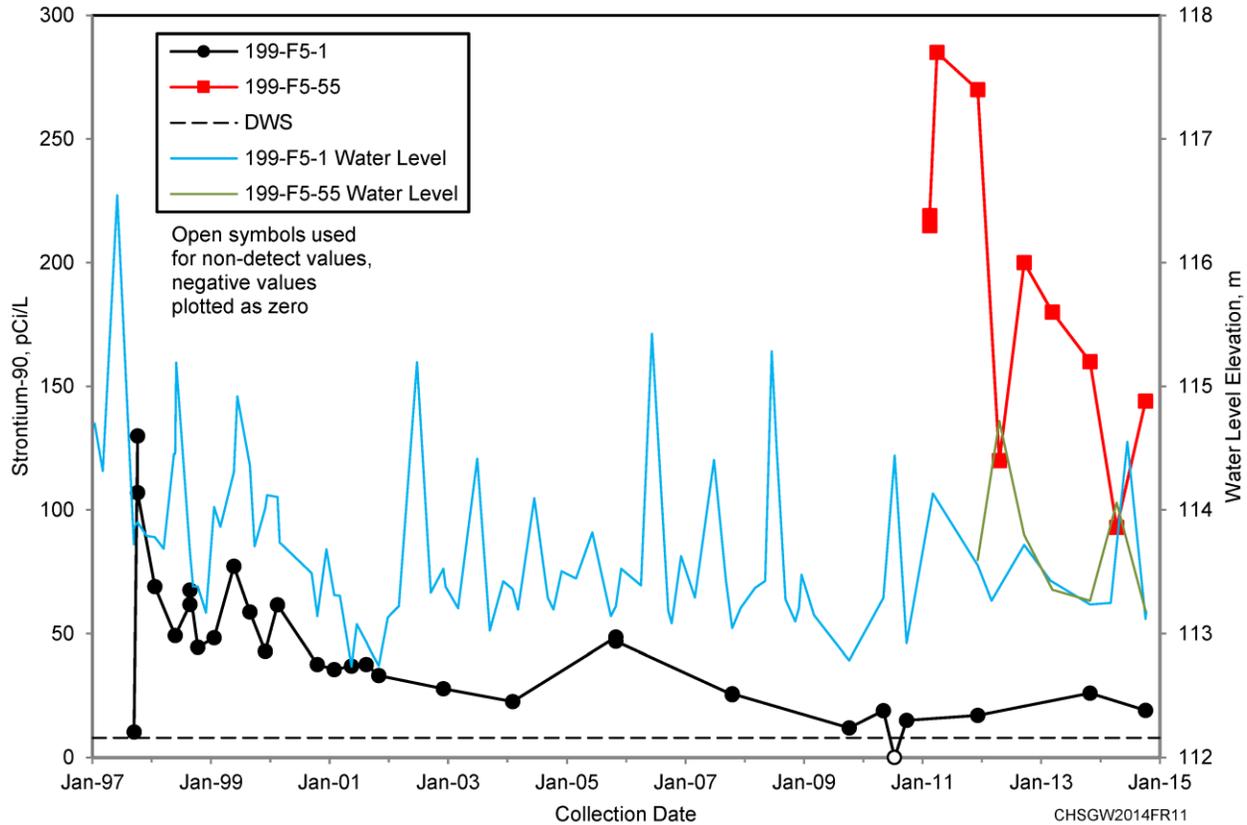


Figure 3-17. 100-FR Strontium-90 Data and Water Levels for Well 199-F5-1 and 199-F5-55

3.7 Uranium

Uranium is not a COC for 100-FR groundwater ([DOE/RL-2010-98](#)). However, it is monitored in one well under the routine groundwater SAP ([DOE/RL-2003-49](#)) because of one previous detection above the 30 $\mu\text{g/L}$ DWS in 199-F5-56 (34.7 $\mu\text{g/L}$ in 2011). The highest concentration in this well in 2014 was 18.1 $\mu\text{g/L}$.