2.4 100-NR-2 Operable Unit

M. J. Hartman and L. C. Swanson

The scope of this section is the 100-NR-2 groundwater interest area, which includes the 100-NR-2 Operable Unit (see Figure 2.1-1 in Section 2.1). The Groundwater Performance Assessment Project (groundwater project) defined the "interest areas" informally to facilitate scheduling, data review, and interpretation. Figure 2.4-1 shows facilities, wells, and shoreline monitoring sites in this region. Strontium-90 is the contaminant of greatest significance in groundwater at this operable unit. Groundwater is monitored to assess the performance of a *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) interim action pump-and-treat system for strontium-90, to monitor three *Resource Conservation and Recovery Act* (RCRA) sites, and to track other contaminant plumes for the *Atomic Energy Act of 1954* (AEA).

Groundwater flows primarily to the north and northwest, toward the Columbia River (Figure 2.4-2). Water levels fluctuate with river stage and are also affected by groundwater extraction near the 116-N-1 liquid waste disposal facility (116-N-1 facility) and injection near the 116-N-3 liquid waste disposal facility (116-N-3 facility) . Data from a new shoreline well cluster showed an upward gradient, as expected in this discharge area. The deepest well is ~6 meters deeper than the shallowest well and the upward gradient in June 2004 was ~0.013.

The remainder of this section describes contaminant plumes and concentration trends for the contaminants of concern under AEA, CERCLA, or RCRA monitoring.

2.4.1 Groundwater Contaminants

This section describes distributions and trends for the constituents of interest for the 100-NR-2 groundwater interest area. In addition to the strontium-90 plume, contaminants of concern include tritium, nitrate, sulfate, petroleum hydrocarbons, manganese, and chromium.

Groundwater monitoring in the 100-NR-2 groundwater interest area includes the following monitoring activities:

CERCLA Monitoring

- ***Six wells are sampled semiannually for strontium-90 and co-contaminants.***
- ***Fifteen wells are sampled annually for strontium-90 and/or co-contaminants.***
- ***In FY 2004, all wells were sampled as scheduled.***
- ***Additional baseline monitoring began in June 2004.***

Facility Monitoring

- ***Five wells are sampled semiannually for the 116-N-1 liquid waste disposal facility for requirements of RCRA and AEA.***
- ***Five wells are sampled semiannually for the 120-N-1 percolation pond and 120-N-2 surface impoundment for requirements of RCRA and AEA.***
- ***Five wells were sampled semiannually for the 116-N-3 liquid waste disposal facility for requirements of RCRA.***
- ***In FY 2004, one RCRA well was not sampled as scheduled (see text and Appendix B).***
- ***Monitoring is coordinated with other programs to avoid duplication.***

AEA Monitoring

- ***Wells sampled annually or triennially to track plumes, trends, and general chemistry.***
- ***Monitoring is coordinated with other programs to avoid duplication.***

2.4.1.1 Strontium-90

The size and shape of the strontium-90 plume change very little from year to year, extending from beneath the 116-N-1 and 116-N-3 facilities to the Columbia River at levels above the 8 pCi/L drinking water standard (Figure 2.4-3).

Changes in strontium-90 concentrations often relate to water-table fluctuations because strontium-90 from the vadose zone beneath former waste sites is mobilized by a high water table (Figure 2.4-4). Concentrations are highest in well 199-N-67, where the maximum value in fiscal year (FY) 2004 was 7,390 pCi/L, exceeding the U.S. Department of Energy (DOE) derived concentration guide of 1,000 pCi/L.

Strontium-90 is the most significant groundwater contaminant beneath the 100-NR-2 Operable Unit. The general shape of the plume has not changed in many years.

The portion of the plume downgradient of the 116-N-1 facility is the focus of a pump-and-treat system that has been operating since 1995 (Section 2.4.2). Strontium-90 trends in extraction wells are shown in Figure 2.4-5. Well 199-N-103A had a relatively stable trend since FY 2001, while wells 199-N-75, 199-N-105A, and 199-N-106A appear to have decreasing trends in recent years. Well 199-N-106A, located farthest north beyond the tail end of the trench, continued to have the highest concentrations in any of the extraction wells.

Wells on the south edge of the plume show declining concentrations, which may indicate the plume is gradually shrinking in this region. For example, the strontium-90 concentration well 199-N-57 dropped to 7.3 pCi/L in FY 2004, the first time it has been below the drinking water standard (Figure 2.4-6).

In FY 2004, staff conducted additional studies of strontium-90 concentrations near the Columbia River shoreline. Previous data from a series of steel casings set into the gravel at the river shore demonstrated that concentrations of the contaminant are highest at the shoreline near wells NS-2, NS-3, and NS-4. In FY 2004, new clusters of wells and aquifer tubes were installed in the high-strontium portion of the shoreline. Sampling results from the wells confirmed observations elsewhere in the 100-N Area that strontium-90 contamination is concentrated in the top of the aquifer. For example, in September 2004, well 199-N-119, which is completed at the top of the aquifer, had 280 pCi/L of strontium-90 while deeper wells 199-N-120 and 199-N-121 had 4.6 and 4.9 pCi/L, respectively. Additional details on this study are included as Section 2.4.4.

2.4.1.2 Tritium

The tritium plume has diminished in the years since effluent discharge to the 116-N-1 and 116-N-3 facilities ceased in 1991. The remaining plume extends from the south part of the 116-N-3 facility to the river to the northwest at levels above the 20,000-pCi/L drinking water standard (see Figure 2.4-5 in PNNL-14548 for FY 2003 plume map). Tritium contamination is observed throughout the upper aquifer and also in well 199-N-80, which monitors a confined aquifer in the Ringold Formation.

The highest concentrations are currently in wells near the Columbia River where levels continued to decline (Figure 2.4-7). The maximum concentration was 28,600 pCi/L in well 199-N-14.

2.4.1.3 Nitrate

A plume of nitrate with concentrations exceeding the 45-mg/L drinking water standard appeared to expand in FY 2004 as concentrations increased in many wells (Figure 2.4-8). The reason for the increase is unknown and nitrate trends are different from those of other 100-N Area contaminants. The highest nitrate concentrations in FY 2004 were again in well 199-N-67 near the 116-N-1 facility, with a maximum concentration of 270 mg/L.

Plume areas (square kilometers) above the drinking water standard at the 100-NR-2 Operable Unit:

Nitrate — 0.35
Strontium-90 — 0.57
Tritium — 0.27

Figure 2.4-9 shows nitrate trend plots for wells near the 116-N-1 and 116-N-3 facilities for their entire period of record. The 116-N-1 facility was in use through 1985 and the 116-N-3 facility was in use from 1983 to 1991. Nitrate concentrations were

high in the mid-1980s in both wells and declined sharply by 1990. Recent concentrations have returned to levels observed in the mid-1980s.

Near the 120-N-1 percolation pond in south 100-N Area, nitrate concentrations also increased in the 1990s (Figure 2.4-10). During the pond's period of use (1977 to 1990), only low levels of nitrate (~1 mg/L) were detected in effluent to the facility (see Appendix B of DOE/RL-96-39). Monitoring began in 1987 and nitrate concentrations in groundwater were also low (1 to 4 mg/L). Nitrate levels exceeded the drinking water standard in well 199-N-59 from 1998 to 2002, which was the last time the well could be sampled. Nearby well 199-N-72 has lower nitrate levels but showed a sharp increase in FY 2004.

Nitrate concentrations continued to increase in FY 2004.

Anomalously low nitrate concentrations continued to be observed in well 199-N-18 (undetected). The low concentrations are believed to be caused by chemical reduction of the nitrate caused by biodegradation of hydrocarbons (Section 2.4.1.5). Other chemical constituents and parameters also support the interpretation of chemical reduction around well 199-N-18: low dissolved oxygen, low pH, detectable nitrite, and high concentrations of metals (especially iron and manganese).

2.4.1.4 Sulfate

The former 120-N-1 percolation pond introduced sulfate and sodium to 100-N Area groundwater. Sulfate concentrations remained elevated in groundwater north and northwest of the 120-N-1 site. A second area of elevated sulfate concentrations underlies the 116-N-3 trench. This contamination is residual from previous flow conditions that carried sulfate from the 120-N-1 percolation pond inland and then toward the north. Sulfate distribution changed little between FY 2003 and 2004 (see Figure 2.4-8 of PNNL-14548 for FY 2003 plume map).

The highest sulfate concentration in FY 2004 was 201 mg/L in well 199-N-3, at the north edge of the main plume. Levels have been steady in well 199-N-3 since 2002. Well 199-N-59, adjacent to the former source, had sulfate concentrations above the 250-mg/L secondary drinking water standard in previous years, but it could not be sampled in FY 2004 because it was dry.

2.4.1.5 Petroleum Products

Petroleum products continued to be detected in 100-N Area groundwater. DOE installed a passive treatment system in a well with floating petroleum product.

Petroleum products from a 1960s leak (DOE/RL-95-111) continued to be detected in 100-N Area groundwater. Of the affected wells, 199-N-18 is closest to the former leak site and had the highest levels of groundwater contamination. Total petroleum hydrocarbons (TPH) in the diesel range was 150 mg/L in March and 340 mg/L in September (Figure 2.4-11).

Fluor Hanford, Inc. began a remedial action to remove the free product from well 199-N-18 in October 2003 and continued the action throughout FY 2004. A passive treatment method removes residual amounts of diesel from the well. The method employs a polymer that selectively absorbs petroleum from the surface of the water like a sponge. A cylinder of the material is lowered into the well for a 2-week period, after which it is removed, weighed, and replaced with a new unit. This procedure will be repeated every 2 weeks for a year. The 1-year observation period will be used to evaluate the mass removal rate of the petroleum hydrocarbon from well 199-N-18.

Evidence of low levels of hydrocarbon contamination has been observed in wells 199-N-3, 199-N-19, and 199-N-96A in the past (PNNL-14187, Section 2.4). These wells are located near 199-N-18 and may be influenced by contamination from the same source. In FY 2004, total organic carbon was elevated in wells 199-N-3 (1,800 μg/L) and 199-N-96A (4,000 μg/L).

Near the N Reactor building, well 199-N-16 also has evidence of petroleum contamination, believed to be from a separate past source. TPH-diesel was measured at up to 6.1 mg/L in FY 2004, about the same as in 2003.

2.4.1.6 Manganese and Iron

Manganese continued to exceed the 50-µg/L secondary drinking water standard in two wells affected by petroleum contamination: 199-N-16 (860 µg/L) and 199-N-18 (2,480 µg/L). Iron also exceeded its secondary drinking water standard (300 µg/L) in these wells (1,510 and 26,300 µg/L in wells 199-N-16 and 199-N-18, respectively). Biodegradation of the hydrocarbons creates reducing conditions, which increases the solubility of metals such as manganese and iron from the well casing or aquifer sediment.

The manganese concentration in well 199-N-26, located in south 100-N Area, increased in FY 2004 from 12.5 µg/L in 2003 to 88.9 µg/L in 2004. Iron decreased during the same period. The high manganese value may be erroneous and the well will be sampled again in FY 2005.

Manganese concentrations exceeded the secondary drinking water standard in one sample each from new wells 199-N-119, 199-N-120, and 199-N-121, and new aquifer tube NS-2A-23cm. Subsequent samples showed lower concentrations, suggesting the elevated values were related to installation activities and do not represent groundwater quality.

A pump-and-treat system at the 100-NR-2 Operable Unit satisfied its objectives in FY 2004, but has not affected the distribution or concentration of strontium-90 in the aquifer to any observable extent.

2.4.1.7 Chromium

Only one well in the 100-N Area has chromium concentrations above the 100-µg/L drinking water standard. Well 199-N-80, which is completed in a thin, confined aquifer in the Ringold Formation, typically has chromium concentrations of ~170 µg/L. The source for chromium in this deep horizon is unknown. The highest concentration in shallow wells in FY 2004 was 11.7 µg/L in well 199-N-41.

2.4.2 Interim Groundwater Remediation for Strontium-90

A pump-and-treat system has been operating in the 100-N Area since 1995 as part of a CERCLA interim action for the 100-NR-2 Operable Unit (ROD 1999b). The objectives of the pump-and -treat system include the following:

- Reduce strontium-90 contaminant flux from the groundwater to the Columbia River.
- Evaluate commercially available treatment options for strontium-90.
- Provide data necessary to set demonstrable strontium-90 groundwater cleanup standards.

The remedial action objectives in the 100-NR-2 Operable Unit (ROD 1999b) are:

- ***Protect the Columbia River from the adverse impact of groundwater contamination by limiting exposure pathways, reducing or removing sources, controlling groundwater movement, or reducing the concentration of contaminants.***
- ***Protect the unconfined aquifer by implementing remedial actions that reduce the concentration of contaminants.***
- ***Obtain information to evaluate technologies to remove strontium-90 and evaluate the impact to ecological receptors.***
- ***Prevent destruction of sensitive wildlife habitat and minimize the disruption of cultural resources.***

During their 5-year review (EPA 2001), EPA added a requirement for DOE to investigate alternative remedial action technologies for strontium-90.

The monitoring requirements for the pump-and-treat system at this operable unit are specified by Tri-Party Agreement Change Control Form M-15-96-08 as modified by Fluor Hanford, Inc.[(a)] Wells, constituents, and sampling frequencies for interim action monitoring are shown in Appendix A. During FY 2004, all wells were sampled as scheduled.

DOE initiated supplemental monitoring of the shoreline area affected by the pump-and-treat system in June 2004 to establish a baseline of monthly sampling results with which to compare results after

(a) Letter FH-0205249 from RT Wilde (Fluor Hanford, Inc.) to JS Fruchter (Pacific Northwest National Laboratory), *Revised FY 2003 Sampling Schedule for Groundwater Remediation Monitoring*, dated November 11, 2002.

a possible shutdown of the pump-and-treat system (date is yet to be determined). The supplemental monitoring program, which is not described in a formal monitoring plan, is summarized in Appendix A. This monitoring is integrated with a special study of 100-N groundwater described in Section 2.4.4.

2.4.2.1 Progress During FY 2004

The pump-and-treat system satisfied its objectives again in FY 2004, but has not affected the distribution or concentration of strontium-90 in the aquifer to any observable extent. The extraction wells create a hydraulic sink between the 116-N-1 facility and the Columbia River and, thus, reduce or reverse the hydraulic gradient in the groundwater toward the Columbia River. The reduction or reversal of the hydraulic gradient results in less groundwater and strontium-90 discharging to the Columbia River through the N Springs area. However, the pump-and-treat system is not capable of completely controlling the water discharged because of the cyclical river stage and bank storage effects of the Columbia River.

Additional details on the pump-and-treat system and operational data for calendar year 2003, are available in DOE/RL-2004-21. An upcoming report will present results for calendar year 2004.

No cesium-137 or cobalt-60 was detected in 100-N Area groundwater in FY 2004.

2.4.2.2 Influence on Aquifer Conditions

The extraction wells have created an area of lower strontium-90 concentrations between the 116-N-1 trench and the Columbia River (Figure 2.4-3). However, this area does not represent significant clean up of the aquifer. The low concentrations are believed to be caused by (a) drawdown of the water table (strontium-90 concentrations are highest at the top of the aquifer and in the vadose zone); and (b) dilution with river water drawn in by pumping.

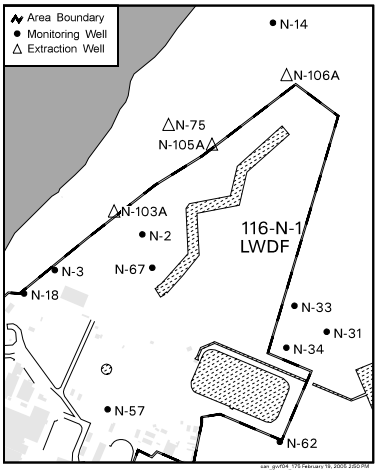
Figure 2.4-5 shows strontium-90 concentrations with time in 100-N Area extraction wells. Concentrations vary in response to a fluctuating water table and other changes in groundwater flow, but there are no clear upward or downward trends overall.

Because the pump-and-treat system is ineffective as a long-term remediation solution, other technologies are being considered to accelerate removal of the strontium-90 from the groundwater. Two promising technologies were tested in the laboratory in FY 2004: phytoremediation (using plants as a strontium-90 uptake mechanism) and sequestration by apatite (creating a permeable reactive barrier that would capture strontium-90 as groundwater flows through the barrier). Additional studies and scaled-up activities are planned for FY 2005. These efforts include (1) completing the greenhouse phytoremediation studies and starting a field demonstration, and (2) completing the aqueous apatite injection, sorption/desorption studies in laboratory columns and conducting intermediate scale tests.

During FY 2004, the pump-and-treat system extracted ~116 million liters of groundwater from the 100-N Area, removing ~0.2 curie of strontium-90. The pump-and-treat system has removed ~1.6 curies of strontium-90 from the 100-N Area groundwater since startup in 1995, compared to a total inventory in the aquifer estimated to exceed 75 curies. Current estimates indicate that it will take >300 years before the strontium 90 concentrations reach permissible levels (DOE/RL-95-110) as a result of radioactive decay. For this reason, DOE is investigating and evaluating alternative remediation technologies.

2.4.3 Facility Monitoring

This section describes results of monitoring individual facilities: the 116-N-1 and 116-N-2 liquid waste disposal facilities, 120-N-1 percolation pond, and 120-N-2 surface impoundment. Groundwater is monitored at these facilities to meet the requirements



of RCRA for hazardous waste constituents and AEA for source, special nuclear, and by-product materials. Data from facility-specific monitoring are also integrated into the CERCLA groundwater investigations. Hazardous constituents and radionuclides are discussed jointly in this section to provide comprehensive interpretations for each facility. As discussed in Section 2.1, pursuant to RCRA units, DOE has sole and exclusive responsibility and authority to regulate source, special nuclear, and by-product materials. Groundwater data for these facilities are available in the Hanford Environmental Information System (HEIS 1994) and on the data files accompanying this report. Additional information including well and constituent lists, maps, flow rates, and statistical tables are included in Appendix B.

2.4.3.1 116-N-1 (1301-N) Liquid Waste Disposal Facility

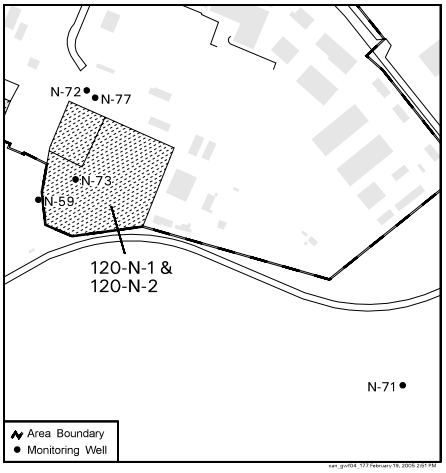
This facility contaminated groundwater with radionuclides during its period of use in the 1960s through 1985. Strontium-90 and tritium are the only radionuclides that remain elevated in groundwater today. Results of monitoring were discussed in Section 2.4.1. The facility is being excavated to remove shallow vadose zone sediment, where most of the radionuclide contamination resides. Wells 199-N-67, 199-N-103A, and 199-N-105A were monitored for strontium-90 and gamma activity semiannually to look for potential impacts of source remediation and dust control on groundwater. Strontium-90 results did not suggest any impacts of remediation and no gamma-emitters were detected.

This facility is included in the Hanford Facility RCRA Permit (Ecology 1994a). The closure plan (see Appendix A of DOE/RL-96-39) states that RCRA monitoring during closure activities will follow the requirements of BHI-00725. That plan and a supplemental plan (PNNL-13914) are similar to an interim status indicator evaluation program (40 CFR 265.93(b), as referenced by WAC 173-303-400).

Upgradient and downgradient wells were sampled twice in FY 2004 for contamination indicator parameters (pH, specific conductance, total organic carbon, and total organic halides) and once for groundwater quality and site-specific parameters, as planned (see Appendix B). The fall sampling of upgradient well 199-N-34 was delayed until October 2004, but results are included with this FY 2004 discussion.

Average specific conductance in downgradient well 199-N-3 continued to exceed the critical mean value in March and September 2004. Prior assessment results (WHC-SD-EN-EV-003) indicated the elevated specific conductance is related to constituents from an upgradient facility. Other indicators remained below critical mean values in FY 2004. The site will remain in detection monitoring and there are no plans to modify the network in FY 2005. Upgradient/downgradient comparison values for indicator parameters have been revised based on recent data for use in FY 2005 comparisons (see Appendix B).

2.4.3.2 120-N-1 (1324-NA) Percolation Pond and 120-N-2 (1324-N) Surface Impoundment



These facilities were used to treat and dispose of corrosive, non-radioactive waste from 1977 to 1990. They have been remediated and backfilled.

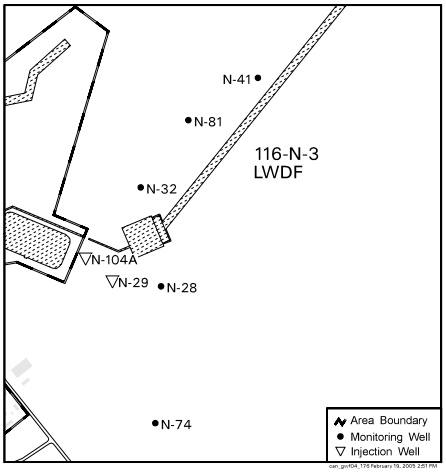
These facilities are included in the Hanford Facility RCRA Permit (Ecology 1994a). The closure plan (see Appendix B of DOE/RL-96-39) states that RCRA monitoring during closure activities will follow the requirements of BHI-00725. That plan, and a supplemental plan (PNNL-13914), are similar to an interim status indicator evaluation program (40 CFR 265.93(b), as referenced by WAC 173-303-400).

During FY 2004, four of the five monitoring wells for this site were sampled twice for contamination indicator parameters and groundwater quality and site-specific parameters, as planned (see Appendix B). Downgradient well 199-N-59 contained too little water to sample in March and September 2004.

Average specific conductance values in wells downgradient of the facilities continued to exceed the critical mean values in FY 2004. A previous groundwater quality assessment indicated that the high specific conductance is caused by sulfate and sodium (WHC-SD-EN-EV-003), which are not listed hazardous waste constituents. Because an assessment has already been completed and non-listed constituents caused the high conductance, detection monitoring will continue. Other indicators remained below critical mean values in FY 2004 and there are no plans to modify the network in FY 2004. Upgradient/downgradient comparison values for indicator parameters were revised based on recent data for use in FY 2005 comparisons (see Appendix B).

2.4.3.3 116-N-3 (1325-N) Liquid Waste Disposal Facility

This facility contaminated groundwater with radionuclides during its period of use from 1983 to 1991. Strontium-90 and tritium are the only radionuclides that remain elevated in groundwater today. Results of monitoring were discussed in Section 2.4.1. The facility was excavated to remove the shallow vadose zone material, which contains the highest concentrations of radionuclides. The site is scheduled to be backfilled with clean soil in FY 2005. Well 199-N-81 was monitored for strontium-90 and gamma semiannually to look for potential impacts of source remediation and dust control on groundwater. Strontium-90 results did not suggest any impacts of remediation and no gamma-emitters were detected.



This facility is included in the Hanford Facility RCRA Permit (Ecology 1994a). The closure plan (Appendix A of DOE/RL-96-39) states that RCRA monitoring during closure activities will follow the requirements of BHI-00725. That plan, and a supplemental plan (PNNL-13914), are similar to an interim status indicator evaluation program (40 CFR 265.93(b), as referenced by WAC 173-303-400).

During FY 2004, upgradient and downgradient wells were sampled twice for contamination indicator parameters (pH, specific conductance, total organic carbon, and total organic halides) and once for groundwater quality and site-specific parameters, as planned (see Appendix B).

Average specific conductance values in downgradient well 199-N-41 continued to exceed the critical mean value in March and September 2004, although levels are declining. This was a continuation of previous exceedances noted in 1999 through 2003. DOE notified Washington State Department of Ecology of that original exceedance and submitted an assessment report that concluded the exceedance was caused by past discharges to an upgradient facility. Detection monitoring will continue in FY 2005. Other indicators remained below critical mean values in FY 2004 and there are no plans to modify the network during FY 2005. Upgradient/downgradient comparison values for indicator parameters were revised based on recent data for use in FY 2005 (see Appendix B).

Preliminary results from monitoring three new river tubes show that in most cases strontium-90 concentrations were highest in June when the river stage was highest.

2.4.4 100-N Science and Technology Project

Under the remediation task of DOE's Science and Technology Project, Pacific Northwest National Laboratory is performing a series of activities to develop better estimates of groundwater and contaminant flux to the river and provide technical basis for developing a remedial approach. The project completed the following activities during FY 2004:

- Installed three clusters of river tubes to monitor water beneath the river bed.
- Installed a cluster of wells on the shoreline to monitor three depths in the aquifer near the river.
- Ran water-level recorders in additional wells.

Preliminary results of this work are summarized below. Details will be published in upcoming reports for the Science and Technology Project.

Eight river tubes were installed at three locations in the river bed where strontium-90 concentrations were expected to be highest (Figure 2.4-12). The river tubes are similar to aquifer tubes installed elsewhere on the Hanford Site (DOE/RL-2000-59), but differ slightly in their construction and depth. The river tubes are constructed of galvanized pipe ~3 centimeters in diameter with ~45 centimeters of perforated pipe and a screen mesh at the bottom. The new tubes and their depths are listed in Table 2.4-1.

In February and March 2004, the Science and Technology Project installed data loggers in cluster NS-3A for a continuous record of specific conductance, temperature, and water level. Figure 2.4-13 shows how specific conductance changed in each tube between March and September 2004. When river stage began to increase in late April, specific conductance began to rise in the river tubes, most notably in the shallowest tube (10 centimeters) and the deepest tube (176 centimeters). These increases in specific conductance were the opposite of what was expected. Specific conductance in other aquifer tubes decreases with increasing river stage. After a few weeks, specific conductance in the 100-N Area river tubes declined again as river stage continued to increase. Specific conductance increased again in June, then declined through late summer.

A cluster of new wells monitors three depths on the 100-N Area shoreline.

Another surprising result was that the shallowest tube, completed just 10 centimeters below the riverbed, had higher specific conductance than either of the deeper tubes for virtually the entire period of record. At other aquifer tubes on the Hanford Site, the shallowest tubes typically have the lowest specific conductance. Note that the 100-N Area river tubes are shallower than typical aquifer tubes.

The Science and Technology Project sampled the river tubes at low, high, and intermediate river stage conditions (April, June, and September 2004, respectively). The groundwater project began sampling the tubes in June, with a comprehensive set of analyses quarterly and screening parameters monthly. Preliminary results show that in most cases strontium-90 (and gross beta) concentrations were higher in samples collected in June (high river) than in April (low river) or September (falling river) (Figure 2.4-14). As with the specific conductance results, the higher strontium-90 result in June was unexpected. Although strontium-90 can increase with high water-levels in inland wells due to mobilized contamination from the vadose zone, that effect would not be expected in the river tubes, where the sediments are continually saturated. The project will continue to collect and evaluate data in FY 2005.

The river tubes also provided data on depth distribution of strontium-90 and other contaminants beneath the river. In clusters NS-3A and NS-4A, the highest concentrations were observed in the mid-depth tubes (87 centimeters below the river bottom; Figure 2.4-14). At NS-4A, the shallow tube (17 centimeters) had higher concentrations than the deep tube (138 centimeters).

Three new monitoring wells were installed on the 100-N Area shoreline in FY 2004 (Table 2.4-1). Well 199-N-119 monitors near the water table, 199-N-120 monitors the middle of the aquifer, and 199-N-120 monitors the base of the aquifer (see Figure 2.4-12 for locations). Figure 2.4-15 shows gross beta (indicating strontium-90) and specific conductance concentrations with depth in the well cluster. Gross beta is highest in the shallowest well, which is consistent with data collected elsewhere in the 100-N Area. Specific conductance was low in the shallow and mid-level wells, and higher in the deeper well. Tritium was undetected in wells 199-N-119 and 199-N-120 and ranged from 597 to 1,640 pCi/L in the deeper well, 199-N-121.

Table 2.4-1. Construction Details for New River Tubes and Wells

Well ID	Well/Tube Name	Type	Depth Below Land Surface (or River Bottom)
C4585	NS-2A-23cm	River tube	23 cm
C4586	NS-2A-87cm	River tube	87 cm
C4587	NS-2A-168cm	River tube	168 cm
C4588	NS-3A-10cm	River tube	10 cm
C4590	NS-3A-87cm	River tube	87 cm
C4589	NS-3A-176cm	River tube	176 cm
C4640	NS-4A-17cm	River tube	17 cm
C4641	NS-4A-183cm	River tube	183 cm
C4471	199-N-119	Well	7.0 m
C4472	199-N-120	Well	9.3 m
C4473	199-N-121	Well	12.8 m

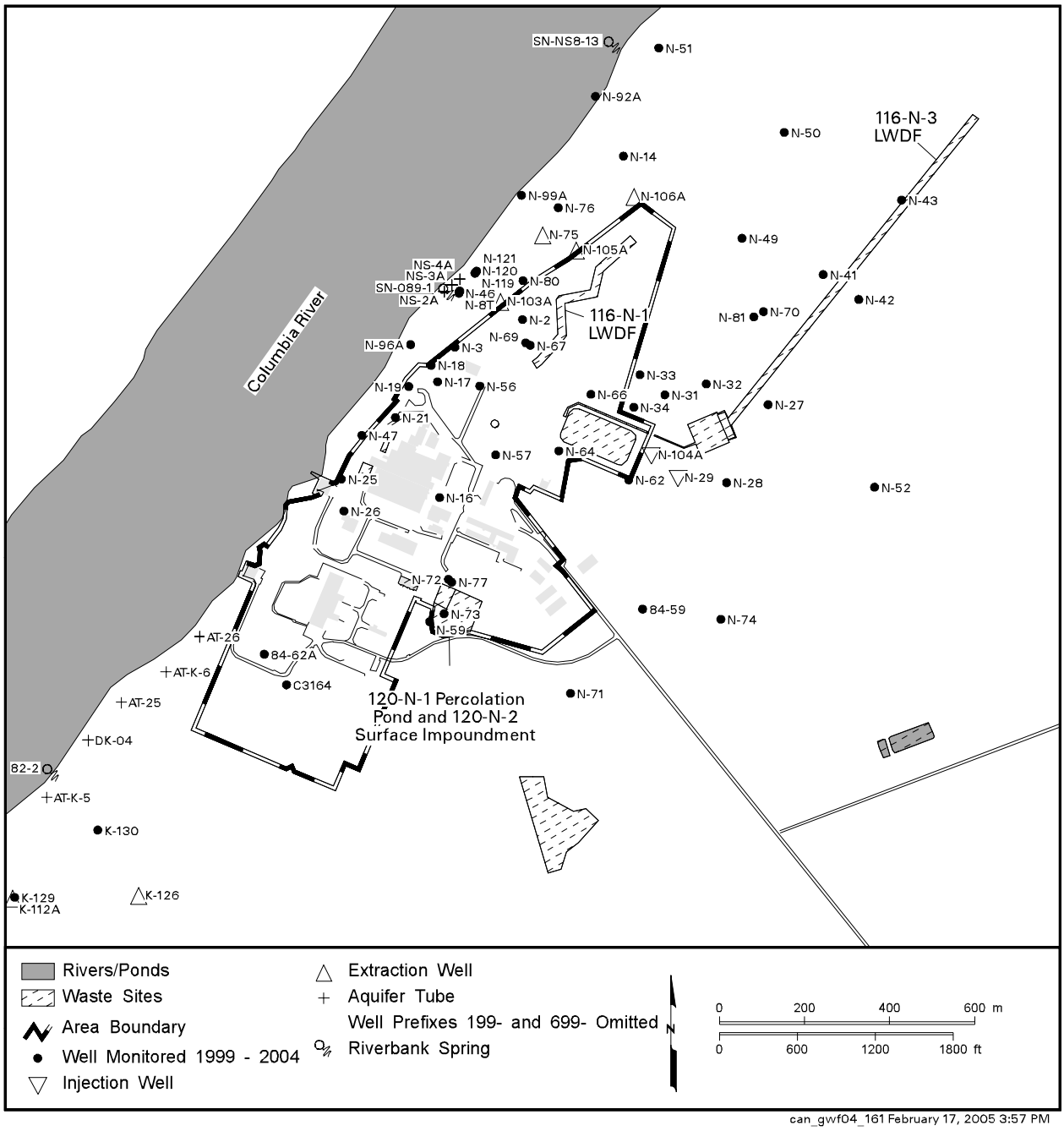


Figure 2.4-1. Groundwater Monitoring Wells in the 100-N Area

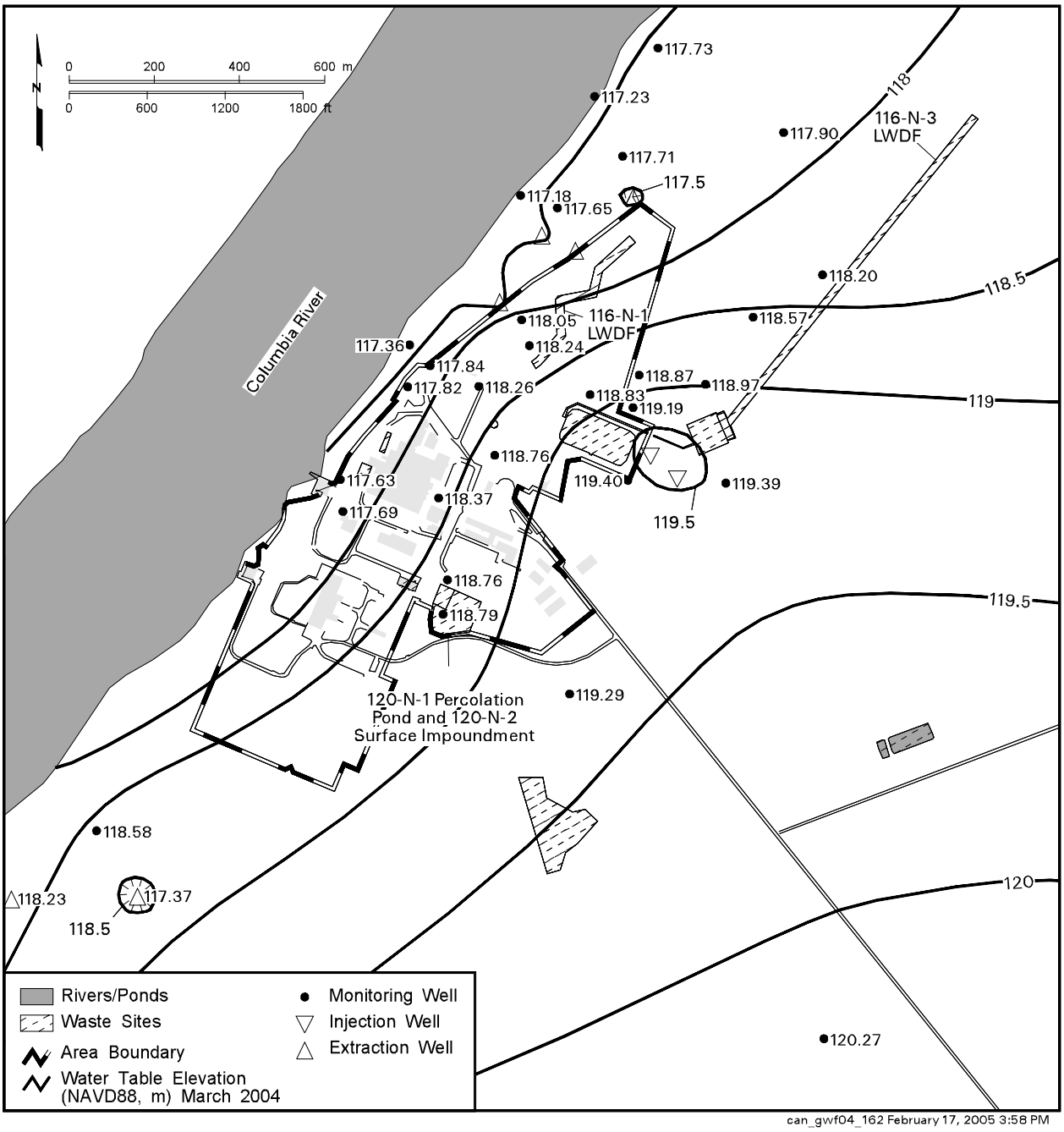


Figure 2.4-2. Water Table Beneath 100-N Area, March 2004

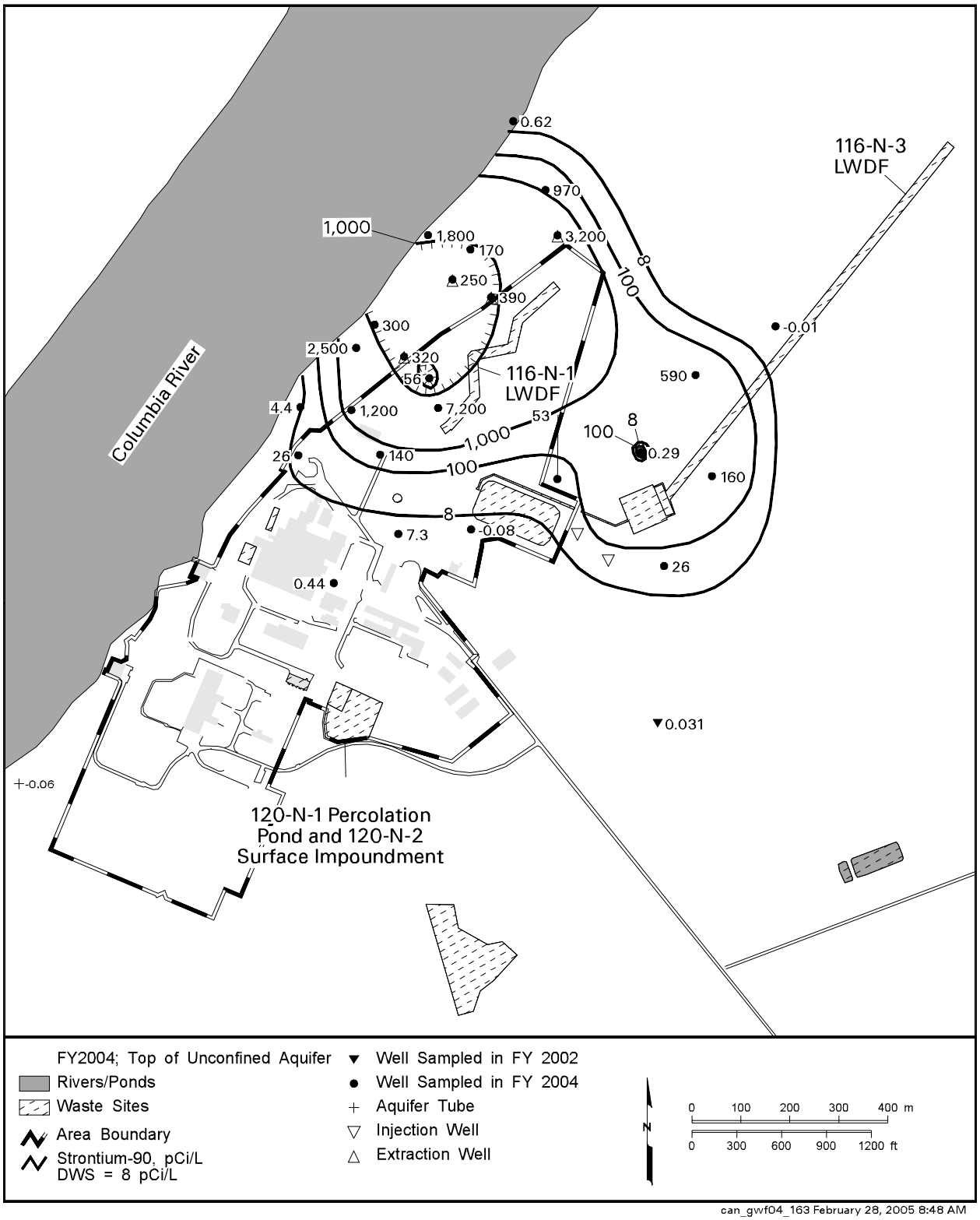


Figure 2.4-3. Average Strontium-90 Concentrations in the 100-N Area, Top of Unconfined Aquifer

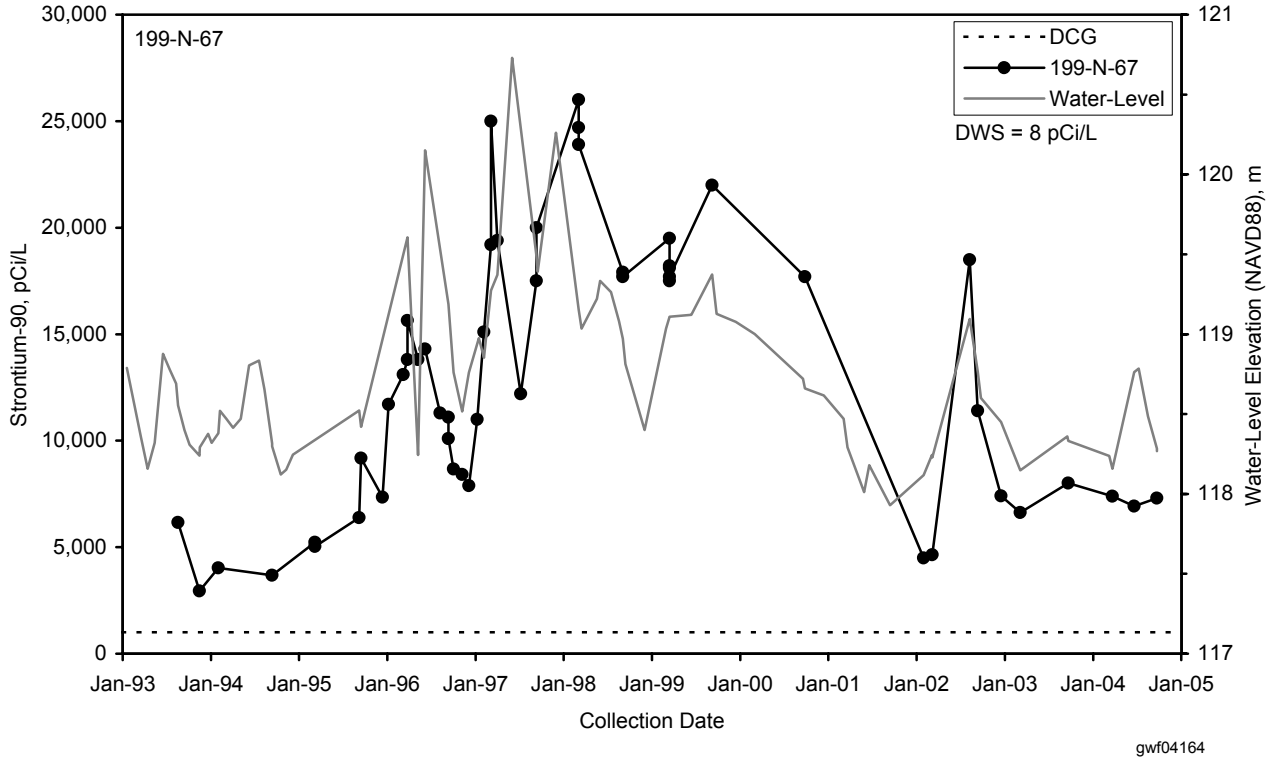


Figure 2.4-4. Strontium-90 Concentrations and Water Level Near the 116-N-1 Facility

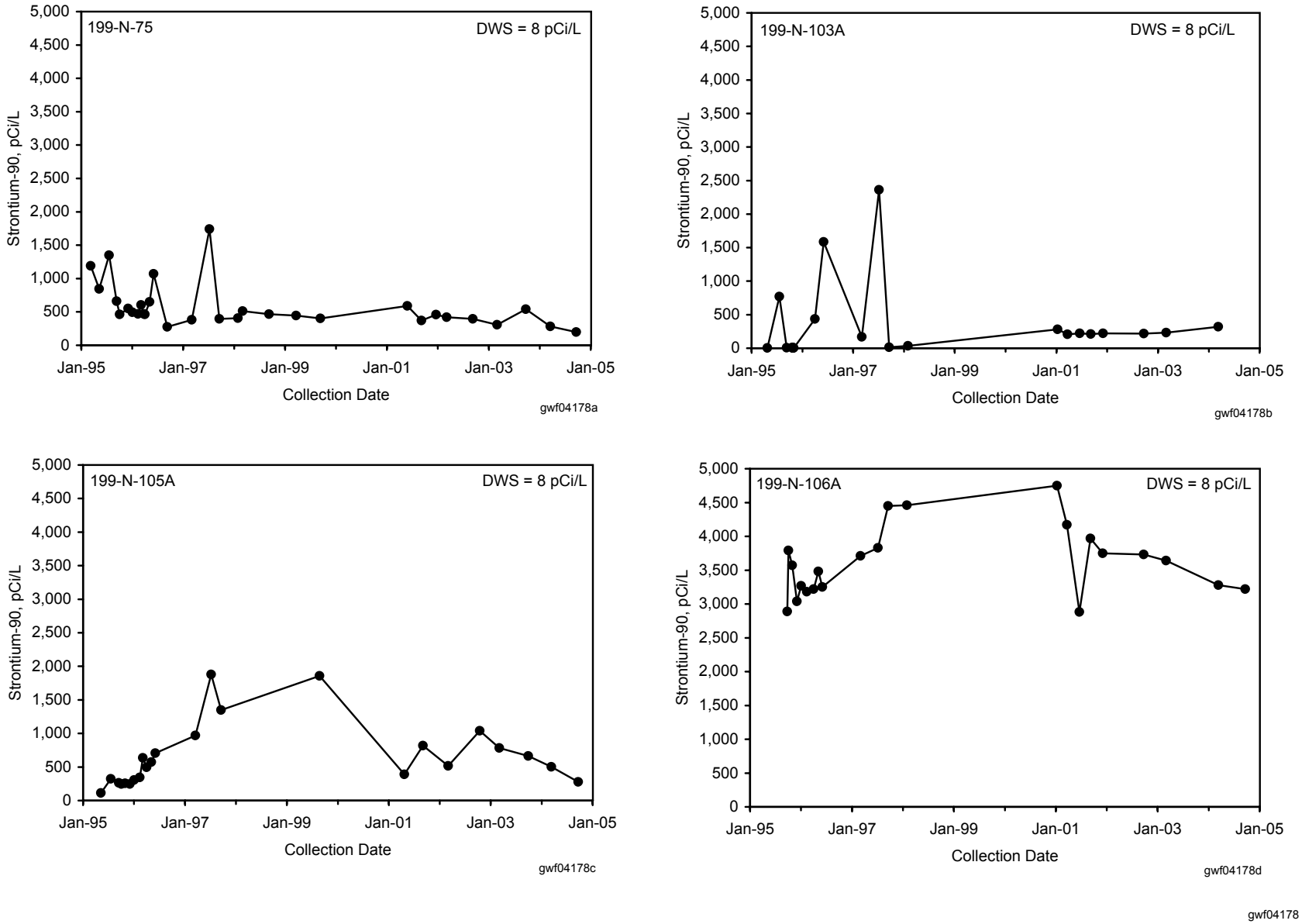


Figure 2.4-5. Strontium-90 Concentrations in 100-N Area Extraction Wells

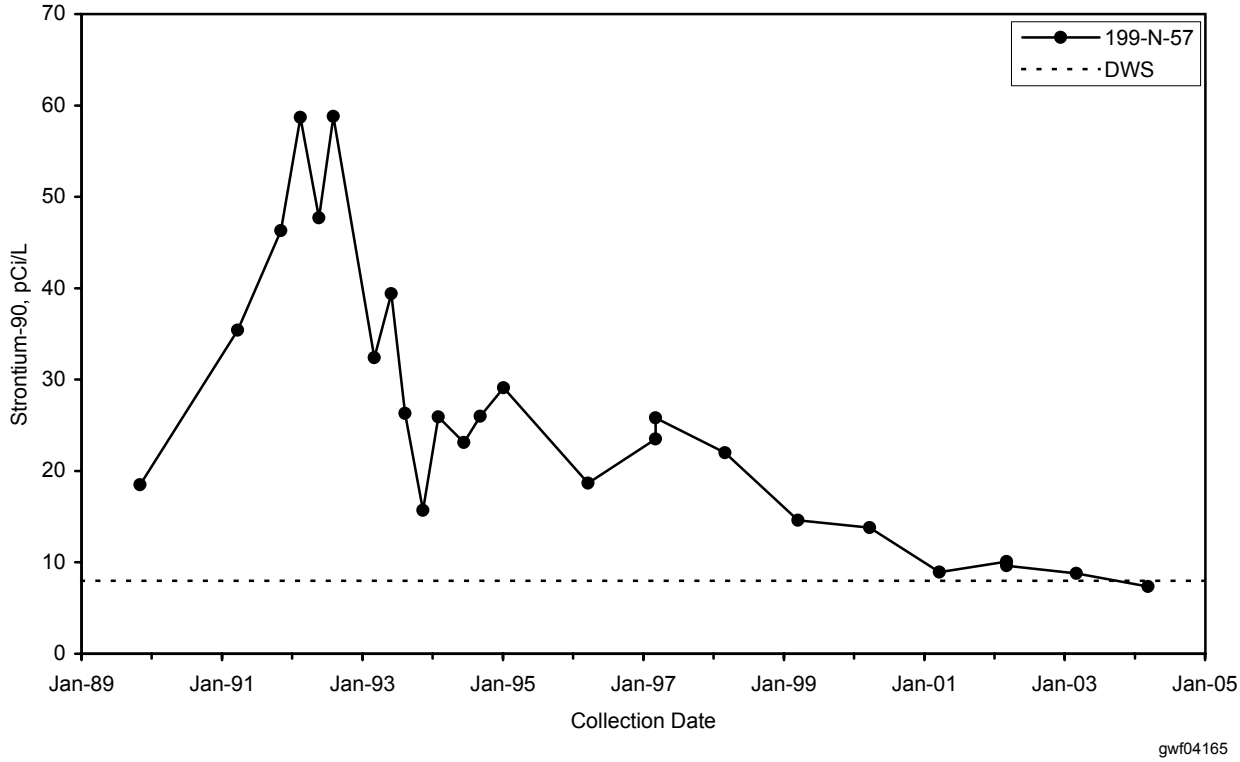


Figure 2.4-6. Strontium-90 Concentrations at the South Edge of the Plume

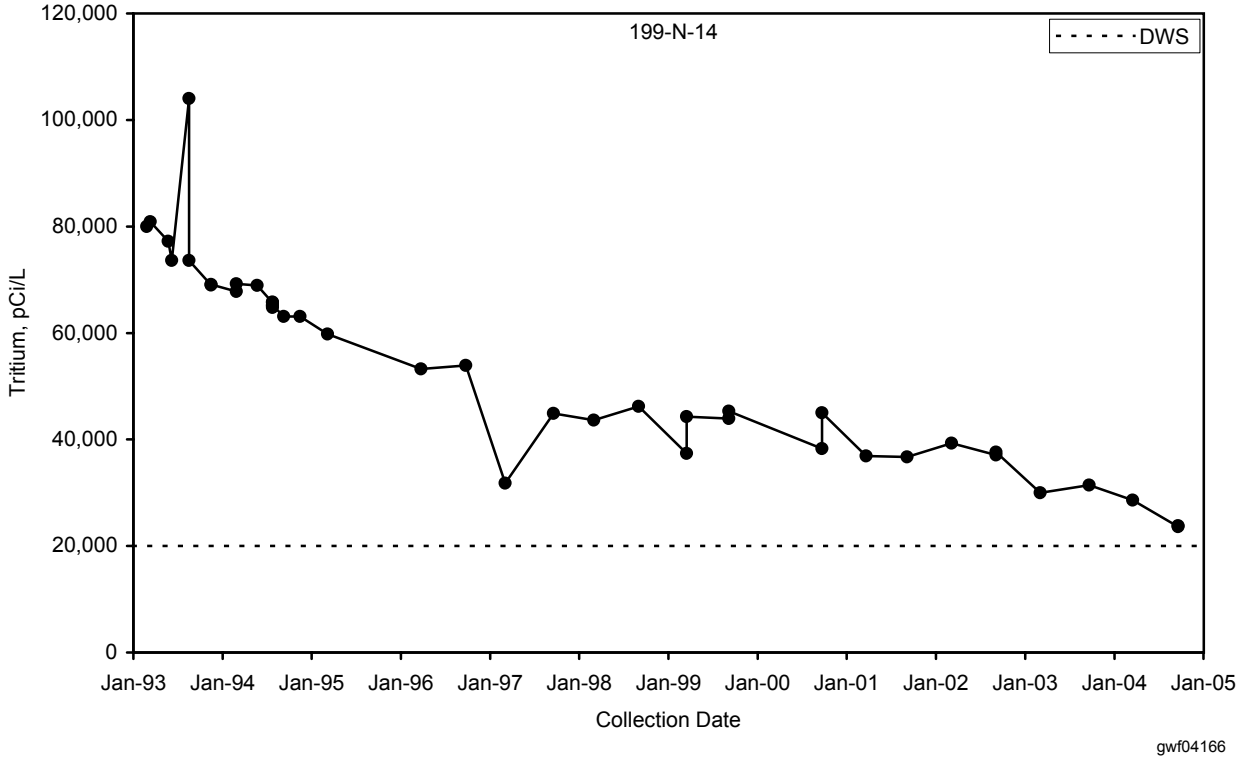


Figure 2.4-7. Tritium Concentrations North of the 116-N-1 Facility

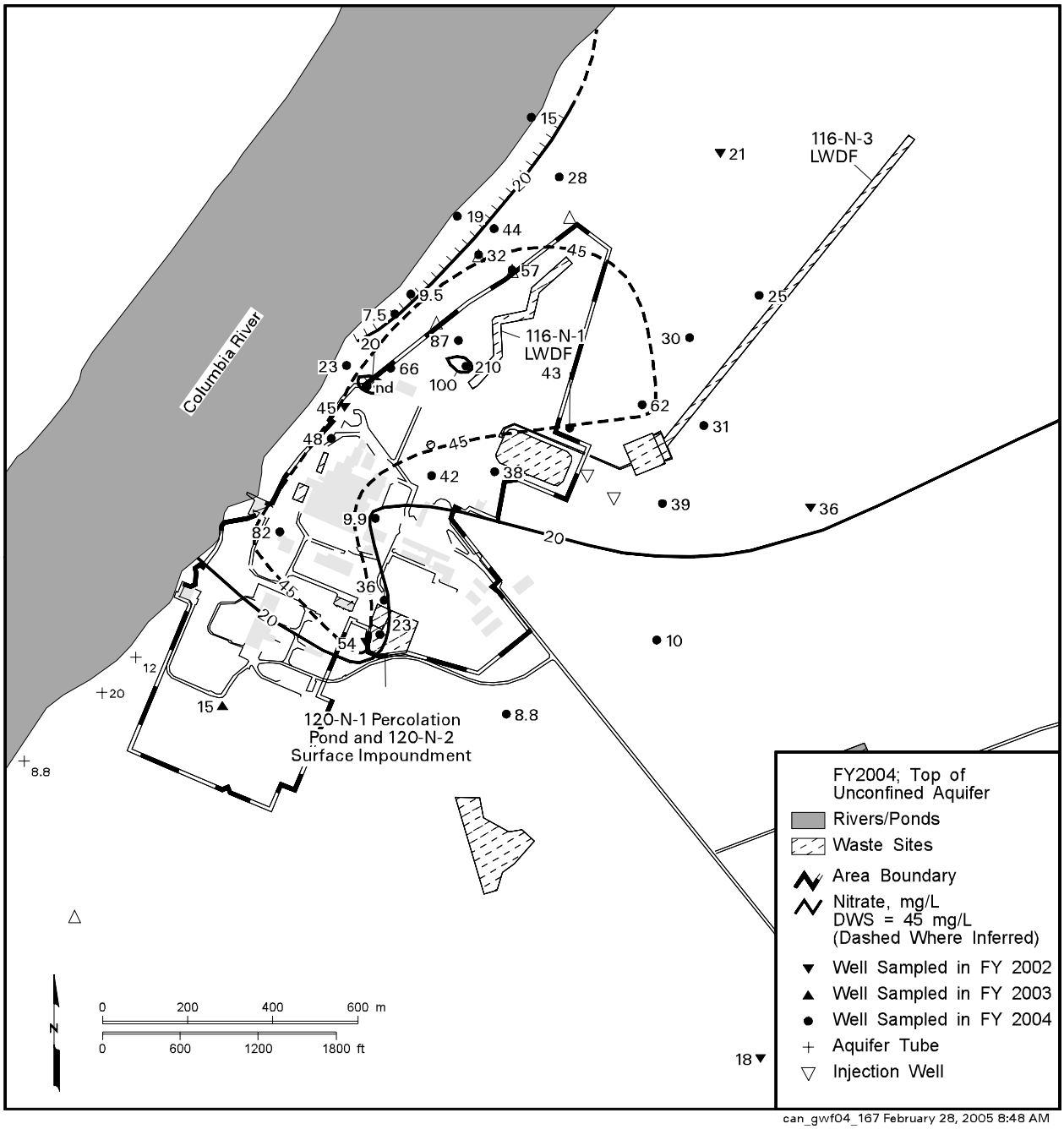


Figure 2.4-8. Average Nitrate Concentrations in the 100-N Area, Top of Unconfined Aquifer

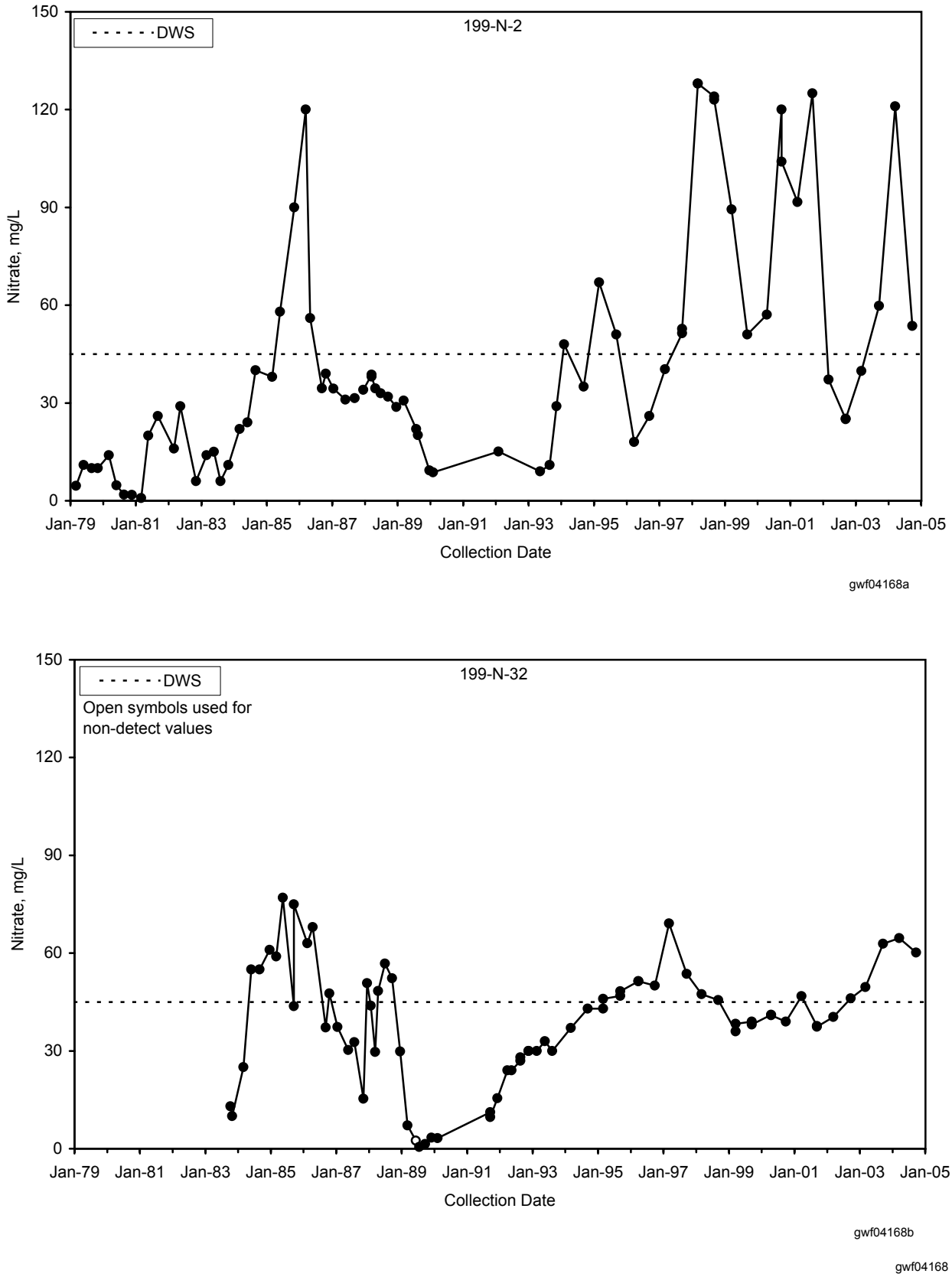


Figure 2.4-9. Nitrate Concentrations Near the 116-N-1 Facility (199-N-2) and 116-N-3 Facility (199-N-32)

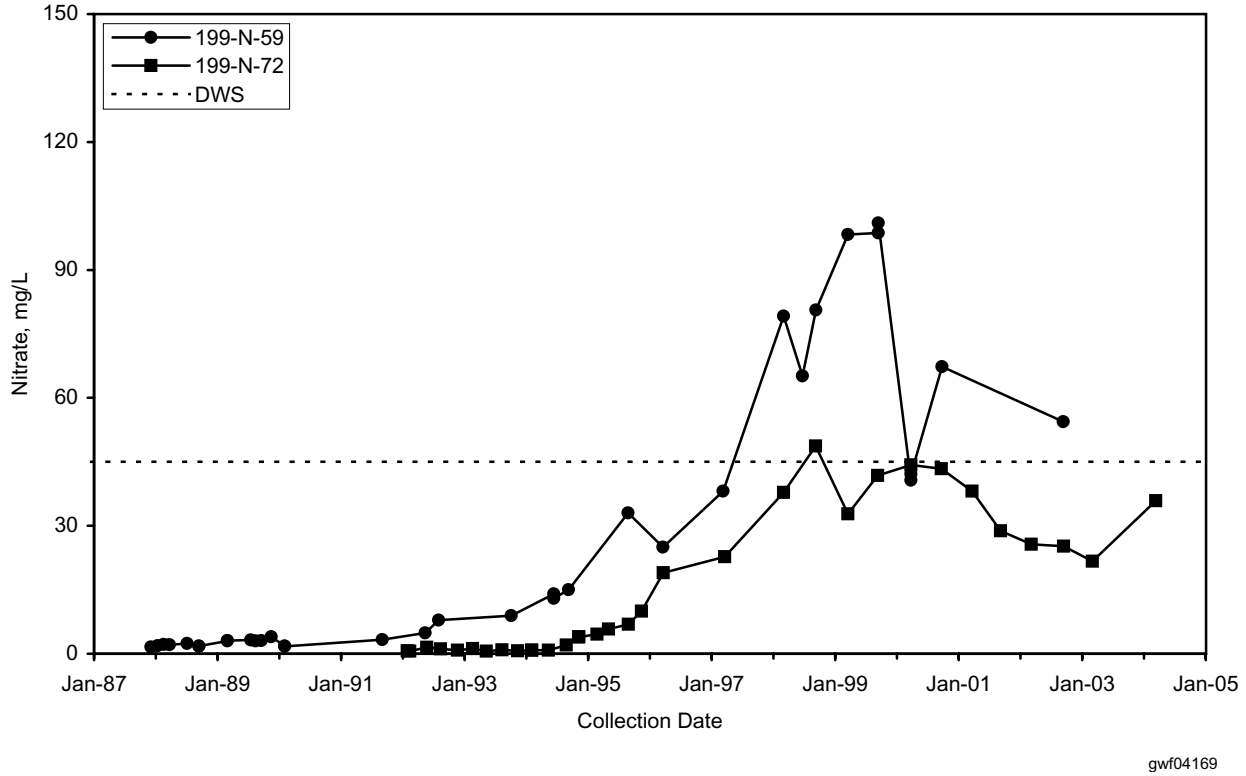


Figure 2.4-10. Nitrate Concentrations Near the 120-N-1 Percolation Pond in South 100-N Area

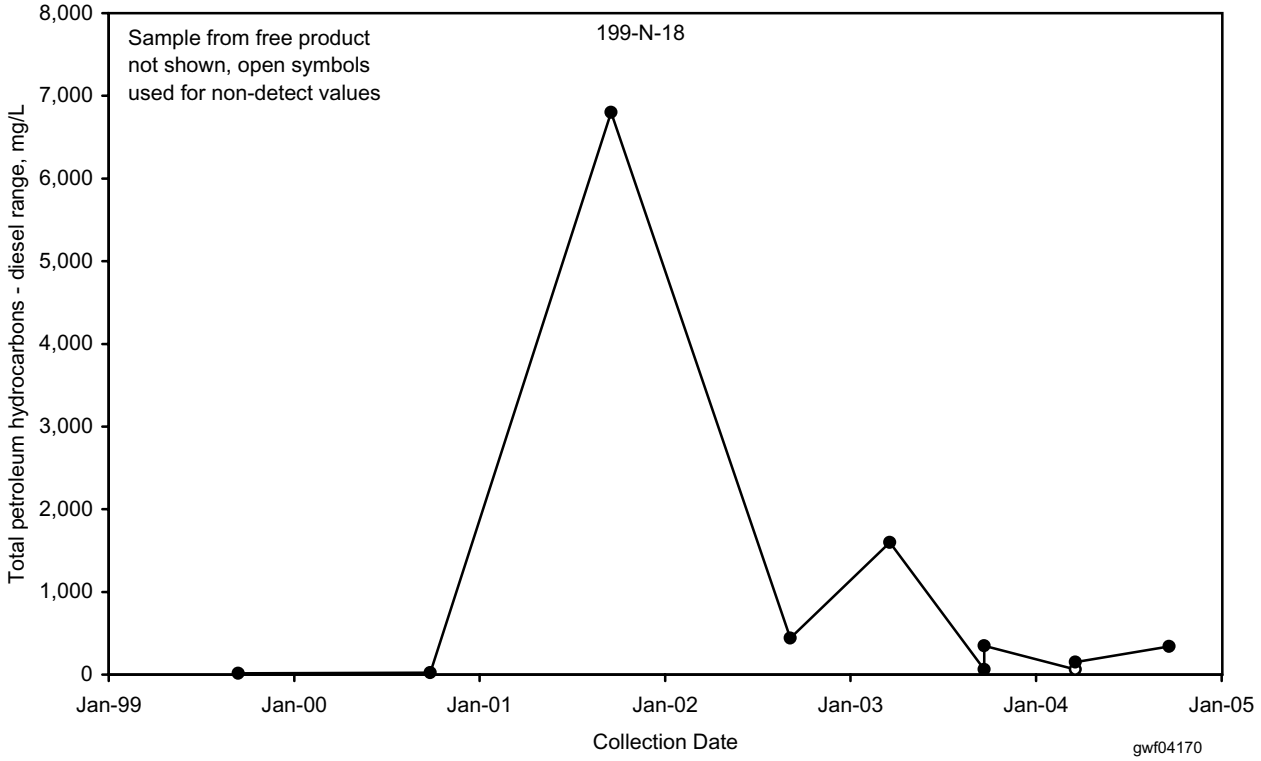


Figure 2.4-11. Petroleum Hydrocarbons Near Former Petroleum Leak Site

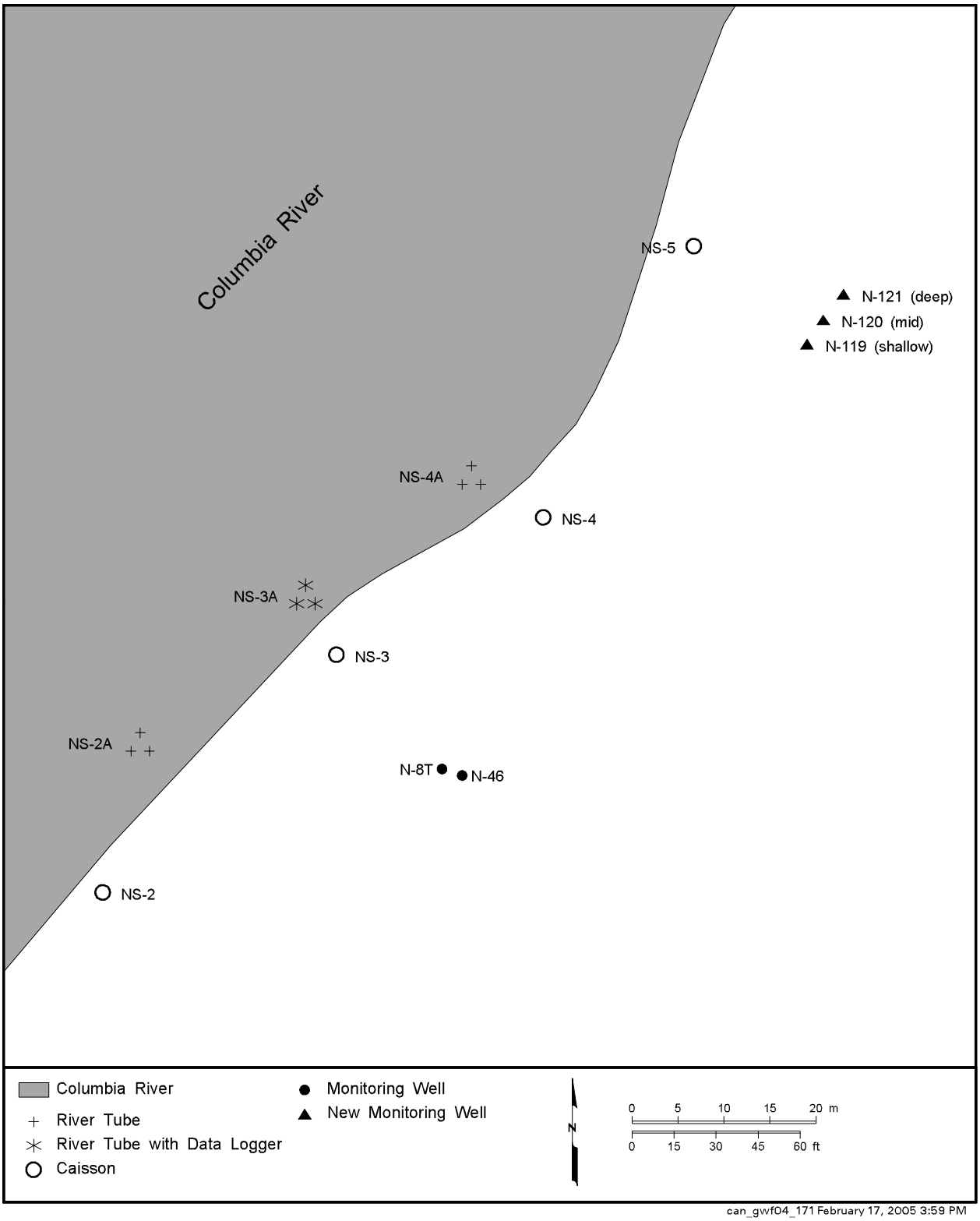


Figure 2.4-12. Monitoring Sites at the 100-N Area Shoreline

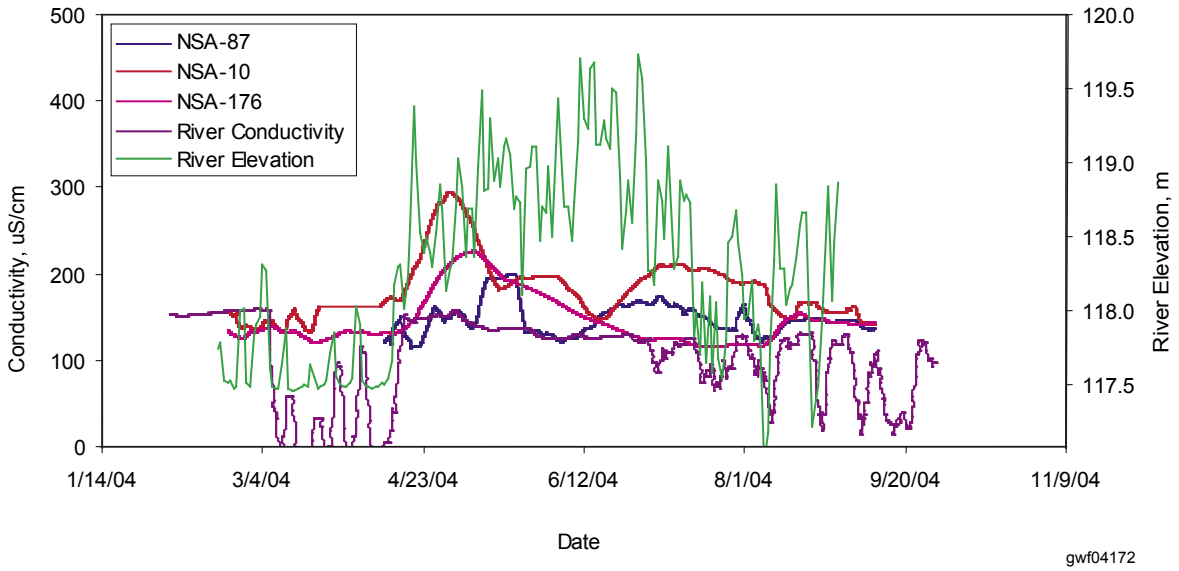


Figure 2.4-13. Three-Day Average of Specific Conductance Relative to River Stage, FY 2004

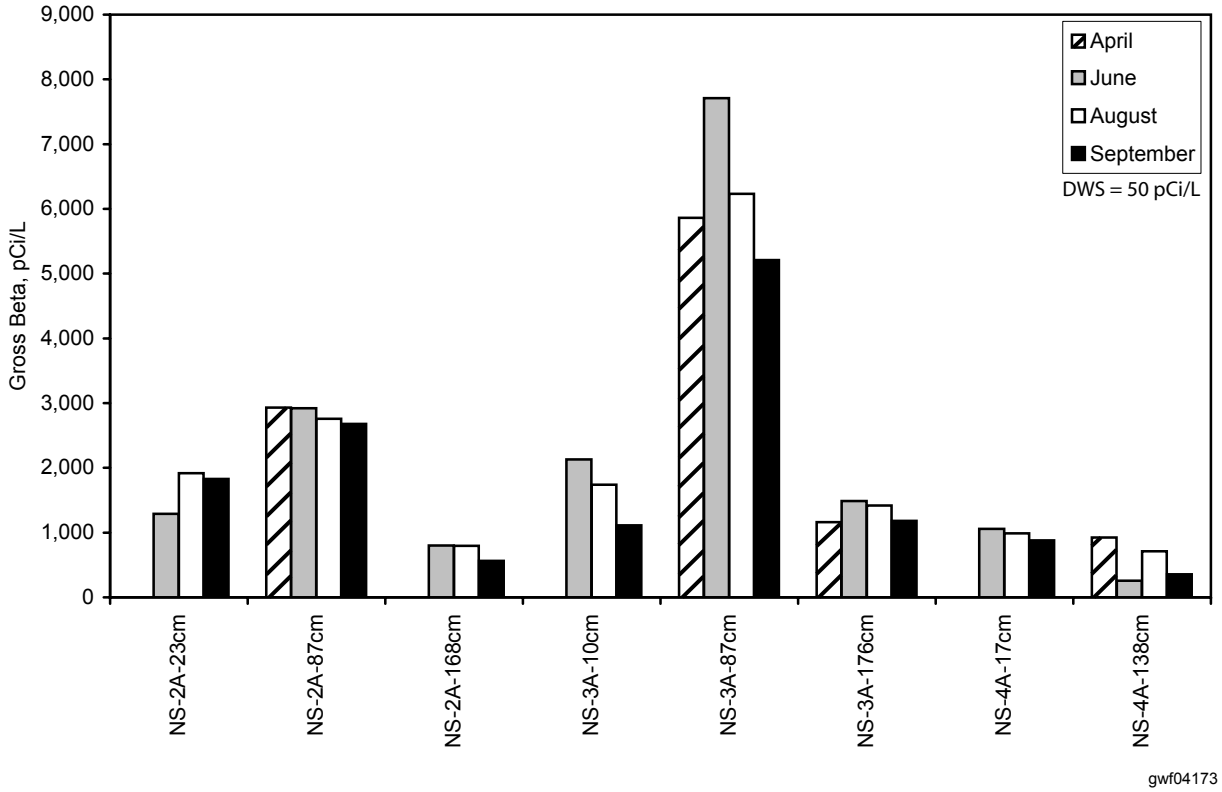


Figure 2.4-14. Gross Beta Concentrations in 100-N Area River Tubes, FY 2004

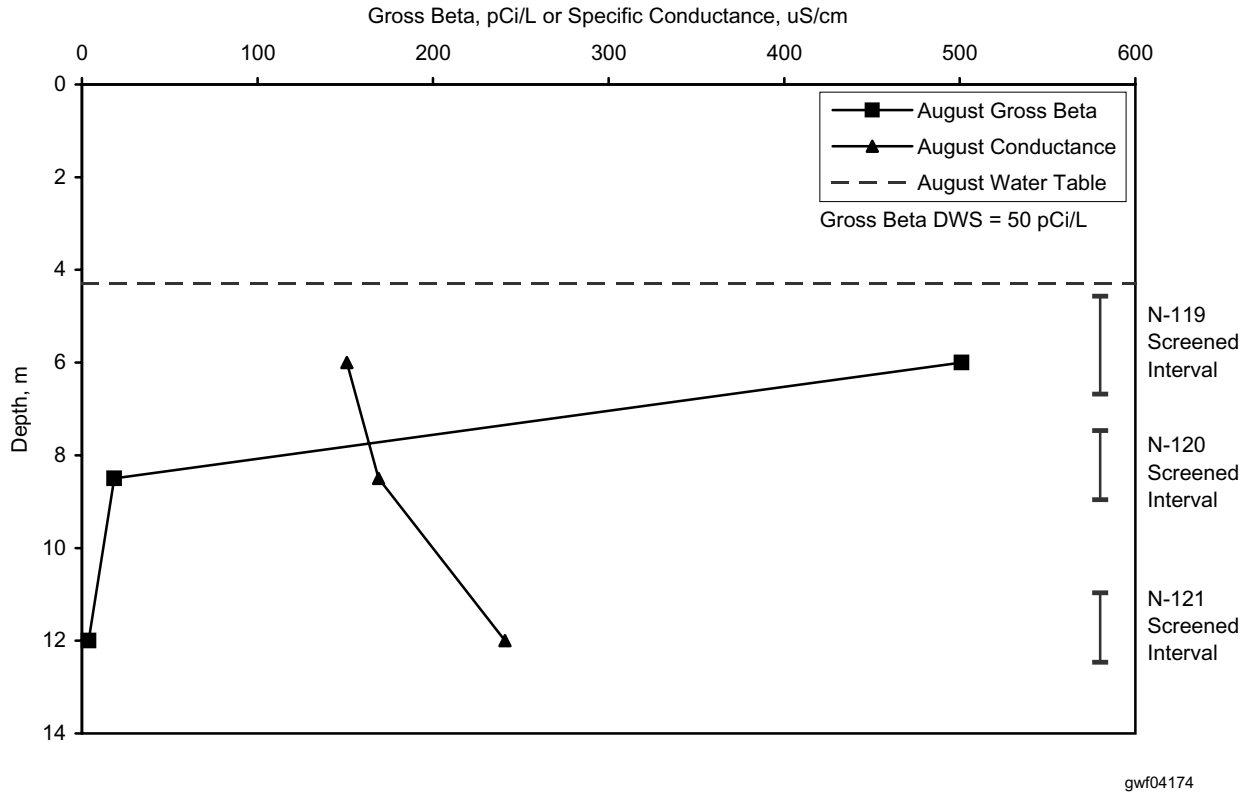


Figure 2.4-15. Gross Beta and Specific Conductance with Depth in Wells on the 100-N Area Shoreline, FY 2004