

# Hanford Site Groundwater Monitoring for Fiscal Year 2007

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Date Published  
March 2008

Prepared for the U.S. Department of Energy  
Assistant Secretary for Environmental Management



**United States  
Department of Energy**  
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*J. D. Nardal* 02/29/2008  
Release Approval Date

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## 2.12 300-FF-5 Operable Unit

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The 300-FF-5 Operable Unit is a component of the 300 National Priorities List Site, located in the southeastern portion of the Hanford Site. The operable unit includes groundwater affected by releases from waste sites and facilities associated with the 300-FF-1 and 300-FF-2 Operable Units. The various subregions within the 300-FF-5 Operable Unit and their relationship to the 300-FF-1 and 300-FF-2 Operable Units are shown in Figure 2.12-1. The 300-FF-5 Operable Unit lies within a larger groundwater interest area (see Figure 1.0-1 in Section 1.0), which has been defined informally for scheduling, data evaluation, and interpretation purposes. Remedial investigation activities are underway in the groundwater interest area as part of the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) program to (a) track changes in the nature and extent of groundwater contamination, (b) monitor trends in contaminant levels with time, and (c) comply with *Resource Conservation and Recovery Act* (RCRA) requirements associated with the former 300 Area process trenches.

Primary sources for contaminants that have impacted groundwater in the 300-FF-5 Operable Unit are the former liquid waste disposal facilities in the 300 Area, the 618-11 burial ground near the Energy Northwest complex, and the former 316-4 crib, which is located near the 618-10 burial ground. The 300 Area contains former nuclear fuel fabrication facilities, fuels research laboratories, liquid effluent disposal sites, and several solid waste burial grounds. An index map to 300 Area monitoring wells, waste sites, buildings, and shoreline monitoring sites is shown in Figure 2.12-2. The two outlying subregions of the operable unit (i.e., the 618-11 and 618-10 burial grounds) received primarily solid radioactive waste from the 300 Area during the period 1954 to 1967. The former 316-4 cribs, which are located adjacent to the 618-10 burial ground, received uranium-bearing organic liquid waste during the period 1948 to 1956. Index maps to these outlying 300-FF-5 subregions are provided in Figure 2.12-3.

Groundwater in the unconfined aquifer beneath the 300-FF-5 interest area flows generally to the east and southeast (Figure 2.12-4). Flow converges into the

***The 300-FF-5 Operable Unit includes groundwater beneath the 300 Area and outlying subregions near the 618-11 and 618-10 burial grounds.***

***Groundwater monitoring in the 300-FF-5 groundwater interest area includes the following: Interim Action Monitoring under CERCLA (Appendix A)***

- *Forty-six wells in the 300 Area are sampled quarterly to annually. Three wells were not sampled as scheduled in FY 2007.*
- *Twelve wells in the north part of the 300-FF-5 Operable Unit are sampled quarterly to semiannually.*
- *Eight aquifer tube sites near the Columbia River are sampled semiannually.*
- *Riverbank springs and near-shore river water are sampled annually (coordinated with the Public Safety and Resource Protection Program).*

***Facility Monitoring (Appendix B)***

- *Four pairs of wells are sampled eight times per year at the 300 Area Process Trenches.*

***Groundwater flows toward the east and southeast across the 300-FF-5 interest area and discharges to the Columbia River.***

300 Area from regions to the northwest, west, and southwest, and ultimately discharges to the Columbia River through the riverbed and to a lesser degree, along the shoreline as riverbank springs. In the northern and central portions of the 300 Area, flow direction is predominantly toward the southeast, while in the southern portion, flow is more eastward, as inferred from water-table elevations recorded during most of any particular year. This flow pattern reflects medium-to-low river stage conditions. As river discharge rises during late May or June, the direction of groundwater flow temporarily shifts to more southward in the northern portion of the 300 Area. The stage of the Columbia River has a profound effect on groundwater flow patterns and rates in the 300 Area. Seasonal changes in river stage are reflected in water levels measured at wells located as far as inland as 360 meters from the Columbia River (PNL-8580).

Because of highly transmissive aquifer materials, groundwater flow velocities can be quite high, with a recent tracer test revealing a rate of up to 15 meters/day (PNNL-16571). Other investigations have documented plume migration rates as high as 10 meters/day (PNL-5408, pp. 45-49). However, in spite of high flow velocities, the net rate of discharge to the Columbia River appears to be relatively low. This is a consequence of rapidly changing hydraulic gradients and their orientation, which results from the daily, weekly, and seasonal cycles in river stage. Efforts to more accurately quantify these rates continued during fiscal year (FY) 2007 as part of the 300-FF-5 Phase III Feasibility Study (DOE/RL-2005-41).

Variability in hydraulic gradients and the vertical position the water table influences contaminant concentrations as well as flow rates and patterns. During the Columbia River's spring runoff period when high river stage conditions are present, river water infiltrates the banks and mixes with groundwater, thus diluting the concentrations of contaminants carried by groundwater. The rate at which groundwater discharges to the river is lowest during this period of high river stage because of bank storage effects (e.g., reduced gradients and actual reversal of flow direction near the shoreline). Farther inland, higher water-table elevations may result in groundwater coming in contact with contaminants held in the lower vadose zone, thus remobilizing those contaminants. Consequently, higher concentrations may be observed during the early summer months, particularly in areas beneath former liquid waste disposal sites. These processes are described in detail for the uranium plume beneath the 300 Area (PNNL-17034).

The remainder of this section describes contaminant plumes and concentration trends for contaminants of concern or potential concern as listed in sampling and analysis plans associated with CERCLA and RCRA requirements. Following those descriptions, the status of operable unit activities conducted under CERCLA and the facility monitoring under RCRA are discussed.

### **2.12.1 Groundwater Contaminants**

Contaminants of concern, or potential concern, for the 300-FF-5 Operable Unit have been identified in several regulatory decision documents. Under CERCLA, the initial record of decision (ROD 1996b) and subsequent explanation of significant difference (EPA 2000) identify contaminants of concern for each of the three subregions of the groundwater operable unit. Under RCRA, constituents of concern

***Areas of plumes where the drinking water standard is exceeded in the 300-FF-5 Operable Unit:***

***\*Tritium — 0.22***

***Uranium — 0.50***

***\*Excludes tritium from 200-PO-1 Operable Unit.***

for corrective action monitoring of groundwater beneath the former 300 Area process trenches are identified in a groundwater monitoring plan (WHC-SD-EN-AP-185, as amended).

The contaminant of greatest significance in groundwater beneath the 300 Area is uranium, which has persisted as a plume long after fuel fabrication activities ceased. Additional contaminants of potential concern from 300 Area sources are the volatile organic compounds cis-1,2-dichloroethene, tetrachloroethene, and trichloroethene. Trichloroethene has been recently discovered at elevated concentrations at depths below those normally monitored. While not specifically listed in the record of decision, strontium-90, gross alpha, and gross beta are also monitored because those radiological contamination indicators have exceeded standards. Contaminants from sources outside of the 300 Area that migrate into the subregion include tritium, nitrate, and trichloroethene.

For the 300-FF-5 outlying subregions, the contaminant of greatest significance is tritium, which has been released from the 618-11 burial ground. The resulting plume is of limited areal extent, but contains tritium concentrations that greatly exceed the drinking water standard of 20,000 pCi/L. This plume lies upgradient of and beneath the Energy Northwest complex. At the 618-10 burial ground and former 316-4 cribs subregion, contaminants of potential concern are uranium and tributyl phosphate. These two contaminants are known to have been disposed to the former 316-4 cribs, and there is some evidence that uranium may also have been released from waste in the 618-10 burial ground. No evidence to date suggests a release of tritium from the 618-10 burial ground, as has occurred at the 618-11 burial ground. Technetium-99, tritium, and nitrate have migrated into the 300-FF-5 outlying subregions from upgradient sources in the 200 East Area.

Most contaminants of potential concern, as identified in regulatory decision documents, show either a decrease or relatively constant concentration trend during the years since the initial remedial investigation for the operable unit was conducted in the early 1990s (PNNL-15127).

### **2.12.1.1 Uranium**

Uranium is a contaminant in groundwater beneath the 300 Area and beneath the 618-10 burial ground/316-4 cribs subregion. In the 300 Area, it was introduced to groundwater by disposal of fuel fabrication effluent to large infiltration ponds and trenches. Disposal of uranium-bearing effluent to waste facilities ended in 1986 (PNNL-13645), although discharge of uncontaminated effluent continued until December 1994. Excavation of contaminated soil at the major liquid waste disposal sites occurred primarily during the period 1997 to 2000, with backfilling at all excavated sites completed by early 2004. At the former 316-4 cribs, uranium was disposed to open-bottomed infiltration cribs along with liquid effluent containing organic compounds. These cribs were removed and the site stabilized in 2004, with some uranium and tributyl phosphate remaining in the soil beneath the excavation (DOE/RL-2006-20, Rev. 1, page 3.8).

At the 300 Area, residual amounts of contaminant uranium remain in the vadose zone and aquifer, with some sorption onto sediment particles. The mobility of uranium within waste sites, the underlying vadose zone, and in the aquifer is highly variable and depends on (a) sediment texture and mineralogy, (b) chemical makeup of the waste effluent, and (c) the subsurface geochemical environment, especially

*Uranium is the principal contaminant of concern in the 300-FF-5 Operable Unit, with volatile organic compounds and tritium being potential concern.*

***The 300 Area uranium plume has persisted much longer than predicted by the initial remedial investigation in the 1990s. Concentrations in the plume vary seasonally in response to Columbia River conditions.***

***The uranium plume beneath the 300 Area covers approximately 0.5 square kilometers at concentrations above the drinking water standard and contains approximately 45~77 kilograms of dissolved uranium.***

the bicarbonate content, pH, and surface properties of minerals (PNNL-14022; PNNL-15121; PNNL 17031; PNNL 17034). Uranium in groundwater is typically monitored using chemical analyses for total uranium in an unfiltered sample. In the river environment, uranium in shoreline media and river water is monitored using analyses for specific isotopes. Results for each type of analysis can be converted to the other to provide comparable data sets.

The U.S. Environmental Protection Agency (EPA) National Primary Drinking Water Standard for uranium is 30 µg/L. The standard is based primarily on uranium's chemical toxicity to humans, which is associated with damage to internal organs. Protection standards for freshwater aquatic organisms have not been established by EPA. A recent literature review regarding the chemical toxicity of uranium to non-human biota describes the relationship between toxicity and water hardness (i.e., the amount of calcium and other cations) for aquatic organisms (Sheppard et al. 2005). The range of predicted no-effect concentrations is from 5 µg/L for freshwater plants and invertebrates (without considering hardness) to 2,800 µg/L for fish (assuming water hardness similar to the Columbia River). Until further regulatory guidance becomes available for the toxicity of uranium to freshwater organisms, the drinking water standard is being used as the level for protection along the 300 Area shoreline where contaminated groundwater discharges to the river.

***300 Area Uranium Plume.*** The uranium plume in the 300 Area has been recently described in detail as part of a continuing feasibility study for remedial action of groundwater (PNNL-17034). Key aspects of the plume include persistence beyond the time predicted by earlier investigations (DOE/RL-94-85), distinct seasonal variability that is associated with the elevation of the water table, and incomplete information as to the source that continues to supply uranium to the plume. Current plume conditions are illustrated in Figures 2.12-5 and 2.12-6, which show conditions during December 2006 and June 2007, respectively, for the upper portion of the unconfined aquifer. The December 2006 period represents typical long-term average conditions for the 300 Area. The June 2007 configuration represents shorter-term conditions during the period of the seasonal high water table. During FY 2007, the seasonal high water table started in late March 2007 and continued into July 2007 (Figure 2.12-7), which is longer than usual, because of warm spring conditions. At the time that June water levels were measured (June 28 and 29), the water table had been elevated for several months and was beginning to decline. During a more typical June, water table conditions in the northern portion of the 300 Area would cause a westerly to southwesterly flow direction, but for 2007, measurements were made as the water table began its decline, and the resulting map closely resembled the December 2006 long-term average condition.

The uranium plume in the 300 Area is defined by concentrations exceeding 10 µg/L. Natural background concentrations for uranium in this sub-region are in the range of 3 to 8 µg/L, based on data from wells where groundwater has not been influenced by waste disposal. For the Hanford Site, natural background for uranium in groundwater falls in the range 0.5 to 12.8 µg/L (DOE/RL-96-61). Concentration trends since 2000 within the plume are illustrated in Figure 2.12-8 for three wells located in the vicinity of the former 300 Area process trenches, which is the most recently active liquid waste disposal site. Concentrations in shallow wells during FY 2007 were all less than 200 µg/L.

The area where uranium-contaminated groundwater exceeds the drinking water standard of 30 µg/L is 0.4~0.5 square kilometers. The areal extent remains fairly consistent from year to year, although concentrations within the plume show significant variability during the seasons. Estimates for the mass of dissolved uranium in this area of the plume suggest a value in the range 45 to 77 kilograms. These estimates are based on new data that have become available to describe the hydrogeologic framework of the plume (see Section 2.12.3). Seasonal variations in concentrations and distribution patterns within the plume are related to cyclic changes in river stage.

At locations near the Columbia River, uranium concentrations are reduced by mixing between groundwater and river water that infiltrates the aquifer during high river stage conditions. Also, changes in geochemical conditions caused by the mixing of river water and groundwater may promote adsorption of dissolved uranium onto sediment near the river. The bicarbonate content of river water is lower than that of groundwater, and the lower amount enhances the tendency for adsorption (PNNL-17031; PNNL-17034). Throughout most of the year (i.e., August through April), the river maintains low-to-moderate stage elevation, while during late May and June, the stage is typically high. It is during the seasonal high river stage that dilution of contaminants in groundwater near the river is greatest, and during 2007, this period extended for longer than usual. The dilution effect is illustrated by lowered uranium concentrations at near-river wells during June (compare Figure 2.12-6 with Figure 2.12-5) and by uranium concentration trends at wells 399-1-16A and 399-1-10A (Figure 2.12-9), which are located near the river and within the uranium plume.

At inland locations, the water table beneath the 300 Area responds quickly to changes in river stage because of the highly permeable sediment at the water table. Higher uranium concentrations are frequently observed in some portions of the plume when the water table is elevated above long-term levels, e.g., during the spring high river stage conditions each May and June). These higher concentrations may be the consequence of remobilizing uranium that is sequestered in the lower portion of the vadose zone (PNNL-17034). This is most pronounced beneath liquid waste disposal sites, such as the former 300 Area process trenches (316-5 waste site) and 307 process trenches (316-3 waste site). The increases in uranium concentrations when the water table is elevated are revealed by the uranium concentration trend at well 399-1-11, which is located within the footprint of the former 300 Area process trenches (Figure 2.12-10).

The uranium plume maps shown in Figures 2.12-5 and 2.12-6 represent conditions in the upper portion of the unconfined aquifer. Several wells in the 300 Area have open intervals for sampling that are in the lower portion of the unconfined aquifer (e.g., wells with a “B” suffix and well 399-1-8). Uranium concentrations in samples from these wells are typically near background levels, suggesting little to no downward migration of contaminant uranium beyond the extent of saturated Hanford sediment. The highest value observed during FY 2007 was 12.6 µg/L at well 399-1-16B, which is located downgradient from the former 300 Area process trenches where uranium-bearing effluent was most recently released. The range in that well during FY 2007 was 7.2 to 12.6 µg/L, which is very close to the range assumed for natural uranium in saturated Hanford sediment. Many results for samples from other “B” wells are non-detects, suggesting that those wells may be completed in lithologic units with a lower background level of uranium. Also, uranium has not been detected in the fine-

*Contaminant concentrations in groundwater near the Columbia River are reduced by infiltrating river water. At inland locations near former waste disposal sites, concentrations typically rise when the water table is elevated.*

*Uranium contamination is contained within the upper portion of the unconfined aquifer, i.e., saturated portion of the Hanford gravel.*

***Analysis of water samples from aquifer tubes near the Columbia River provides information on the lateral and vertical extent of uranium contamination.***

grained subunit of Ringold Formation unit E where elevated levels of trichloroethene have been recently discovered (PNNL-16435; see also Section 2.12.1.2). At depths below the unconfined aquifer (i.e., wells with a “C” suffix), contaminant uranium has not been detected, as corroborated by new information from a recent limited field investigation (PNNL-16435).

Groundwater is also monitored at eight sites located along the 300 Area shoreline. Aquifer tubes were installed at multiple depths at each of these sites in 2004 and have now been sampled numerous times, with several sampling events conducted during FY 2007: December 2006/January 2007 and again in August 2007. The results of this sampling are shown on Figure 2.12-11, along the results from previous events. The values shown on the map are the highest observed at a tube site for a particular sampling event. The highest uranium value ever recorded for a tube sample is 394 µg/L, although this result is believed to be nonrepresentative of aquifer conditions. A more reasonable maximum value for recent uranium concentrations in groundwater near the river is ~200 µg/L, based on other results from aquifer tubes and from near-river monitoring wells.

Information derived from monitoring at tube sites is reasonably consistent with information based on sampling near-river wells in December 2006. For example, the highest values associated with samples from tubes are generally at sites adjacent to the central core area of the groundwater plume, as shown on Figure 2.12-11, i.e., near sites AT-3-3 and AT-3-4. An exception to this generalization occurs along the northern portion of the plume at the shoreline, where uranium concentrations are frequently higher in samples from tubes at site AT-3-1 than in samples from adjacent wells 399-1-10A and 399-1-1.

Several mechanisms contribute to differences in concentrations observed in samples from tubes and from wells. First, vertical variability in contamination characteristics will likely produce different results in samples collected from screened intervals of various lengths (e.g., 0.15 meter for tubes; 3 to 6 meters for wells). Second, wells may be more influenced than tubes by infiltrating river water, thus diluting the contaminant. Third, lateral variability in a plume causes different concentrations at different locations. In spite of these mechanisms that bias sampling results, data from tubes and wells contribute to defining the lateral extent and concentration range for the contaminant plume. Tube results also provide information on the vertical distribution of the contaminant.

A second representation of uranium results for samples from tubes and near-river wells is shown in Figure 2.12-12, which is a cross section oriented along the 300 Area shoreline. The tube results illustrate the variability in uranium concentrations within the aquifer, much of which is likely to be the result of lateral and vertical variability in concentrations within the plume. The position of near-river monitoring wells has been projected onto this cross section to provide perspective on the representativeness of samples collected from the various types of sampling facilities. Also projected onto the cross section is the contact separating the Hanford gravels from the underlying Ringold Unit E, as identified at the monitoring wells. This figure supports the conclusion that most uranium contamination is contained within the saturated Hanford gravels. The only tubes to be completed in the underlying Ringold Unit E (AT-3-3-D, and possibly AT-3-6-D and AT-3-7-D) show very low uranium concentrations. Finally, the maximum depth of the adjacent river channel is projected onto this cross section, to illustrate that the river channel incises the entire contaminated portion of the aquifer.

**Uranium Near 618-10 Burial Ground and 316-4 Cribs.** Uranium concentrations are elevated above the natural background level of 5 to 8 µg/L at several wells near the southeast side of the 618-10 burial ground and the former 316-4 cribs. Well 699-S6-E4A, which is located within the excavation footprint for the former cribs, has revealed the highest concentrations in the past, but has shown a steady decline during FY 2007, with September 2007 results well below the 30-µg/L drinking water standard (Figure 2.12-13). The cause for the earlier variability in uranium concentrations at this well is likely related to excavation and backfilling activities. Well 699-S6-E4L, which is located adjacent to the southeast side of the burial ground, also showed elevated uranium concentrations during excavation activities, although since January 2006, concentrations have followed a steady downward trend to values approximately one-half the drinking water standard.

### 2.12.1.2 Volatile Organic Compounds

Contaminants of concern or potential concern in groundwater beneath the 300 Area include trichloroethene and tetrachloroethene, along with their degradation product cis-1,2-dichloroethene. Although carbon tetrachloride was used in fuel manufacturing process, it has not been detected with certainty in the groundwater beneath the 300 Areas and has not been identified as a contaminant of potential concern. The origins of these volatile organic compounds in groundwater include past disposal to 300 Area facilities and movement into the 300 Area from off-site sources to the southwest. Beneath the 618-10 burial ground and former 316-4 cribs, organic compounds previously identified as of potential concern include tributyl phosphate and petroleum hydrocarbons.

**300 Area Volatile Organic Compounds.** During FY 2007, cis-1,2-dichloroethene, trichloroethene, and tetrachloroethene continued to be detected in 300 Area groundwater as monitored at wells and aquifer tubes along the river shoreline. In the upper portion of the unconfined aquifer (i.e., near the water table), concentrations of these compounds are lower than the relevant drinking water standard. In the lower portion of the unconfined aquifer, cis-1,2-dichloroethene has persisted at concentrations that exceed the drinking water standard at one well since monitoring began at that well in 1991. During 2006, elevated volatile organic compounds were also discovered at concentrations that exceed the drinking water standard in a sandy subunit of the unconfined aquifer. This discovery is at a depth in the aquifer that is lower than the depths typically covered by the existing monitoring well network.

Trichloroethene is the most widespread of the contaminant volatile organic compounds (Figure 2.12-14); the drinking water standard is 5 µg/L. It was detected at numerous wells within the 300 Area and in wells located to the southwest of the 300 Area, where additional potential sources for trichloroethene are located. The highest concentration observed during FY 2007 in the upper portion of the unconfined aquifer was 4.8 µg/L at well 399-1-7, which is located downgradient from the former 300 Area process trenches, a likely disposal site for volatile organic compounds. Trichloroethene is occasionally detected at wells screened in the lower portion of the unconfined aquifer (i.e., “-B” suffix well names), but at levels below the drinking water standard in recent years. At aquifer tube sites along the rivershore, trichloroethene was generally not detected in shallowest tubes, but was detected at greater depths in the unconfined aquifer, i.e., in the sandy subunit mentioned above. The discovery of volatile organic compounds in the sandy subunit is illustrated in Figure 2.12-15, which shows the concentrations observed in water samples collected

*Volatile organic compounds have been present in the upper portion of the 300 Area aquifer at low levels for many years. The sources are local waste disposal during operations and migration into the 300 Area from sources to the southwest.*

during drilling, and also the concentrations in relatively deep aquifer tubes at the river. (Note: New wells 399-3-21 and 399-3-22 are screened at depths equivalent to the “-B” suffix wells).

Tetrachloroethene was detected at very low concentrations (0.27 to 0.40  $\mu\text{g/L}$ ) at three wells during FY 2007; its drinking water standard is also 5  $\mu\text{g/L}$ . Most of the detections are in wells screened at the water table in the central and southern portions of the 300 Area, with no definitive evidence pointing to a specific source. Historically, tetrachloroethene has been observed at concentrations as high as 38  $\mu\text{g/L}$  near the south end of the former 300 Area process trenches, a known source site. However, during FY 2007, results for monitoring in that location are reported with a lab qualifier that indicates non-detection.

Cis-1,2-dichloroethene continues to be at concentrations that exceed the 70- $\mu\text{g/L}$  drinking water standard at one well located along the downgradient flow path from the former 300 Area process trenches. The occurrence is at well 399-1-16B, which is screened in the lower portion of the unconfined aquifer. The concentration at this well rose during initial monitoring in the 1990s, and then remained remarkably constant until increased variability began in 2005 (Figure 2.12-16). The cause for the increased variability has not been identified. The origin for cis-1,2-dichloroethene is presumed to be decomposition of waste trichloroethene and tetrachloroethene. An additional degradation product under certain environmental conditions, vinyl chloride, has not been detected in 300 Area groundwater.

During the limited field investigation in the 300 Area (Section 2.12.3.2), volatile organic compounds were found in water samples collected in May 2006 during the drilling of four characterization boreholes 399-1-23, 399-3-18, 399-3-19, and 399-3-20 (PNNL-16435; see Figure 2.12-2 for locations). Concentrations found in shallow samples collected during drilling were comparable to those monitored by the routine network. However, at depths below typical screened intervals, some unexpectedly high concentrations were encountered in a fine-grained sandy interval within Ringold Unit E. Trichloroethene concentrations as high as 630  $\mu\text{g/L}$  were encountered at well 399-3-20, which is located adjacent to the southeast corner of the 307 process trench (316-3 waste site). The trichloroethene degradation product cis-1,2-dichloroethene was also present in these samples, as was tetrachloroethene. Samples were collected from aquifer tube sites along the shoreline adjacent to well 399-3-18 have also revealed elevated trichloroethene concentrations (SGW-35028). An August 2007 result from tube AT-3-3-D showed a concentration of 290  $\mu\text{g/L}$ . All of the drilling samples, and likely the sample from tube AT-3-3-D, came from a relatively fine-grained unit within the upper portion of the Ringold Formation (Figure 2.12-16).

The discovery of elevated volatile organic compounds at depth in the unconfined aquifer led to additional drilling to determine the extent of this contamination (SGW-32607). Four characterization boreholes were drilled in the region adjacent to the limited field investigation boreholes 399-2-5, 399-3-21, 399-3-22, and 399-4-14 (see Figure 2.12-2). Boreholes 399-2-5 and 399-4-14 were subsequently completed as water table monitoring wells, while 399-3-21 and 399-3-22 were completed with screens in the lower portion of the unconfined aquifer (equivalent to the earlier “-B” series of wells). Although the Ringold Unit E fine-grained unit was encountered, volatile organic compounds were not generally detected, and where they were detected, the values were  $< 1 \mu\text{g/L}$  (preliminary results). This suggests contamination

***Recent drilling has revealed additional contamination at depth in the unconfined aquifer. High levels of trichloroethene are present in a fine-grained hydrologic unit, which transmits groundwater very slowly.***

in a relatively small area that is located near the east end of the 307 process trenches and eastern side of the former South Process Pond. A report describing the results of this investigation is planned for early in 2008.

The travel time for volatile organic compounds to move from the area of discovery through the fine-grained sediment to the river would be long compared to travel times for contaminants in the overlying portion of the aquifer, because of the difference in permeability of these two hydrologic units. Once at the aquifer/river interface, discharge would therefore occur at a relatively low rate, and volatilization in the river flow would occur rapidly, thus reducing the concentrations in river water to negligible levels in a very short distance.

**Organic Compounds in the Outlying 300-FF-5 Subregions.** Tributyl phosphate has been detected in the past in groundwater beneath the former 316-4 cribs (see Figure 2.12-3 for location map). The cribs received liquid waste associated with research conducted at the 321 Separations Laboratory in the 300 Area during the period 1948 to 1954 (BHI-00012). The waste included tributyl phosphate and uranium. Tributyl phosphate concentrations were elevated somewhat in early 2004, along with uranium, during the period when crib removal actions were underway. During FY 2007, estimated concentrations at well 699-S6-E4A, located within the footprint of the 316-4 cribs excavation, have ranged from 2.6 to 6.5 µg/L. The compound was not detected at nearby wells 699-S6-E4K and 699-S6-E4L during FY 2007. The semivolatile compound tends to bind to soil in the vadose zone, where it slowly degrades with time. It is not very soluble in water and, therefore, not widely dispersed via water transport mechanisms. A drinking water standard for tributyl phosphate has not been established.

Petroleum hydrocarbons (both diesel and gasoline) were detected in groundwater during the refurbishment of well 699-S6-E4A in 1995. The source may have been past leaks or spills from a fuel tank associated with operation of the former 316-4 cribs. Monitoring conducted between 1995 and 2005 has shown non-detections at wells in the general vicinity, and analyses for petroleum hydrocarbons are no longer performed.

### 2.12.1.3 Tritium

Tritium-contaminated groundwater in the 300-FF-5 Operable Unit is associated with two primary sources. One is the site-wide tritium plume that originates in the 200 East Area (see Figure 1.0-2 in Section 1.0 and Section 2.11.1.1) and extends beneath all subregions of the 300-FF-5 Operable Unit. The second source is the 618-11 burial ground, which is located just to the west of the Energy Northwest complex. Concentrations attributed to the site-wide plume as it reaches the 300-FF-5 subregions are shown in Figure 2.12-17 and are generally <20,000 pCi/L, depending on location. In the region just to the north of the 300 Area, concentrations are decreasing with time, as the site-wide plume attenuates by radioactive decay and dispersion (see discussion of 200 East Area tritium plume in Section 2.11.1.1).

**Tritium at 618-11 Burial Ground.** High concentrations of tritium were detected in early 1999 at well 699-13-3A, which is located immediately to the east of the 618-11 burial ground. Subsequent investigations (PNNL-13675) identified a contaminant plume that extends downgradient as a narrow plume of concentrations much higher than the surrounding site-wide plume from 200 East Area (Figure 2.12-18). Concentrations near the presumed burial ground source have

*A groundwater plume containing tritium is present near the 618-11 burial ground. The source is presumed to be release of tritium from irradiated material in the burial ground.*

declined since peak values in 1999 and 2000, with the FY 2007 concentration at well 699-13-3A being the lowest value since monitoring began (Figure 2.12-19). The trend near the burial ground at well 699-13-3A suggests the possibility that an episodic event of unknown nature caused a release of tritium from buried materials and/or mobilization of tritium in the vadose zone. The removal of tritium sources in the 618-11 burial ground is expected to be no later than 2018, per Tri-Party Agreement (Ecology et al. 1989) Milestone M-016-00B. Changes in concentrations at wells farther away from the burial ground reflect migration of the plume, i.e., they include constant or gradually increasing concentrations trends.

*The drinking water standard for nitrate is exceeded in groundwater that migrates into the southern portion of the 300 Area from sources to the southwest.*

#### **2.12.1.4 Nitrate**

**300 Area.** Nitrate concentrations in groundwater beneath the 300 Area are generally lower than the 45-mg/L drinking water standard, except for the southern portion of the 300 Area (Figure 2.12-20). The relatively higher concentrations in the southern portion currently reflect the migration of nitrate-contaminated groundwater into the 300 Area from sources to the southwest, which possibly include agricultural and industrial activities. Gradually increasing concentrations are observed in wells and at shoreline sites as this nitrate-laden groundwater migrates into the 300 Area. Nitrate also migrates into the 300 Area from the northwest as part of the sitewide plume that originates in the 200 East Area, but at concentrations below the drinking water standard. During earlier periods, additional contributions to groundwater came from disposal of operations-related effluent and sanitary sewer systems. Throughout the 1970s and 1980s, nitrate concentrations in groundwater were somewhat higher than today, but still never greatly exceeded the drinking water standard. Remedial investigation monitoring results indicate a relatively constant level of contamination, but with some variability in concentrations, during the period 1992 to 2004 (PNNL-15127, Table 2.10).

**618-11 and 618-10 Burial Ground Subregions.** The outlying waste sites in the 300-FF-5 Operable Unit lie within the large contaminant plume that originates in the 200 East Area. Background levels for nitrate upgradient of the 618-11 burial ground are in the range of 20 to 40 mg/L, while in the vicinity of the burial ground concentrations are somewhat higher and exceed the 45-mg/L drinking water standard (Figure 2.12-20). For example, values during FY 2007 at well 699-13-3A were in the range 68 to 78 mg/L and at well 699-12-2C in the range 54 to 83 mg/L. The cause for these higher values near the burial ground is not fully understood; they may reflect some hydrogeologic characteristic that has caused retention of more contaminated groundwater from earlier years (PNNL-13228). Trends for the last several years indicate relatively constant nitrate levels, but with some variability. At the 618-10 burial ground, nitrate concentrations are generally consistent with values expected for the leading edge of the site-wide plume and are lower than the drinking water standard, with the exception of several results at 699-S6-E4L during the year (54 to 66 mg/L). The cause for these somewhat elevated results has not yet been identified.

#### **2.12.1.5 Other Constituents**

In addition to the contaminants of concern or potential concern that are formally recognized in decision documents, other constituents of interest are being monitored at various locations in the 300-FF-5 Operable Unit because they either exceed the drinking water standard or are helpful in characterizing contamination in the aquifer. These include radiological constituents gross alpha, gross beta, strontium-90, and tritium.

**300 Area.** Radiological contamination in the 300 Area, other than uranium, is generally at low levels. Gross alpha, which is associated with uranium, exceeds the drinking water standard of 15 pCi/L at numerous 300 Area wells, as expected because of the uranium plume. Gross beta, a second radiological criteria for drinking water, exceeded the 50-pCi/L standard at two 300 Area wells during FY 2007 and was elevated above background at numerous wells. Potential sources for this activity include daughter isotopes from radiological decay of uranium. Other potential contributors include low levels of technetium-99 and strontium-90 at isolated locations, and background levels from natural sources (e.g., potassium-40).

Strontium-90 has been detected at relatively low levels and as an isolated occurrence at well 399-3-11 in previous years (PNNL-13788). The result for a sample collected in December 2006 from well 399-3-11 was 2.6 pCi/L (the drinking water standard is 8 pCi/L). The well is located in the general vicinity of facilities that had strontium-90 in various waste streams, e.g., the 307 Retention Basins and associated underground transfer lines, which are known to have leaked (WIDS Unplanned Release UPR-300-1).

During the excavation of the 618-2 burial ground in 2006, unexpected occurrences of plutonium and other radiological contamination in the soil were encountered. Some contamination was measured in a test pit excavated to the water table, leading to concerns about previously undetected impacts to groundwater. Increased monitoring was conducted at the nearest monitoring well (399-1-2) and plutonium was not detected in groundwater samples. Previous measurements at other wells in the vicinity have not revealed plutonium. To further investigate this occurrence, three boreholes were drilled to groundwater at a strategic location within the excavated burial ground. Water samples were collected in December 2006 and analyzed for plutonium, uranium, and gross alpha/gross beta. All results for plutonium isotopes were nondetects. Uranium (total) was detected, but at levels consistent with natural background for the 300 Area. The results of this sampling are in HEIS (boreholes C5387, C5388, and C5399) and in data files attached to this report.

**618-11 and 618-10 Burial Ground Subregions.** These subregions lie within the large contaminant plume that originates at the 200 East Area. This site-wide plume contains the mobile radiological contaminants tritium, technetium-99, and iodine-129 (see Section 2.11 for description of the site-wide plumes). Tritium and technetium-99 associated with site-wide plumes are at detectable levels at the 300-FF-5 outlying waste sites, although iodine-129 is not. While detectable, the concentrations for site-wide plume contaminants at the two subregions are below drinking water standards.

At the 618-11 burial ground, tritium releases from the burial ground are superimposed on the site-wide plume, creating a localized plume that greatly exceeds the drinking water standard. Also, technetium-99 is somewhat elevated relative to expected site-wide plume concentrations in the vicinity of the burial ground, and may be the likely cause for gross beta concentrations that exceed the 50-pCi/L drinking water standard at well 699-12-2C. The concentration trends for technetium-99 and tritium at well 699-13-3A, which is adjacent to the burial ground, are similar, suggesting that small amounts of technetium-99 may have been associated with the release that created the local tritium plume in 1999~2000. At the 618-10 burial ground, gross alpha measurements also exceed the drinking water standard at two wells, presumably as the result of uranium contamination.

*Radiological contamination indicators such as gross alpha and gross beta are used to monitor groundwater near source remedial action sites.*

*Groundwater in the 300-FF-5 Operable Unit includes contaminants associated with the sitewide plume that originates in the 200 East Area.*

## 2.12.2 Operable Unit Activities

A decision for interim action involving groundwater beneath waste sites in the 300 Area portion of the 300-FF-5 Operable Unit was made in 1996 (ROD 1996b). The geographic extent of the operable unit under this record of decision was subsequently expanded in 2000 to include groundwater potentially impacted by waste sites in two outlying areas north of the 300 Area, i.e., beneath the 618-11 burial ground and 618-10 burial ground/316-4 cribs waste sites (EPA 2000). The interim remedy as stated in the record of decision is:

- Continued monitoring of groundwater that is contaminated above health-based levels to ensure that concentrations continue to decrease.
- Institutional controls to ensure that groundwater use is restricted to prevent unacceptable exposures to groundwater contamination.

In 2004, activities were renewed on the operable unit's remedial investigation and feasibility studies. A new Tri-Party Agreement milestone (M-016-68) was developed in early 2005 for a Phase III Feasibility Study report on remedial action alternatives and a draft proposed plan. A work plan was prepared (DOE/RL-2005-41) that describes these additional efforts, which include updated computer simulations of groundwater flow and uranium transport; a limited field investigation involving multiple characterization boreholes; an update to the human health and ecological

risk assessment; and an assessment of potential remedial action technologies for the 300 Area uranium plume. Work in all these areas continued during FY 2007 and is summarized in Section 2.12.3.

### *The remedial action objectives for interim action involving groundwater are:*

- *Protect receptors from exposure to contaminants in the groundwater and control the sources of contamination to minimize future impacts to groundwater.*
- *Protect the Columbia River such that contaminants in the groundwater or soil after remediation do not result in an impact to the river that would exceed the Washington State surface water quality standards.*
- *Contaminants of potential concern are identified in the record of decision as cis-1,2-dichloroethene, trichloroethene, and uranium. In 2000, the record of decision was expanded to include groundwater beneath outlying burial grounds, and added tritium and tributyl phosphate to the list of contaminants.*

### 2.12.2.1 Interim Remedial Action Monitoring

Implementation of the interim remedy specified in the record of decision (ROD 1996b; EPA 2000) is described in the operable unit operations and maintenance plan, as revised in 2002 (DOE/RL-95-73) and a sampling and analysis plan (DOE/RL-2002-11), which was revised in June 2006. The Executive Summary for the operations and maintenance plan describes specific monitoring objectives for the period of interim action:

- Verify that natural attenuation reduces groundwater contamination concentrations to drinking water maximum contaminant levels over a reasonable time period.
- Confirm that contaminant concentrations in the river seeps do not exceed ambient water-quality criteria or established remediation goals (drinking water standards).
- Validate contaminant fate and transport conceptual models.

Progress toward meeting these interim action monitoring objectives has been described in detail previously in an expanded groundwater report for FY 2004 (PNNL-15127). Continued monitoring since that report has produced information

that is generally consistent with historical trends, expectations, and existing conceptual models. The new information has been reported in the annual Hanford Site groundwater monitoring reports, and in an updated description of uranium contamination in the subsurface at the 300 Area (see Section 2.12; PNNL-17034).

For the 300 Area subregion, ~46 monitoring wells were in service during FY 2007 as part of the groundwater monitoring effort, reflecting a slight increase in number as the results of drilling associated with a limited field investigation. In addition, samples were collected from eight aquifer tube sites and two riverbank springs along the shoreline. Groundwater monitoring included semiannual sampling at many of the monitoring wells during December 2006 and June 2007, with the intent of characterizing average seasonal conditions (December) and the spring period of high water-table elevations (June) that are caused by the spring runoff to the Columbia River. The semiannual sampling applies to wells that monitor the upper part of the unconfined aquifer, including the water table. Other wells that monitor deeper horizons are sampled annually. A subset of wells, and all new wells, were sampled quarterly to provide more resolution of seasonal changes and to establish baseline conditions at their locations, respectively. The planned schedule for FY 2007 and comments on its implementation are listed in Appendix A.

At the 618-11 burial ground subregion, six wells are sampled quarterly for key constituents and semiannually for supporting constituents. All of these wells monitor the upper part of the unconfined aquifer. At the 618-10 burial ground/316-4 cribs subregion, six wells are sampled quarterly, semiannually, or annually, depending on proximity to the waste sites. All of the wells used at these two subregions monitor the upper part of the unconfined aquifer.

### 2.12.2.2 Status of Five-Year Review Action Items

Because contamination remains in the 300-FF-5 Operable Unit, the CERCLA process requires a review of the effectiveness of the record of decision every 5 years. The second five-year review of the 300-FF-5 record of decision was conducted during the period summer 2005 through spring 2006. That review was published in November 2006 (DOE/RL-2006-20). One issue and associated action item are listed for the 300-FF-5 Operable Unit:

- **Issue 19.** Predicted attenuation of uranium contaminant concentrations in the groundwater under the 300 Area has not occurred. DOE is currently performing additional characterization and treatability testing in the evaluation of more aggressive remedial alternatives.

**Action 19-1.** Complete focused feasibility study for 300-FF-5 Operable Unit to provide better characterization of the uranium contamination, develop a conceptual model, validate ecological consequences, and evaluate treatment alternatives. Concurrently test injection of polyphosphate into the aquifer to immobilize the uranium and reduce the concentration of dissolved uranium. (Due date September 2008).

The status of these activities is described in the following sections.

### 2.12.2.3 Phase III Feasibility Study

The work plan for the Phase III Feasibility Study for the 300-FF-5 Operable Unit (DOE/RL-2005-41) is focused on uranium contamination in the 300 Area subregion of the operable unit. This contaminant of concern has persisted at elevated levels far longer than predicted by the initial remedial investigation (DOE/RL-94-85).

*Groundwater monitoring during the period of interim remedial action is conducted under an operations and maintenance plan.*

*Five-year reviews of the record of decision for 300-FF-5 Operable Unit reaffirmed the cleanup goals and remedy selection, but call for additional investigation of potential remedial actions for uranium.*

***A feasibility study of remedies for uranium contamination in the 300 Area includes technology screening, additional hydrogeologic characterization, computer simulation of groundwater flow and transport, and updates to the conceptual site model.***

***A limited field investigation involving four characterization boreholes provides new, detailed information on uranium in the vadose zone and aquifer.***

Therefore, additional evaluation of potential remedial action technologies, i.e., evaluation beyond the information presented in the initial feasibility study report (DOE/RL-93-22), is underway. The objective for the Phase III Feasibility Study is to re-evaluate the remedy for the uranium plume. The ultimate goal for remedial action is to "...select remedial actions that have the potential to (1) restore, to the extent possible, the 300-FF-5 aquifer to its highest and best beneficial use, and (2) reduce risk to human health and the environment" (DOE/RL-2005-41, p. 7).

The Phase III Feasibility Study includes several major components: Evaluation of potential engineered solutions to reduce the level of uranium contamination in 300 Area groundwater; a limited field investigation in the 300 Area to better define the distribution and geochemical characteristics of uranium; computer simulation of groundwater flow and transport in the 300 Area; updated descriptions of uranium contamination in the subsurface of the 300 Area; and an updated assessment of ecological and human health risks posed by contaminants in the 300-FF-5 Operable Unit groundwater.

***Evaluation of Remedial Action Alternatives for 300 Area Uranium.*** During FY 2007, a report was prepared that describes the screening of potential remedial action technologies to achieve the goal stated above (PNNL-16761). The primary subset of technologies that offers promise are those that use in situ methods to reduce the mobility of uranium in the environment and/or cause permanent sequestration of uranium.

***Limited Field Investigation Drilling Project, 300 Area.*** A limited field investigation was conducted during FY 2006 and FY 2007 in the 300 Area to obtain detailed information on (a) the distribution of uranium in the vadose zone and aquifer, and (b) the mobility characteristics of uranium encountered. The primary purpose for the limited field investigation was to provide information for the selection of potential remedial action technologies to reduce uranium contamination in the aquifer (DOE/RL-2005-47).

Four characterization boreholes were drilled at locations chosen to be representative of various combinations of proximity to waste sites and the Columbia River. Continuous core was obtained whenever possible throughout the vadose zone and aquifer at each of these boreholes, two of which extended down through the entire unconfined aquifer (399-1-23 and 399-3-18). Water samples were collected at depth-specific intervals in the saturated zone; hydraulic tests were conducted at multiple depth intervals; and geophysical logging, including spectral gamma and neutron moisture logging, was conducted in each borehole to aid in defining stratigraphic contacts. Spectral gamma logging was also run in an attempt to identify contaminant uranium. However, the level of uranium contamination encountered was less than the detection limit for gamma logging. The four boreholes were completed as monitoring wells, with screened intervals placed across the water table (399-1-23, 399-3-18, 399-3-19, and 399-3-20).

Initial laboratory analyses included moisture content and total uranium in sediment samples from select core intervals, and solution chemistry for all groundwater samples. Subsequent laboratory analyses included particle-size distribution and solution chemistry of water extracts from sediment core samples. The results from this lab work have supported several geochemical investigations involving uranium sequestration in the vadose zone (PNNL-17031; PNNL-17034). Hydraulic test

results were evaluated to determine aquifer flow parameters. Geophysical logs were correlated, calibrated, and evaluated to ground truth the spectral gamma logging results with laboratory-derived uranium results.

The drilling and analytical results, along with initial interpretations, are available in a limited field investigation report (PNNL-16435). The limited field investigation provided significant amount of new information that supported an update to the conceptual model for uranium contamination in the subsurface at the 300 Area, including:

- **Updated Hydrogeologic Framework for the 300 Area.** The data associated with the revised framework is managed in EarthVision™ software. Several computer simulation activities draw from this database for input parameters, such as simulation of groundwater flow and transport (Section 2.12.3.3). Limited field investigation data corroborate earlier suggestions that uranium contamination is primarily restricted to sediment of the Hanford formation.
- **More Accurate Information on the Vertical Distribution of Uranium.** Prior to the limited field investigation drilling activity, it was assumed that easily measurable quantities of contaminant uranium would be encountered in the vadose zone at locations near former liquid waste disposal sites. It was also suspected that relatively elevated uranium concentrations are present in the lower vadose zone near the water table throughout the area of the plume.

However, the results at each of the four characterization “type” locations did not reveal evidence for relatively high levels of contaminant uranium in the vadose zone, nor for an elevated zone of contaminants near the water table. Also, water samples collected from the saturated zone at various depths in the four boreholes revealed uranium concentrations which confirm that contamination is generally confined to the uppermost hydrologic unit (i.e., saturated Hanford gravels). Concentrations in the samples were consistent with those observed during routine groundwater monitoring.

**Simulation of Groundwater Flow and Transport.** Several groundwater flow and transport models are currently associated with the 300 Area. All rely on the same subsurface spatial data maintained in EarthVision™ software for their hydrostratigraphic framework, which has been updated using the results from the limited field investigation. These models use the computer code Subsurface Transport Over Multiple Phases (STOMP) for simulating flow and transport in the vadose zone and aquifer (PNNL-15782). Computer simulation of groundwater flow in the 300 Area is complicated by heterogeneous aquifer properties, and by frequent and rapid changes in the water-table configuration that are caused by fluctuations in Columbia River flows. Therefore, frequent measurement of water levels (e.g., hourly) are required to provide data for simulating water levels and groundwater flow.

The three-dimensional flow model that supports the Phase III Feasibility Study relies on a comprehensive database of hourly water-level measurements that were obtained during the early 1990s as part of the initial remedial investigation for the operable unit (PNL-9437). This model is being used to provide estimates for groundwater flux into and out of the aquifer beneath the 300 Area, including flux to the Columbia River. Additional detailed groundwater flow and transport simulations were prepared during FY 2007 for a smaller subregion of the 300 Area as part of a treatability test for uranium that involves injection of polyphosphate into the aquifer

*Computer simulations of groundwater flow and transport have been developed at several scales to support the remedial investigation and various research projects being conducted in the 300 Area subsurface.*

(PNNL-16571). The domain of this submodel extends from the southern end of the former 300 Area process trenches (316-5 waste site) to the northern part of the former South Process Ponds (316-1 waste site), and includes the area that extends to the river. This submodel uses data collected from a high-frequency water-level monitoring network established in 2004 by the Remedial Action and Closure Science Project (see Section 2.12.3.4). The development and use to date of the three-dimensional groundwater flow simulations at the 300 Area are described in a report scheduled for release in early 2008.

#### **2.12.2.4 Uranium Treatability Test, 300 Area**

A treatability test to immobilize uranium in the aquifer beneath the 300 Area began during FY 2006 and continued during FY 2007 (PNNL-16008). The test initially involved determining the groundwater flow characteristics in the vicinity of the test site, including a bromide tracer test that started in January 2007. This was followed by injection of polyphosphate into the aquifer in June 2007. The site chosen to conduct the test near the south end of the former 300 Area process trenches, where the last waste effluents containing uranium were disposed, and a location where uranium concentrations are typically higher following the seasonally raised water table. The test site is near limited field investigation well 399-1-23 (see Figure 2.12-2). During the latter part of FY 2007, monitoring results following the test injection were being analyzed. A final report on performance of the method is scheduled for May 2008.

#### **2.12.2.5 Research Activities Involving the 300 Area Uranium Plume**

The Remediation and Closure Science Project supports the 300-FF-5 Phase III Feasibility Study and associated treatability tests with a comprehensive program of simulation, laboratory, and field research tasks. The project's objective is to develop improved conceptual and transport-simulation models for uranium movement from the vicinity of waste sites, through the vadose zone and aquifer, and into the Columbia River at the 300 Area. The initial results for some of the hydraulic aspects of this modeling are described in PNNL-15125. A more comprehensive description of groundwater flow and uranium transport is described in Yabusaki et al. (2008). The research provides a scientific foundation for topics related to multi-component uranium surface complexation, kinetically controlled uranium mass transfer between mobile and less mobile phases, and spatially and temporally variable transport processes. The research focuses on developing the capability for long-term predictions of uranium migration and fate, which are required for scientifically defensible evaluations of remedial action alternatives.

Laboratory investigations continued during FY 2007 and included mineralogical analyses of sediment collected during the limited field investigation, characterizing uranium geochemistry in sediment samples from above and below the water table, and refining a surface complexation adsorption-desorption model that accounts for the effects of pore water pH, bicarbonate concentration, and sediment texture. Also, laboratory work on uranium exposure and uptake by aquatic organisms has been conducted during FY 2007.

Field investigations included detailed study of the hyporheic zone along the 300 Area shoreline. A report was prepared that describes the results of work conducted between 2004 and 2006, and includes a description of numerous methods to monitor the interface between groundwater and river water, and to help define stratigraphic

*A field treatability test to reduce uranium concentrations in groundwater is underway in the 300 Area and involves injecting polyphosphate solution into the aquifer.*

contacts (PNNL-16805). The results of this work illustrate the considerable impact that interaction between the groundwater and river hydraulic systems has on the discharge of the uranium plume into the Columbia River (Fritz and Arntzen 2007). Geophysical investigations also continued during FY 2007, during which electrical resistivity and self-potential measurements were used to estimate spatially distributed hydrologic and geochemical properties of the sediment (report being prepared by Pacific Northwest National Laboratory). In time-lapse mode, the data will be used to identify the contributions of recharge, and the mixing of river and groundwater.

Conceptual models for the geochemistry of uranium in the subsurface environment have evolved as the result of these laboratory studies and field investigations. The new laboratory results and field observations are being incorporated in computer simulations of uranium transport in the vadose zone and aquifer. These simulations include provisions for the dynamic hydrologic environment created by Columbia River stage fluctuations, which is a necessity for developing accurate predictions of where contaminants are likely to be exposed in the river environment, and at what levels.

***Update to the Conceptual Model for Uranium in the 300 Area Subsurface.*** During FY 2007, an updated description of uranium contamination in the subsurface at the 300 Area was completed, with the results described in PNNL-17034. The update included a detailed description of conditions as revealed by the monitoring program, updates to the hydrogeologic framework as a result of the limited field investigation (PNNL-16435), development of the 3-D computer simulations of groundwater flow, and a detailed discussion of the geochemical controls on uranium inventories and uranium mobility.

The focus for the update to this conceptual model for uranium was to describe where uranium might be sequestered in the environment and the cause for the persistence of the plume in groundwater. The information provided in PNNL-17034 supports the technical basis for selecting a potential remedial action technology (see Section 2.12.3.1) and its implementation if selected as the remedial action alternative. Key elements of the conceptual model are:

- Uranium continues to be supplied to groundwater at rates that approximate the rates at which uranium is lost via discharge to the Columbia River and via a water supply well.
- The vadose zone beneath former liquid waste disposal sites is a likely source area for residual contaminant uranium that continues to feed the groundwater plume.
- A more widespread zone through which the water table rises and falls also influences the rate at which contaminant uranium re-supplies the groundwater plume.
- Bank storage of Columbia River water influences the concentrations, and potentially the sequestration, of uranium carried by groundwater toward the river.

The next significant update to this conceptual model is likely to result from uranium transport simulation efforts that are being conducted under the Remediation Science and Technology project (Section 2.12.3.4) and the DOE's Integrated Field-Scale Challenge program, which is using the 300 Area uranium plume as a field research site for uranium mobility investigations (PNNL-17067).

***The DOE is supporting a variety of applied research activities in the 300 Area, including the geochemistry and mobility of uranium, interaction between the aquifer and river, and methods to remediate uranium contamination.***

***A report is now available that provides an updated description of uranium contamination in the 300 Area subsurface.***

***Update to Human Health and Ecological Risk Assessment.*** An update to the initial qualitative human health and ecological risk assessment for the 300-FF-5 Operable Unit (DOE/RL-93-21) was performed during FY 2006, as part of providing information to support the Phase III Feasibility Study. The three operable unit subregions, i.e., 300 Area, 618-11 subregion, and 618-10/316-4 subregion were considered in the assessment, as was the city of Richland. Impacts were assessed for five current human use scenarios, plus hypothetical direct access to drinking water from the aquifer and Columbia River. The scenarios are residential farmer, child recreation, casual recreation, avid recreation, and industrial. Food product concentrations for human scenarios with food consumption (i.e., residential farmer, and casual and avid recreation) were calculated in the ecological risk assessment. The results for the assessment were published in FY 2007 (PNNL-16454).

The updated ecological assessment models 81 aquatic and riparian species. The 300 Area is assumed to lie within the riparian zone. The upland zone in this assessment is the 618-11 burial ground and the 618-10 burial ground/316-4 cribs waste sites. In these upland subregions, groundwater is at sufficient depth to prevent access by ecological organisms under current conditions. Therefore, no ecological assessment was done for these outlying subregions. The results of this update are consistent with the earlier findings, and also with the recently completed 100/300 Area River Corridor Baseline Risk Assessment (DOE/RL-2007-21). No changes to the list of contaminants of potential concern for the operable unit have been recommended by these risk assessments.

#### **2.12.2.6 Volatile Organic Compounds Investigation**

During the limited field investigation for uranium (see Section 2.12.3.2), volatile organic compounds were discovered at elevated levels in groundwater associated with a fine-grained interval within Ringold Unit E (PNNL-13645). This fine-grained interval is located stratigraphically deeper than the majority of well screens used for groundwater monitoring groundwater in the 300 Area. The primary contaminant is trichloroethene and the maximum concentration encountered was 630 µg/L (see Section 2.12.1.2 for further description). The discovery occurred in the vicinity of the east sides of the 307 process trenches and former South Process Ponds, and prompted the need for additional characterization activities.

A plan for additional characterization drilling at three new locations, and one deep boring at a limited field investigation boring location, was prepared (SGW-32607). The drilling took place in September 2006 and again in May through November 2007. Initial results indicate that the contamination is limited to the fine-grained interval within Ringold Unit E, and to the area east of the 307 process trenches and former South Process Ponds. One aquifer tube (AT-3-3-D) is completed in this fine-grained interval and revealed a trichloroethene concentration of 290 µg/L for a sample collected in September 2007. The three boreholes that have revealed elevated trichloroethene levels in the fine-grained unit are 399-3-18, 399-3-20, and 399-3-21 (see Figure 2.12-for locations).

A report is planned for early 2008 that will describe the results of the additional characterization drilling and a review of historical operations and potential volatile organic compound source locations. A description of the potential area of riverbed where the fine-grained unit is exposed will be included, based on work performed under the Remediation and Closure Science Project (PNNL-SA-56035).

***Four boreholes were drilled to further investigate the discovery of elevated concentrations of volatile organic compounds at depth in the 300 Area aquifer.***

### 2.12.3 Facility Monitoring: RCRA Compliance at 300 Area Process Trenches

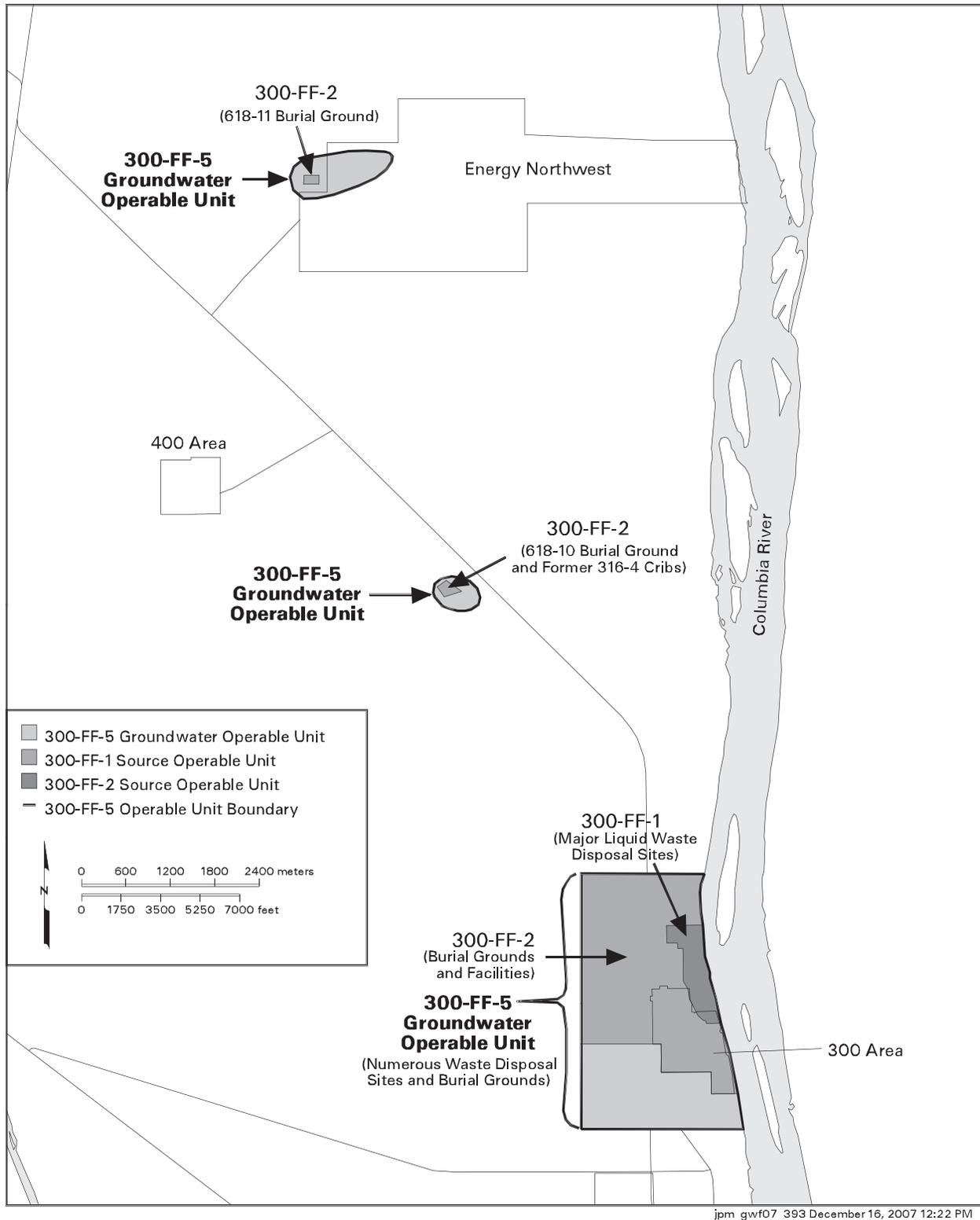
The former 300 Area process trenches (316-5 waste site) received effluent discharges of mixed waste from fuel fabrication and nuclear research laboratories in the 300 Area from 1975 through 1994. The trenches were remediated in 1991 under a CERCLA expedited response action by scraping contaminated soil to the north end of the facility (DOE/RL-92-32). Additional remedial actions were undertaken in 1997 and 1998 by excavating more contaminated soil and ancillary structures (BHI-01164), and final backfilling with clean soil was completed in early 2004 (DOE/RL-2004-74).

In addition to the groundwater monitoring conducted as part of 300-FF-5 Operable Unit activities under CERCLA, this former liquid waste disposal facility has been monitored under the requirements of RCRA for hazardous waste constituents, and under the Atomic Energy Act for uranium. Hazardous constituents and uranium are discussed jointly with respect to RCRA so that a comprehensive description of potential impacts to groundwater associated with this disposal unit is presented. With respect to treatment, storage, or disposal units regulated under RCRA, the DOE has the responsibility and authority to regulate radiological source, special nuclear, and by-product materials at DOE-owned nuclear facilities (see discussion in Section 1.2). Groundwater monitoring required by RCRA is conducted in accordance with WAC 173-303-645(11), "Corrective Action Program," and the Hanford Facility RCRA Permit, Part VI, Chapter 1 (Ecology 1994a). The modified closure plan (DOE/RL-93-73), which is incorporated into the Hanford Facility RCRA Permit, states that groundwater remediation is deferred to the CERCLA 300-FF-5 Operable Unit.

During FY 2007, RCRA groundwater monitoring for this disposal unit was conducted under a plan that has been in effect since 1997 (WHC-SD-EN-AP-185, as amended). Constituents monitored are uranium (total), cis-1,2-dichloroethene, trichloroethene, and tetrachloroethene. (Note: Uranium was included in the monitoring plan for completeness and incorporated by reference into the Hanford Facility RCRA Permit [Ecology 1994b].) The sampling schedule for the RCRA network of eight wells was designed to accommodate two semiannual sampling events, with four time-independent samples collected during each period. This has resulted in a sampling frequency of monthly for 8 months of the year (December, January, February, and March; June, July, August, and September). During FY 2007, this sampling was essentially accomplished as planned (see Appendix B), and reports on the effectiveness of the corrective action monitoring program were prepared semiannually per WAC 173-303-645(11)(g) (PNNL-16492; SQW-35164). The eight wells are situated at four locations: one upgradient (north of the former facility) and three downgradient (east, southeast, and south of the facility). Two wells are present at each location, with one screened near the water table and a second in the lower portion of the unconfined aquifer.

Only two of the four constituents of interest for RCRA monitoring at the former disposal facility continued to exceed their respective drinking water standards during FY 2007, i.e., cis-1,2-dichloroethene and uranium. Cis-1,2-dichloroethene remained at concentrations approximately twice the 70- $\mu\text{g}/\text{L}$  drinking water standard at downgradient well 399-1-16B, which monitors conditions in the lower portion of the unconfined aquifer (Figure 2.12-16). Other volatile organic compounds, such as trichloroethene and tetrachloroethene, continue to be detected in wells near the disposal unit, but at levels below their respective drinking water standards. Uranium remained above the 30- $\mu\text{g}/\text{L}$  drinking water standard in all three of the downgradient wells screened in the upper portion of the unconfined aquifer (Figure 2.12-8)

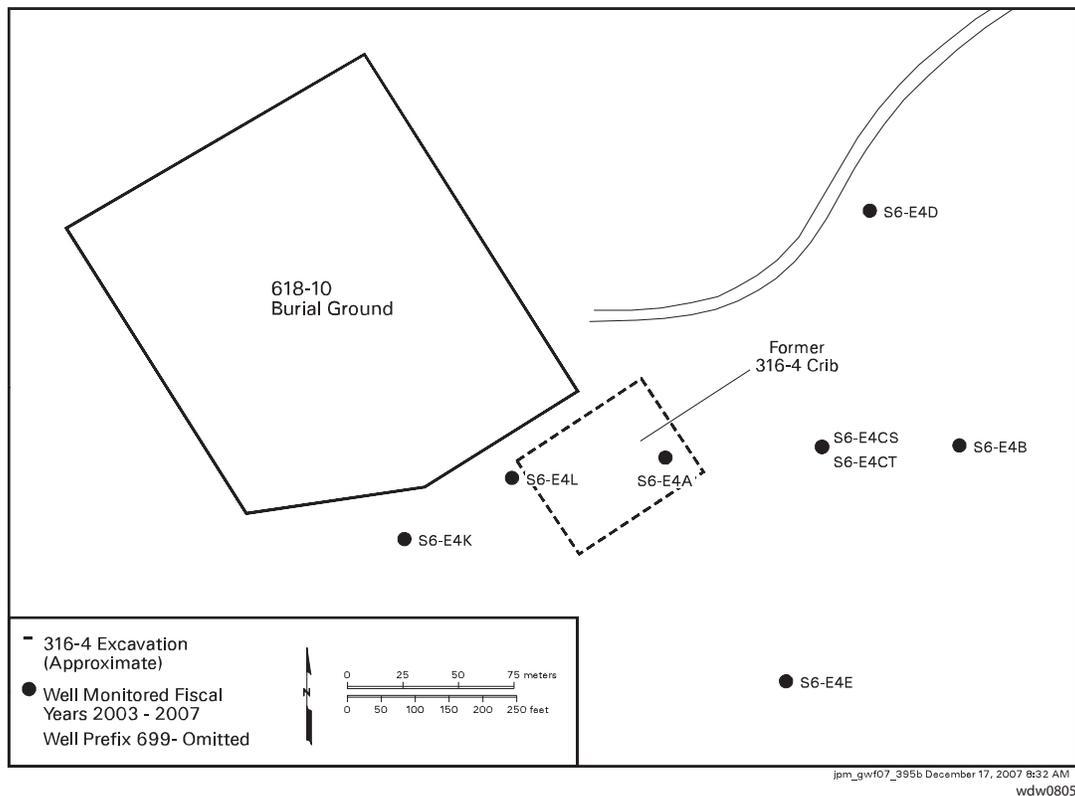
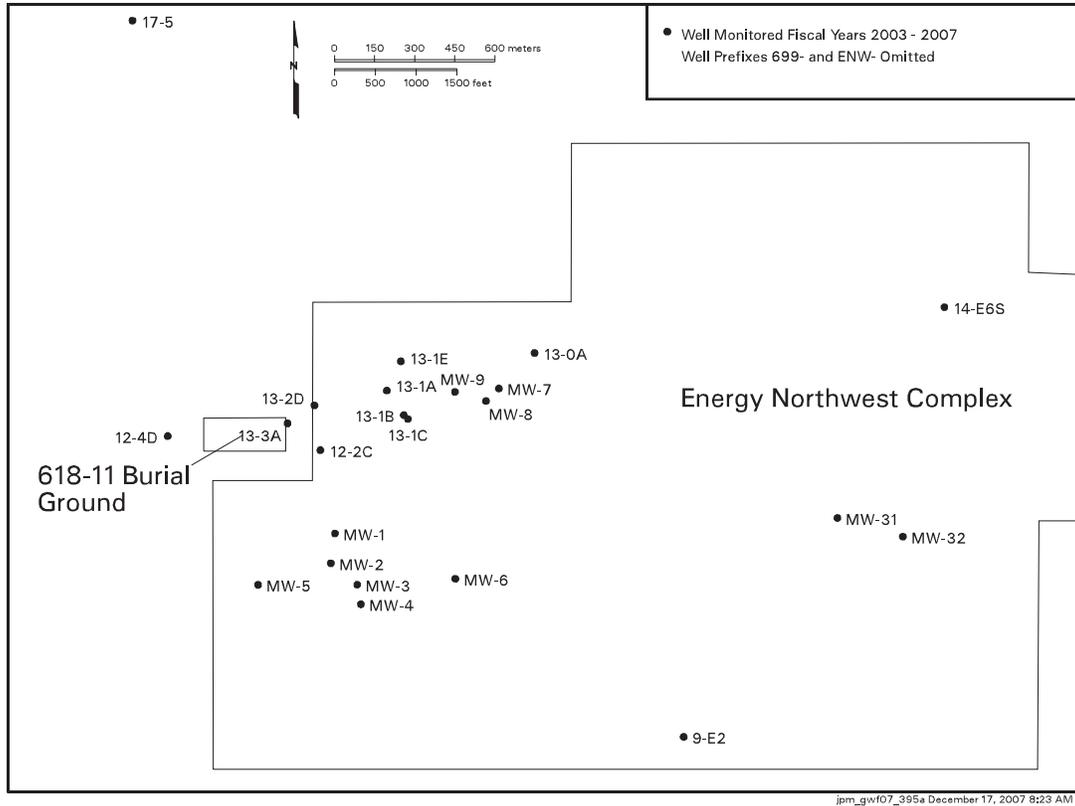
***Groundwater near the former 300 Area process trenches continues to be monitored under a RCRA corrective action program.***



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Figure 2.12-1. Operable Units Defined for the 300 National Priorities List Site





**Figure 2.12-3. Groundwater Monitoring Wells in Outlying 300-FF-5 Subregions**

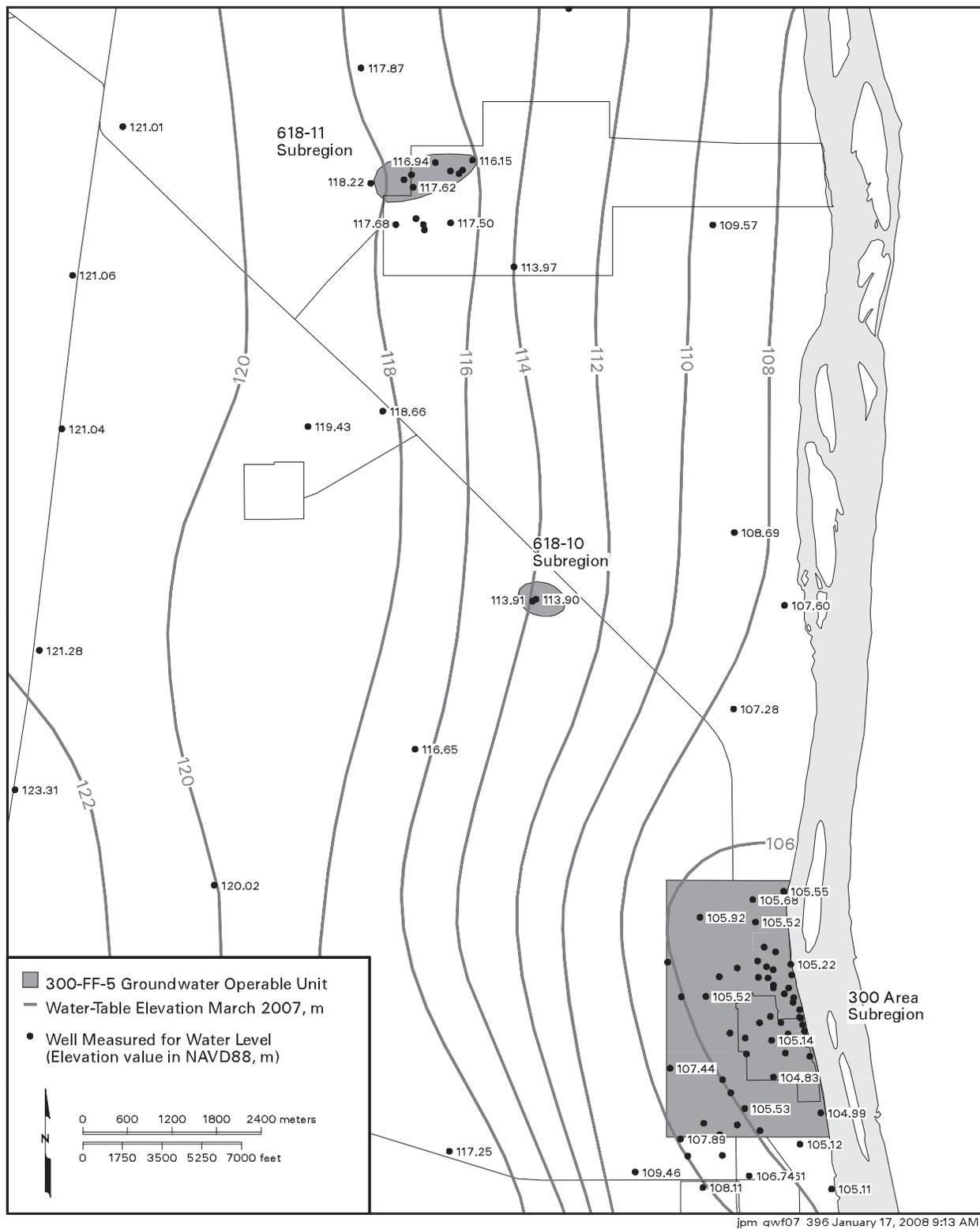
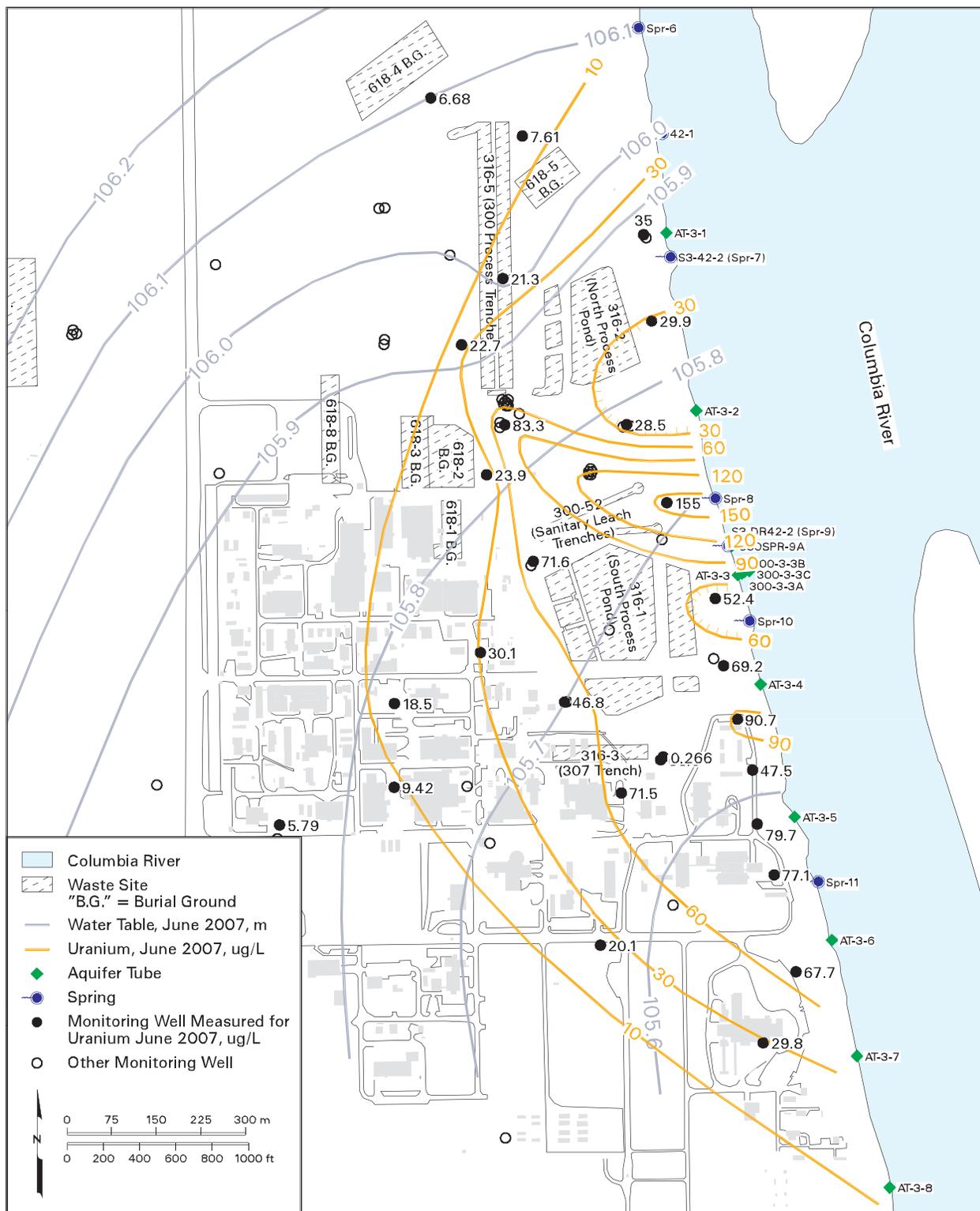
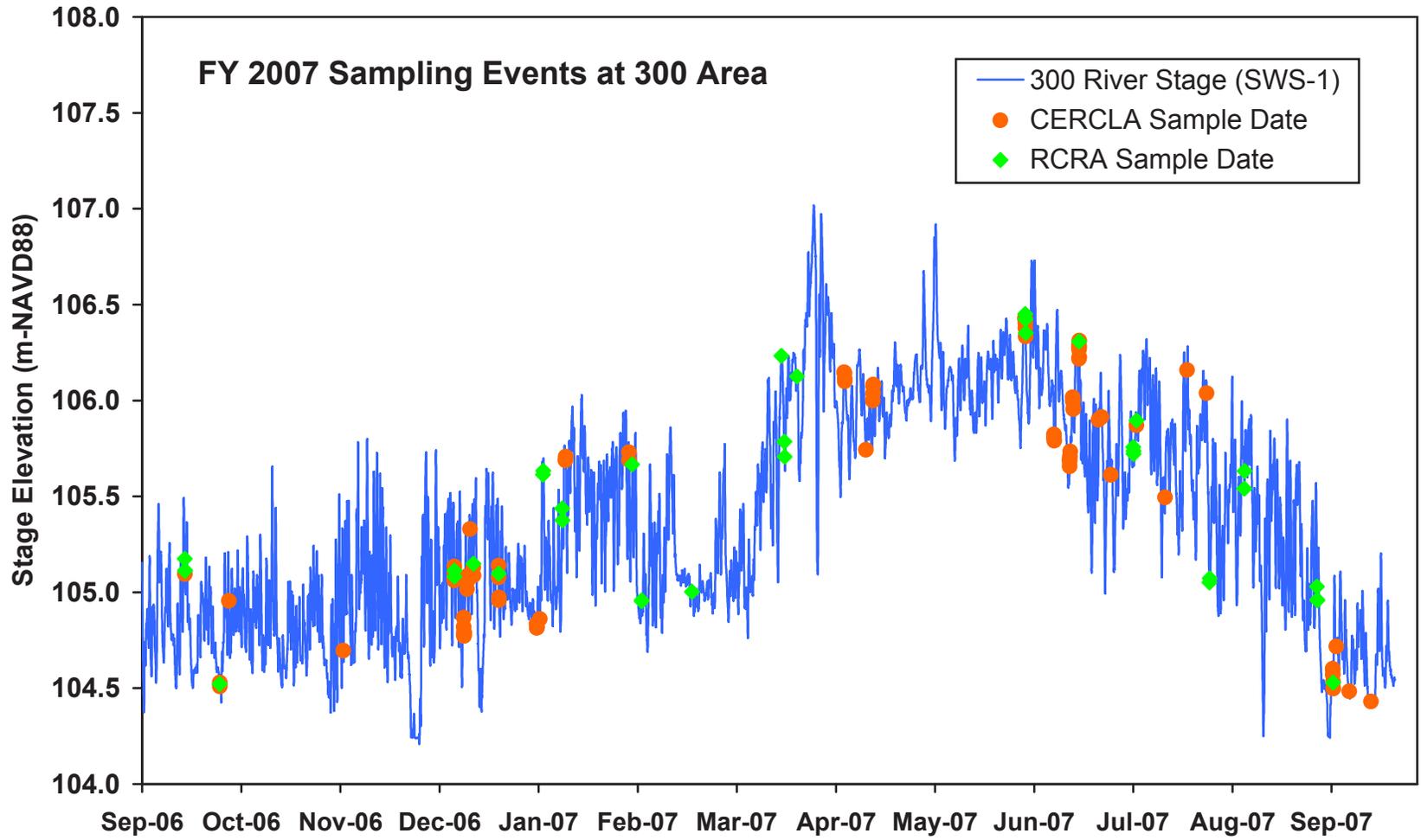


Figure 2.12-4. Water-Table Map for 300-FF-5 Interest Area, March 2007

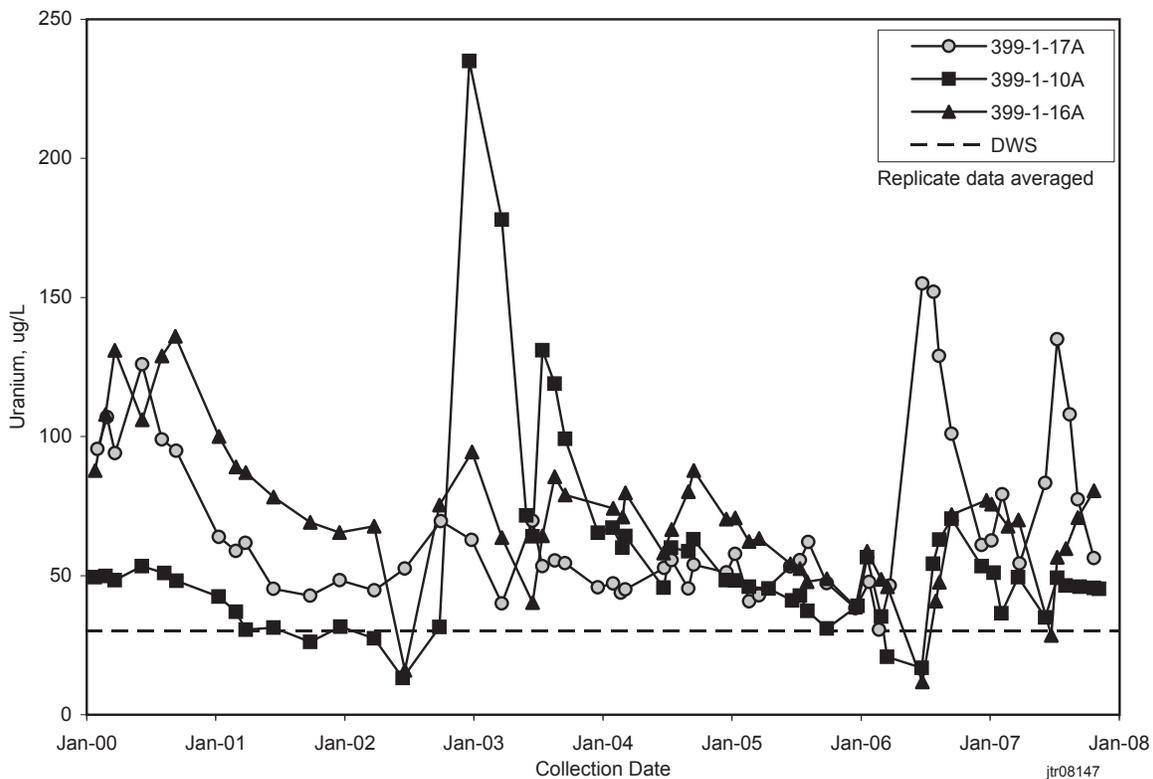




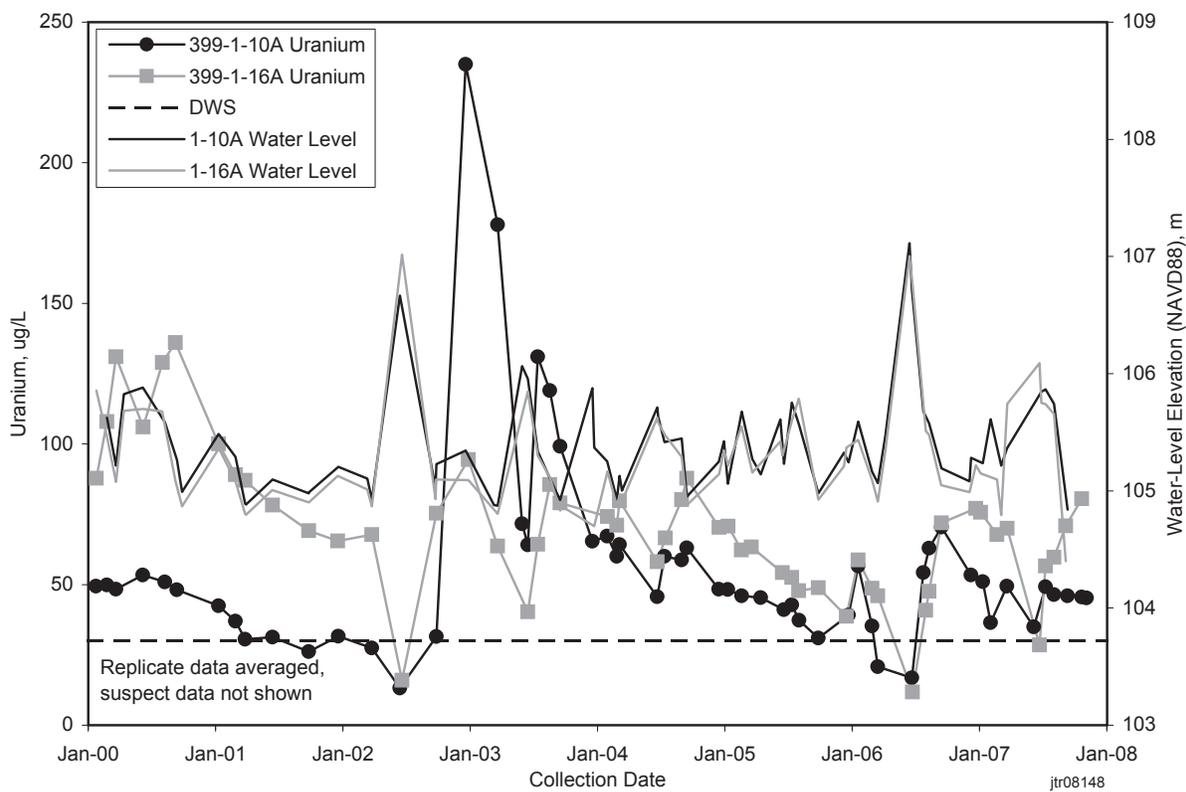


FY07 300-Sampling-WtrTbl.xls (110807)

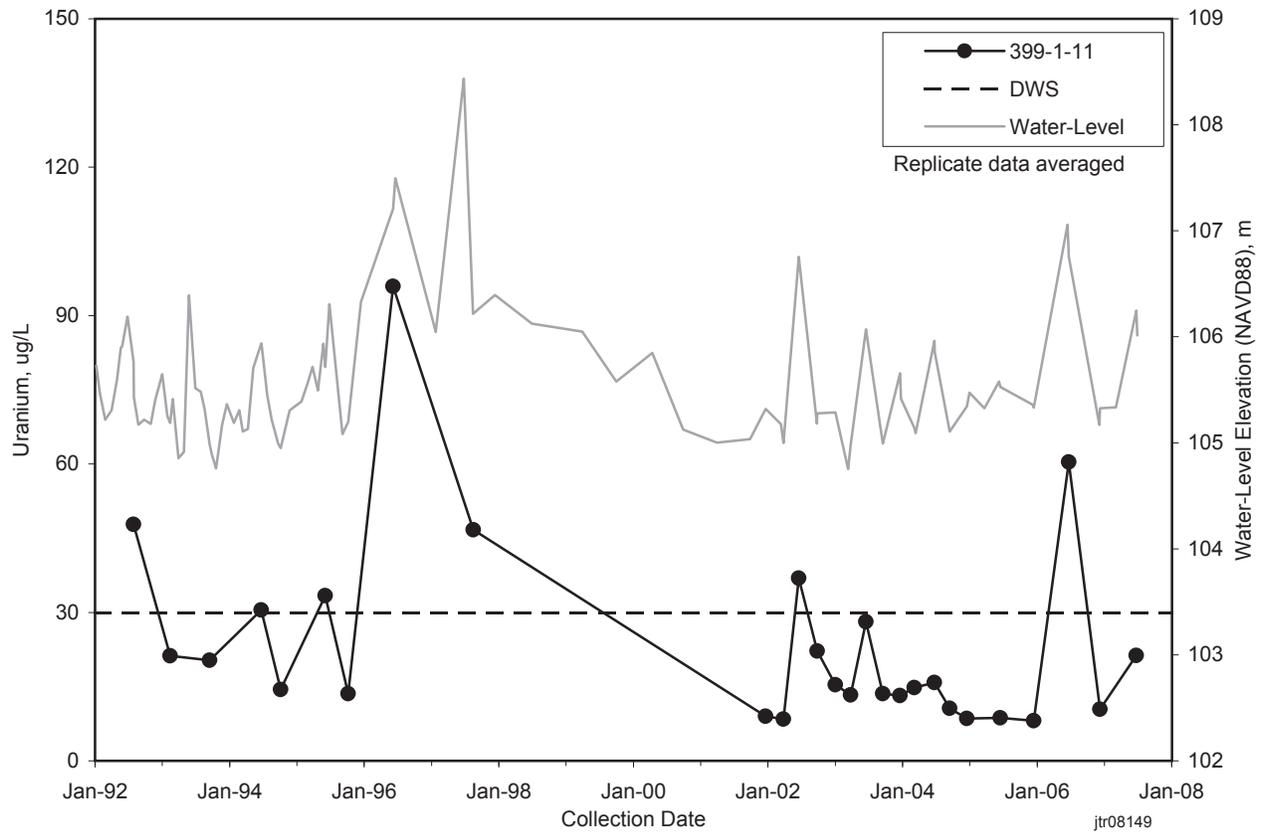
Figures 2.12-7 Columbia River Stage at 300 Area and Groundwater Sampling Dates During FY 2007



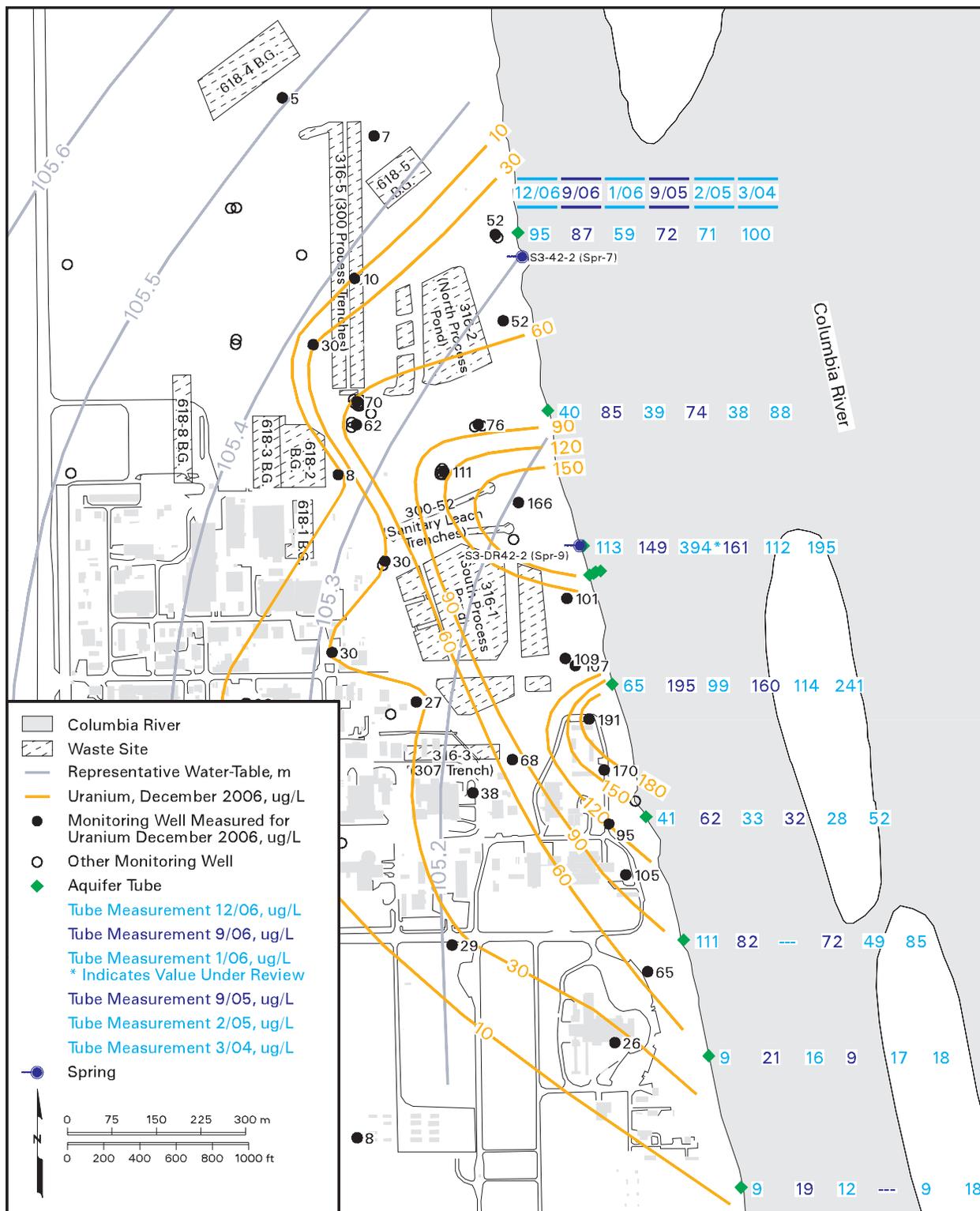
**Figure 2.12-8. Uranium Concentrations in RCRA Monitoring Wells Downgradient from Former 300 Area Process Trenches**



**Figure 2.12-9. Correlation Between Uranium Concentrations and Water-Table Elevation at Wells Close to Columbia River**

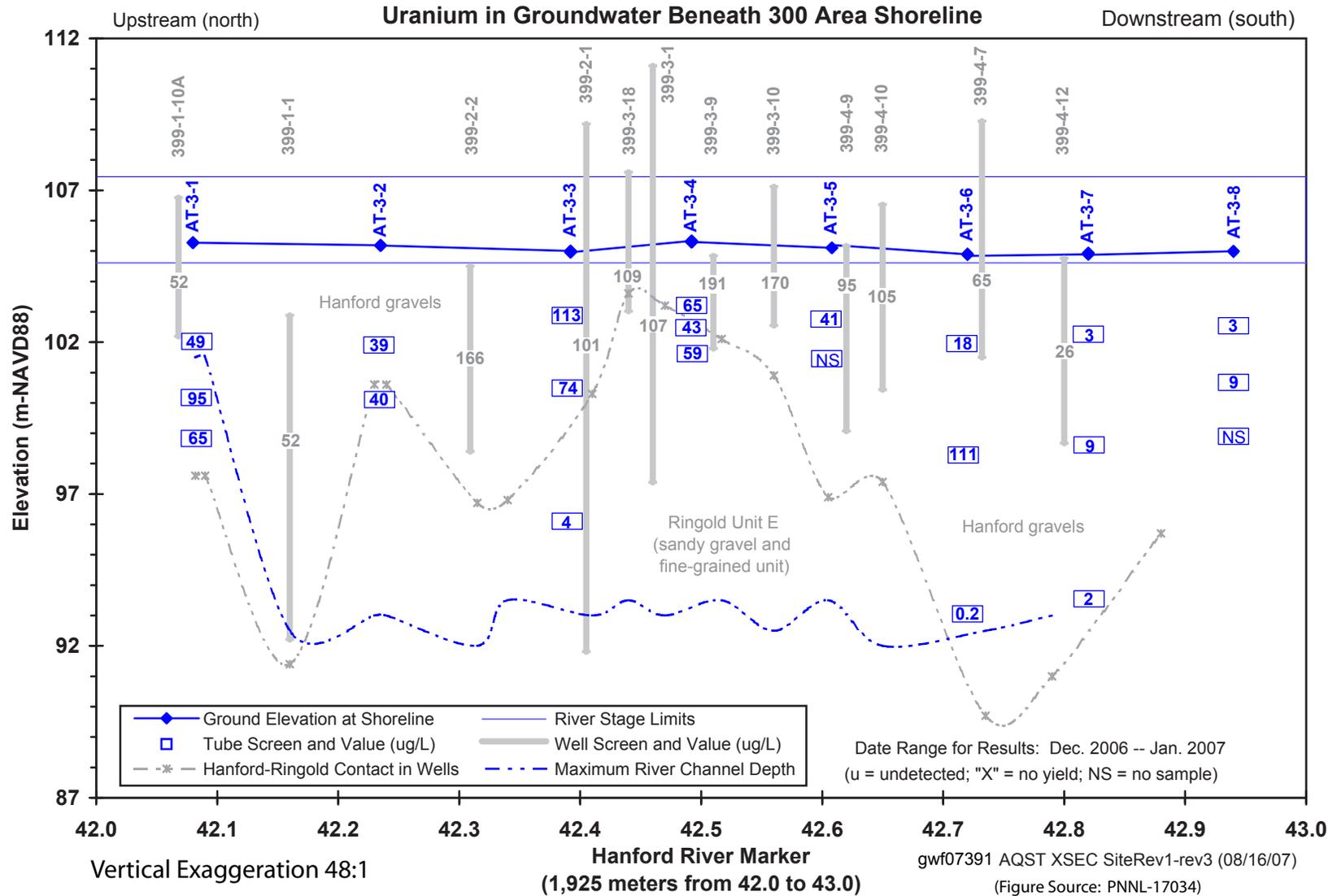


**Figures 2.12-10. Correlation Between Uranium Concentrations and Water-Table Elevation at Well Near Waste Site**

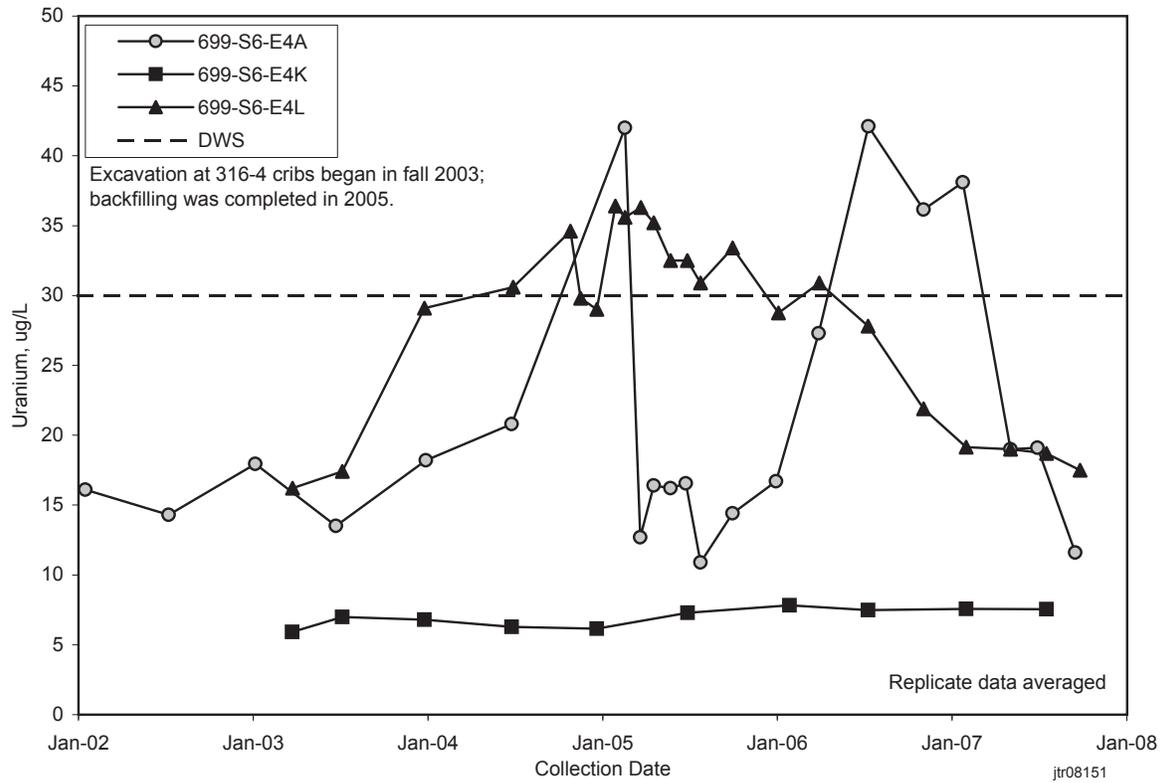


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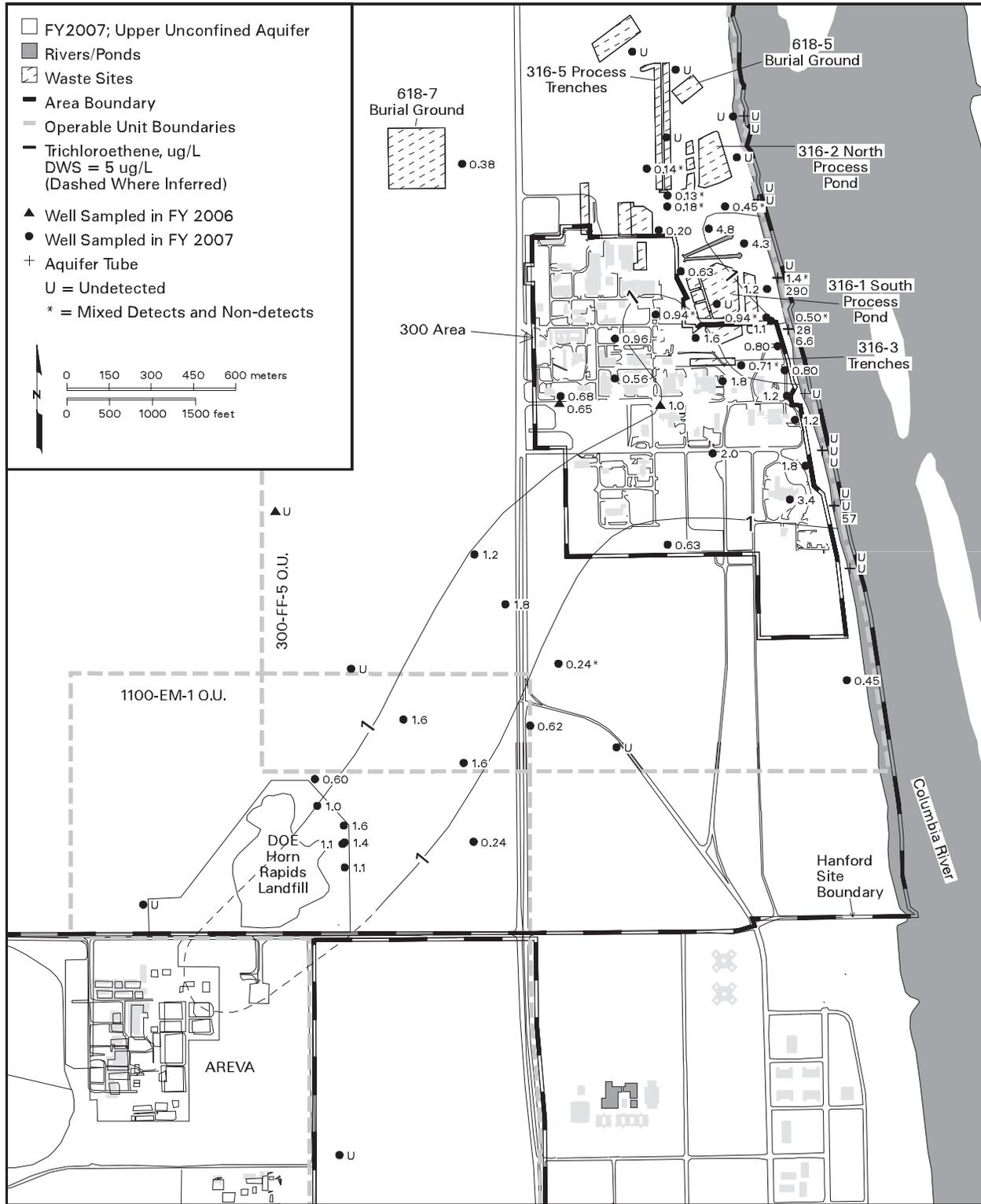
**Figure 2.12-11. Uranium Concentrations at Aquifer Tube Sites Along 300 Area Shoreline (from PNNL-17034)**



**Figures 2.12-12. Cross Section Showing Uranium Concentrations at Multiple Depths in Aquifer Tubes Along 300 Area Shoreline**

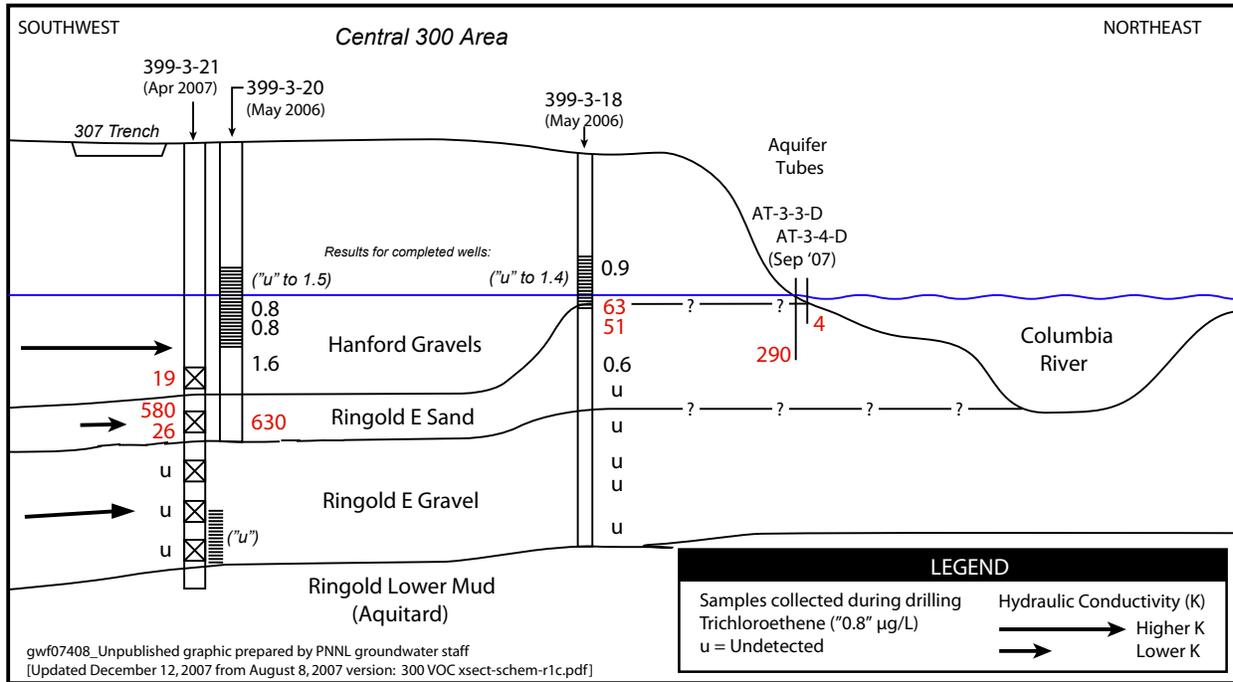


**Figures 2.12-13. Uranium Concentrations at Wells Near 316-4 Cribs Remedial Action Site**

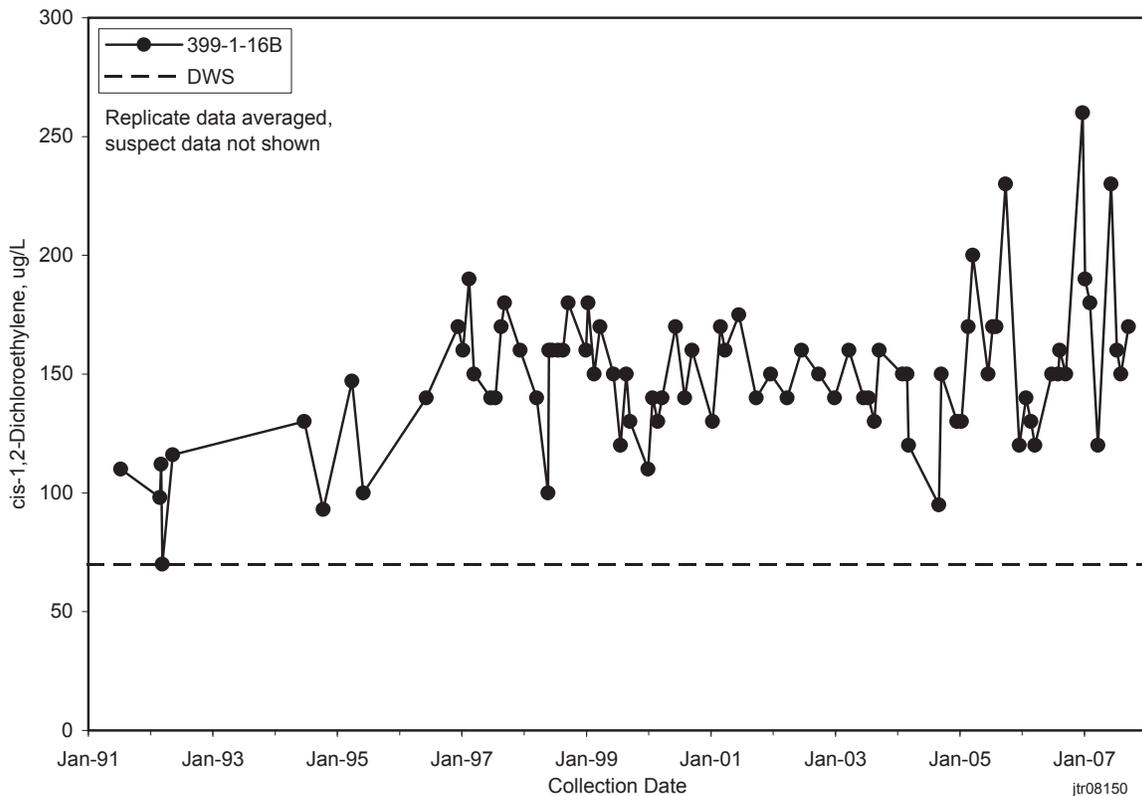


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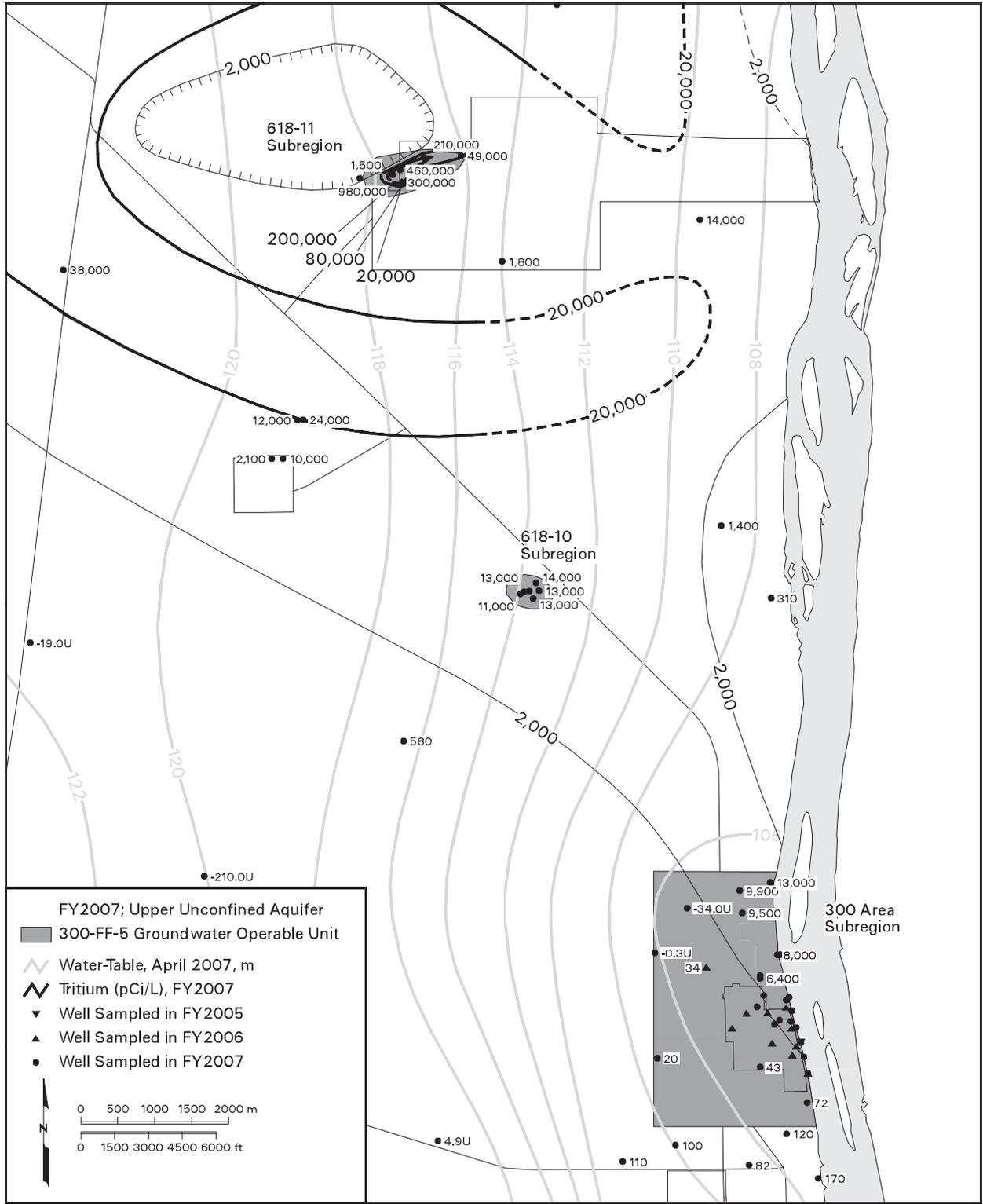
**Figure 2.12-14. Average Trichloroethene Concentrations in the Vicinity of 300 Area, Upper Part of Unconfined Aquifer**



**Figure 2.12-15. Trichloroethene in Samples Collected during Limited Field Investigation and Volatile Organic Carbon Investigation Drilling**



**Figure 2.12-16. Concentrations of cis-1,2-Dichloroethene at Well 399-1-16B Near Former 300 Area Process Trenches**



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**Figure 2.12-17. Average Tritium Concentrations in 300-FF-5 Operable Unit, Upper Part of Unconfined Aquifer**

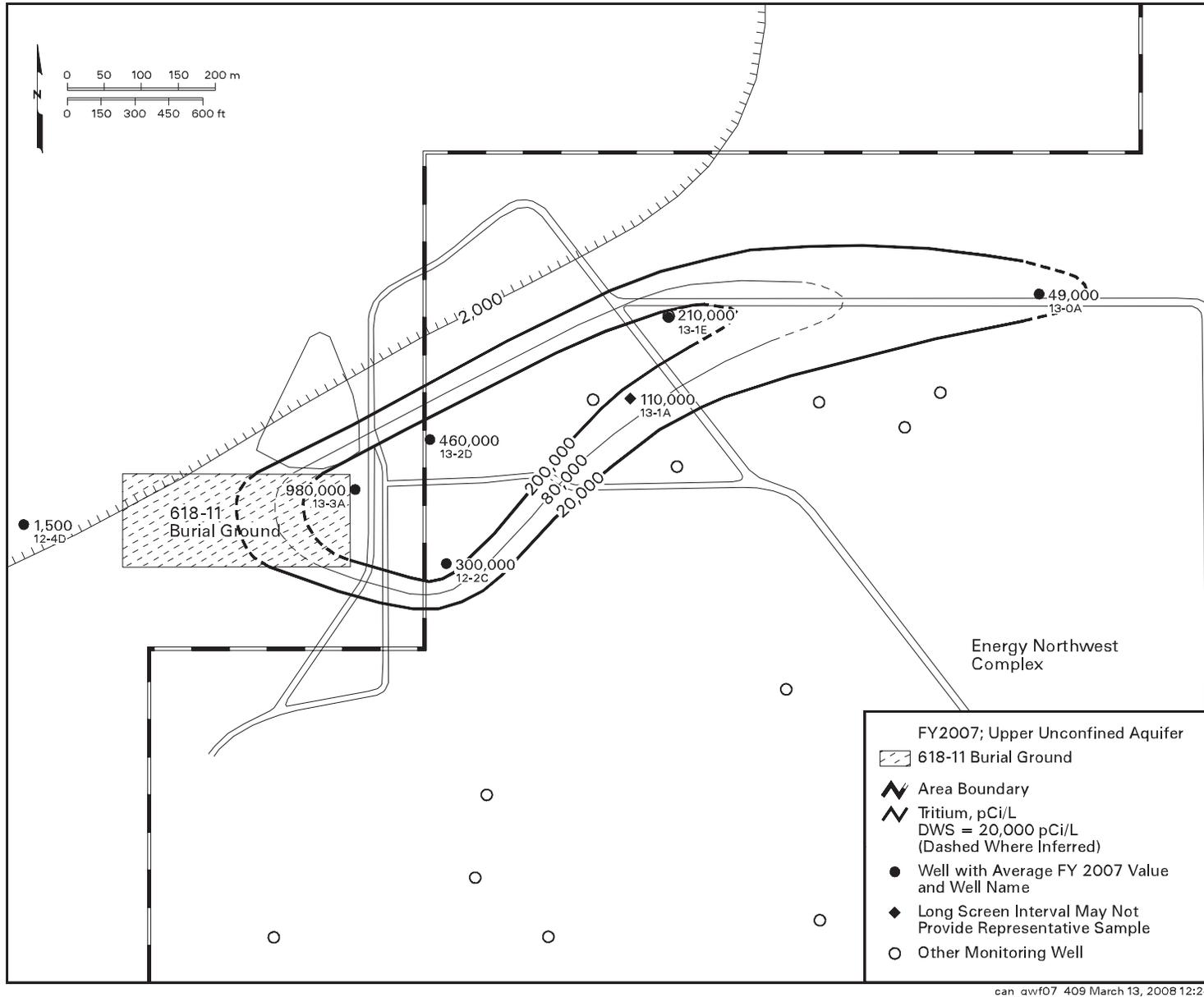


Figure 2.12-18. Average Tritium Concentrations at 618-11 Burial Ground, Upper Part of Unconfined Aquifer

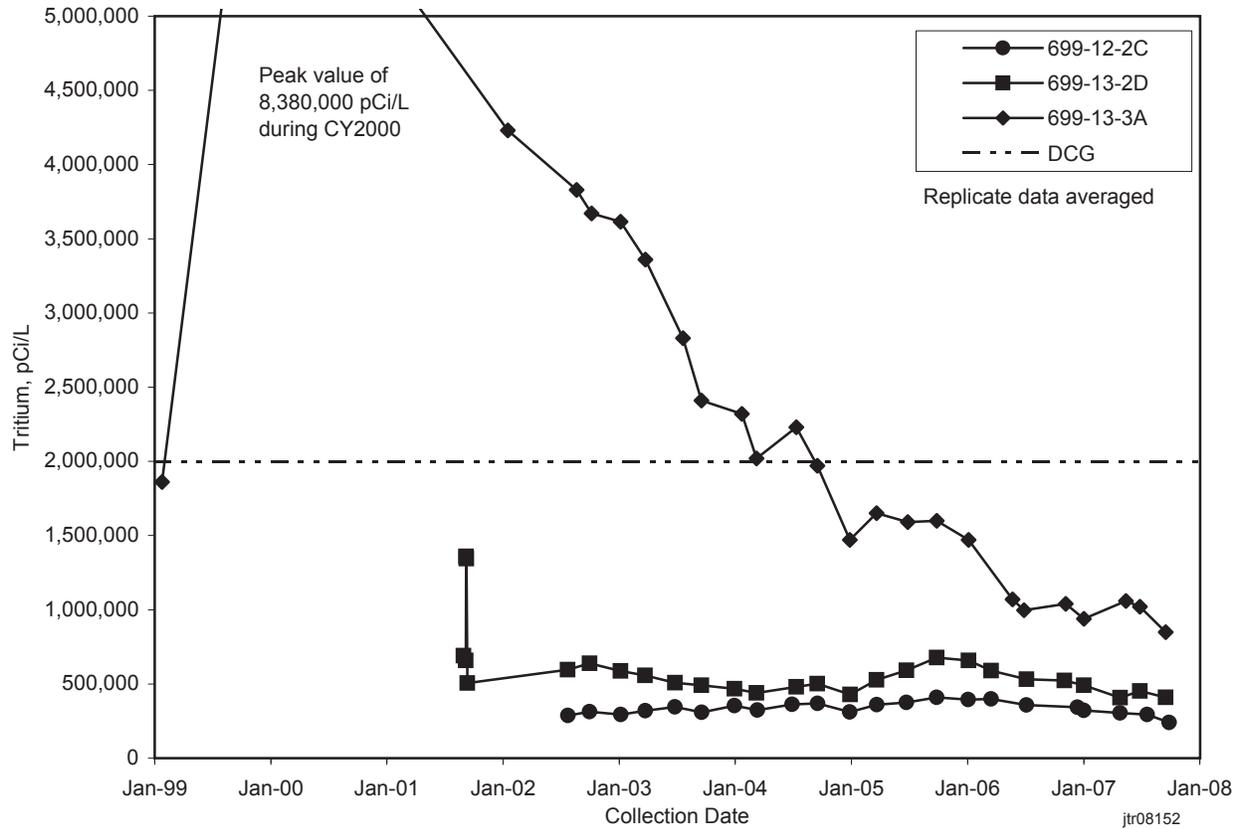


Figure 2.12-19. Tritium Concentration in Wells Near 618-11 Burial Ground

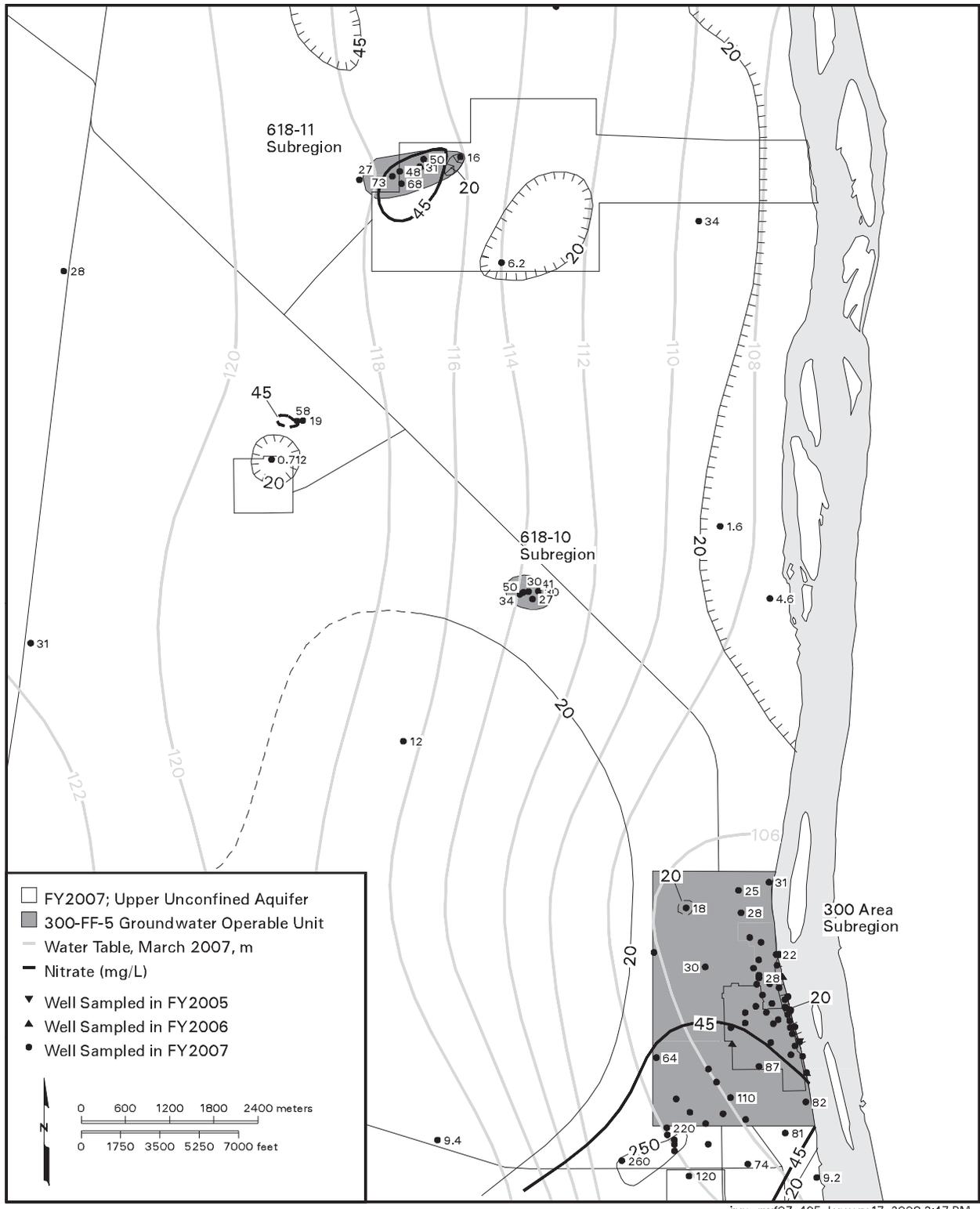


Figure 2.12-20. Average Nitrate Concentrations in 300-FF-5 Operable Unit, Upper Part of Unconfined Aquifer