10 200-PO

Groundwater monitoring in 200-PO (Figures 10-1 and 10-2) is performed to meet AEA, CERCLA, RCRA, and WAC requirements.

10.1 Overview

The 200-PO interest area includes the CERCLA 200-PO-1 OU and adjacent region, seven RCRA units (216-A-29 Ditch, 216-A-36B Crib, 216-A-37-1 Crib, 216-B-3 Pond [B Pond], Nonradioactive Dangerous Waste Landfill [NRDWL], Integrated Disposal Facility [IDF], WMA A-AX [SST]), one state-regulated landfill (Solid Waste Landfill [SWL]), and the 400 Area. No current groundwater remediation systems are implemented within 200-PO. Table 10-1 summarizes some key facts about 200-PO. Section 1.5 provides plume mapping details, including descriptions of terms in figure legends (e.g., Type 1 control point). The listed water quality standards for radionuclides assume that only one radionuclide is present. In many locations in 200-PO, multiple radionuclides are present in groundwater, and the dose is cumulative. As discussed in Section 10.14, the cumulative drinking water dose from beta/photon emitters exceeded the 4 mrem/yr standard at 67 locations in this interest area.

Groundwater beneath the interest area primarily occurs in an unconfined aquifer consisting of Hanford formation and Ringold Formation sands and gravels (Figure 1-7). However, due to the large extent and overall thickness of the aquifer (up to 215 m [705 ft]), it includes localized semiconfined and confined intervals within deeper portions of the aquifer system as well. The Ringold Formation lower mud unit (RLM) (hydrostratigraphic unit 8) locally confines the underlying unit 9. There are also finer grained strata within unit 9 that confine underlying sediments locally. Immediately east of the 200 East Area, the fine-textured deposit of unit 8 is encountered at a shallow depth in contact with the overlying Hanford formation; there are no saturated sediments above unit 8 in that vicinity, and the unconfined aquifer is absent. Detailed discussions of geology and hydrogeology within the 200-PO interest area are provided in DOE/RL-2009-85, Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit; DOE/RL-2011-118, Hanford Site Groundwater Monitoring for 2011; and PNNL-12261.

Groundwater within the 200-PO interest area has been contaminated primarily by releases from cribs, ponds, SSTs, and trenches associated with PUREX and B Plant operations. Groundwater sampling within the interest area is directed by the SAPs, permits, Tri-Party Agreement (Ecology et al., 1989) change notices, and other documents that identify groundwater monitoring requirements. The CERCLA RI completed for the 200-PO-1 OU in 2012 identified tritium, iodine-129, nitrate, strontium-90, technetium-99, PCE, TCE, and uranium as final COPCs (DOE/RL-2009-85).

Plume areas measured from 2003 through 2016 for tritium, iodine-129, nitrate, uranium, and technetium-99 are presented in Figure 10-3. A change in calculated plume area occurred for some contaminants (e.g., nitrate) between 2011 and 2012 due to calculation of areas by interest area boundary starting in 2012, instead of calculation by source area prior to 2012. These COPCs, except technetium-99, are primarily associated with PUREX operations that discharged liquid effluents to the cribs and ditches in the southern part of the 200 East Area from 1956 to 1972 and from 1983 to 1988. Technetium-99 within 200-PO has been detected above the DWS near WMA A-AX.

Figure 10-1. 200-PO Water Table, March 2016
Figure 10-2. 200-PO Sampling Locations, 2016
### Table 10-1. 200-PO at a Glance

**PUREX Plant operations:**
- 1956 to 1972 (plutonium separation)
- 1983 to 1989 (plutonium separation)

#### 2016 Groundwater Monitoring

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Water Quality Standard</th>
<th>Maximum Concentration</th>
<th>Plume Area ( (\text{km}^2) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tritium</td>
<td>20,000 pCi/L</td>
<td>418,000 pCi/L (299-E17-14 and 299-E17-19)</td>
<td>65.0</td>
</tr>
<tr>
<td>Iodine-129</td>
<td>1 pCi/L (^b)</td>
<td>8.91 pCi/L (299-E17-14)</td>
<td>64.1</td>
</tr>
<tr>
<td>Nitrate</td>
<td>45 mg/L</td>
<td>146 mg/L (299-E17-19)</td>
<td>2.4</td>
</tr>
<tr>
<td>Strontium-90</td>
<td>8 pCi/L (^b)</td>
<td>13.7 pCi/L (299-E17-14)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Technetium-99</td>
<td>900 pCi/L (^b)</td>
<td>1,950 pCi/L (299-E25-93)</td>
<td>0.08</td>
</tr>
<tr>
<td>Uranium</td>
<td>30 µg/L</td>
<td>23.9 µg/L (299-E17-14)</td>
<td>0.03</td>
</tr>
</tbody>
</table>

\(^a\) Estimated area at a concentration greater than the listed water quality standard.

\(^b\) Single isotope equivalent DWS. If two or more radionuclides are present, the sum of their annual dose equivalents shall not exceed 4 mrem/yr.

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**Figure 10-3. 200-PO Plume Areas**
10.2 200-PO and 200 East Area Hydraulic Gradient and Groundwater Flow Directions

The depth to the water table varies from more than 90 m (300 ft) near the southern boundary of the 200 East Area to near 0 m (0 ft) at the Columbia River. The use of water level data to determine groundwater flow directions in the 200 East Area has been problematic because of a very low hydraulic gradient magnitude combined with a relatively large depth to water. This results in a low signal-to-noise ratio in the water level elevation measurements, making it difficult to determine the hydraulic gradient. This problem has been reduced by improving the accuracy of the water level measurements (by resurveys of well casing elevations, performing borehole path surveys, and analyzing barometric pressure effects) and analyzing the data by trend surface analysis. Using the average of monthly measurements helps minimize the remaining error. A network of wells used to evaluate the low-gradient region includes most of the 200 East Area. The network currently consists of 62 wells extending from 699-50-56 north of LLWMA-1 to 699-37-43 just outside the southeast corner of the 200 East Area. Geodetic casing elevation surveys and gyroscopic surveys (for borehole verticality) have been performed in all 62 wells. The collection of monthly water-level measurements from this network began during May 2013 and has since expanded to include the 62 wells currently in the network.

Contours representing the average water table elevation across the low-gradient evaluation network, generated using the inverse distance gridding method, are shown in Figure 10-4. The map shows flow generally toward the southeast across the 200 East Area. The contours are more closely spaced in the northwest, indicating that the magnitude of the hydraulic gradient is larger in the northwestern part of the 200 East Area compared to the southeast part. The aquifer is thin in the northwest, causing the transmissivity to be lower, and lower transmissivity equates to higher hydraulic gradient magnitudes (when all other factors are equal).

The configuration of the 200 East Area water table at any given time results from fluctuations in boundary conditions related to Columbia River stage and hydraulic effects related to discharges to the TEDF, located east of the 200 East Area. Discharges to the TEDF are variable, consisting primarily of steam condensate and noncontact cooling water. The normal pattern of discharge is a low-volume background, averaging 6.7 million L per month (1.8 million gal per month) (2011 through 2013), with occasional discharge volumes in excess of 100 million L/month (26 million gal/month) that occur when the 242-A Evaporator is operating. These larger discharges affect the 200 East Area water table. During 2016, high-volume discharges to the TEDF occurred in April with a total of 277 million L (73 million gal).

The water table in the 200 East Area also responds to seasonal Columbia River stage changes via the high-transmissivity paleochannel that originates to the northwest near the 100-BC Area. During the summers of 2013 and 2014, the river stage was near its long-term average for the summer months. During 2015 and 2016 spring and summer river discharge was below its long-term average.

The combination of higher TEDF discharges to the east and lower river stages to the northwest resulted in a lower hydraulic gradient magnitude in the 200 East Area during 2015 and 2016. However, discharges to the TEDF were not great enough to cause the groundwater flow direction to change, and flow continued toward the southeast during 2015 and 2016. The main effect of the TEDF discharges has been to reduce the gradient toward the southeast. Section 10.12 describes groundwater flow directions beneath specific RCRA sites in 200-PO.

Figure 10-4. 200 East Area Low-Gradient Water Table, 2016
10.3 Tritium

For the 200-PO-1 OU, near-field wells are sampled for tritium annually and most far-field wells are sampled triennially (Tables A-11 and A-12 in Appendix A). Triennial sampling events under TPA-CN-205, Change Notice for Modifying Approved Documents/Work Plans in Accordance with the Tri-Party Agreement Action Plan, Section 9.0, Documentation and Records: DOE/RL-2003-4, Revision 1, Sampling and Analysis Plan for the 200-PO-1 Operable Unit, have primarily been conducted in 2010, 2013, and 2016. Far-field area wells comprising the southeast transect and river transect are sampled annually (Table A-12 in Appendix A).

Tritium contamination in groundwater is found at a concentration greater than the 20,000 pCi/L DWS in a large plume that extends from the 200 East Area to the Columbia River. The highest current and historical concentrations have been observed near the PUREX cribs and trenches, which were the major release points of this contaminant (Figure 10-5). The tritium plume continues to be present in the far-field area with a portion of the plume discharging into the Columbia River to the east (Figure 10-6). Concentrations are decreasing and the plume is attenuating in the far-field area due to dispersion and radioactive decay, but concentrations near the PUREX cribs and trenches remain up to 20 times the DWS of 20,000 pCi/L and have been relatively stable since 2000. Section 4.2 of DOE/RL-2009-85 states that vadose zone sources may be present. The interpolated portion of the tritium plume at a concentration above 20,000 pCi/L that discharges to the river has increased in 2016 in comparison to 2015. The increase is based on an increase of concentration in aquifer tube C6353. The tritium concentration at C6353 sampled in 2016 (25,600 pCi/L) is consistent with the 2014 value (25,000 pCi/L) and had previously been showing a reduction of tritium in 2015 (4,420 pCi/L) (Figure 10-6).

In 2016, the locations of 20,000 and 200,000 pCi/L interpolated plume intervals have changed in comparison to the 2015 plume. These changes are primarily localized reduction of the 20,000 pCi/L concentration interval in the far-field area. The tritium plume bounded by the 20,000 pCi/L contour has decreased in size by 65 percent since 1980 (from 185 to 65 km² [71.4 to 25 mi²]).

For 2016, the highest concentrations of tritium in the near-field area were 418,000 pCi/L in well 299-E17-19 (near the 216-A-10 Crib), 394,333 pCi/L in well 299-E17-14 (near the 216-A-36B Crib), and 327,000 pCi/L in well 299-E24-23 (near the 216-A-4 Crib) (Figure 10-7). The highest concentration of tritium detected during 2016 from the far-field area was 799,000 pCi/L for a sample collected in January 2016 at well 699-13-3A, about the same as 2015. The tritium in well 699-13-3A originated at the 618-11 Burial Ground and is discussed in further detail in the 300-FF discussion (Chapter 7).
Figure 10-5. 200-PO Near-Field Tritium Plume, 2016
Figure 10-6. 200-PO Far-Field Tritium Plume, 2016
Well 699-31-31 is one of the wells used to define the boundary of the tritium plume in the area where the plume narrows as it extends to the southeast between the 200 East Area and the distal far-field area (Figure 10-6). Well 699-31-31 and other wells near the plume in this region have been showing a decreasing concentration trend following peak levels that occurred when a high-concentration slug of tritium passed through the area between 1992 and 1994 (Figures 10-8 and 10-9). From 1992 to 2000, the tritium concentrations in this well usually exceeded the DWS. After 2000, concentrations of tritium detected in the well were approximately one order of magnitude lower than the concentration detected in 2000, well below the DWS. The reason for the decrease in the tritium concentration in the well between 2000 and 2001 is not clearly defined. Well 699-31-31 is a host well with two piezometers nested inside, separated by cement seals. The concentration change was once thought to be related to a breach of one of the seals. In reviewing concentration trending for other wells in the area that are equal distance from the plume margin, current concentration trending for well 699-31-31 is consistent with the regional pattern.

Wells screened (or casings perforated) in the middle or lower portions of the unconfined aquifer had tritium results ranging from 2,730 pCi/L (299-E25-32Q) to 8,260 pCi/L (299-E25-29Q) in the near-field area in 2016, and from nondetect to 44,300 pCi/L (near-river well 699-37-E4) in the far-field area in 2016. Since 1997, concentrations of tritium at this well and other near-river wells have decreased (Figure 10-10).
Figure 10-8. 200-PO Tritium Data for Wells 699-31-31, 699-33-42, and 699-34-42

Figure 10-9. 200-PO Tritium Data for Wells 699-26-33, 699-28-40, and 699-31-31
In 2016, tritium concentrations in wells screened in the Ringold confined aquifer beneath the lower mud ranged from nondetect (699-39-39) to 39,100 pCi/L (699-42-40A). These wells are located near B Pond (Figure 10-5). Since 2007, tritium levels have generally been stable at well 699-42-40A. Historical concentrations have shown a decreasing trend in surrounding Ringold-confined wells (Figure 10-11). Well 699-41-40 was sampled in 2016, and results were 25,200 pCi/L, showing a decrease from 34,000 pCi/L in 2013. From 1990 to 2016, the tritium concentration in well 699-41-40 decreased from 226,000 to 25,200 pCi/L (Figure 10-11).

Seven wells screened in basalt-confined aquifers are sampled triennially within 200-PO (Table A-12 in Appendix A). Five of the wells were sampled in 2016, including: wells 699-13-1C and 699-32-22B (Rattlesnake Ridge interbed), well 699-24-1P (Rattlesnake Ridge interbed and Pomona Basalt), Laser Interferometer Gravitational-Wave Observatory well 699-S2-34B (with a completion depth of 591.6 m [1,941 ft] bgs and assumed to monitor a deeper confined aquifer), and well 699-S11-E12AP (Levy interbed). Well 299-E16-1 was sampled in 2015, and tritium was not detected. Tritium has been detected only intermittently at low concentrations below the DWS in samples collected from wells screened in basalt aquifers, with the exception of well 699-42-40C (located near the B Pond). Tritium in well 699-42-40C has been detected since 1982, up to a maximum concentration of 8,320 pCi/L in 1993. Since 1996 concentrations in well 699-42-40C have shown a decreasing trend (Figure 10-12). Appendix D contains additional discussion about connections between the basalt-confined and unconfined aquifers.
Figure 10-11. 200-PO Tritium Data for Wells 699-41-40 and 699-42-40A

Figure 10-12. 200-PO Tritium Data for Basalt-Confined Well 699-42-40C
10.4 Iodine-129

Iodine-129 at a concentration greater than the 1 pCi/L DWS is found in a relatively dispersed plume that covers a large area within 200-PO (Figure 10-13). The highest historical concentrations have been detected near the PUREX cribs and trenches. The majority of the far-field area well sampling (triennial sampling) was completed in 2016. The 2016 interpolated plume extent above the 1 pCi/L concentration in the far-field area is essentially the same as the 2015 plume presented in DOE/RL-2015-07, due to the stability and long half-life of the iodine-129 radionuclide.

Iodine-129 concentrations detected in near-field area wells in 2016 ranged from nondetect to 8.91 pCi/L. The highest concentrations in 2016 were detected near the PUREX cribs and trenches, 216-A-29 Ditch, B Pond, and WMA A-AX. None of the detected concentrations exceeded the DOE-derived concentration standard of 330 pCi/L (Table 5 of DOE-STD-1196-2011). In 2016, the highest concentrations of iodine-129 were detected in wells 299-E17-14 (8.91 pCi/L), 699-43-45 (7.21 pCi/L), 299-E25-93 (7.2 pCi/L), and 299-E25-42 (6.2 pCi/L). Iodine-129 concentrations in well 299-E17-14 near the PUREX cribs show a generally decreasing trend (Figure 10-14). Concentrations in 699-43-45, located near B Pond and the north end of the 216-A-29 Ditch, decreased from the 2015 value (10.1 pCi/L), but have shown an overall slightly increasing trend since sampling began in 1995 (Figure 10-14). The highest concentrations of iodine-129 detected in the far-field area in 2016 occurred at wells 699-41-23 (4.82 pCi/L) and 699-32-22A (3.28 pCi/L) (Figure 10-13).

As with the tritium plume, well 699-31-31 is one of the wells used to define the boundary of the iodine-129 plume as it extends to the southeast between the 200 East Area and the distal far-field area. Concentrations in this well decreased to nondetects following peak levels that occurred when a high-concentration slug of iodine-129 passed through the area between 1993 and 1994 (Figure 10-15). A review of concentration trending for other wells in the area that are equal distance from the plume margin indicated that current iodine-129 concentration trending for this well is consistent with the regional pattern.

The iodine-129 plume has not reached the Columbia River at concentrations above the DWS. It is undetected in 200-PO aquifer tubes, and results in river transect wells in 2016 ranged from less than detection limits to 0.423 pCi/L.

Within the middle and lower part of the unconfined aquifer, iodine-129 was detected at concentrations above the DWS in two near-field area wells near the 216-A-29 Ditch (Figure 10-13). Iodine-129 concentrations of 4.63 and 1.32 pCi/L were measured in wells 299-E25-28 and 299-E25-32Q, respectively. Iodine-129 was not detected at levels above the DWS in far-field wells completed within the middle or lower part of the unconfined aquifer during 2016.

For 200-PO, the Ringold confined aquifer is monitored near the B Pond and the TEDF. In 2016, iodine-129 was detected above the DWS at two confined wells: 2.38 pCi/L in well 699-42-42B and 1.22 pCi/L in well 699-42-40A. Appendix D summarizes results for other Ringold-confined wells.

Three wells screened in basalt-confined aquifers are sampled triennially within the 200-PO for iodine-129 (Table A-11 in Appendix A). Concentrations of iodine-129 within the basalt-confined aquifer wells have historically been near or below detection limits.
Figure 10-13. 200-PO Iodine-129 Plume, 2016
Figure 10-14. 200-PO Iodine-129 Data for Wells 699-43-45, 299-E17-14, 299-E25-42, and 299-E25-93

Figure 10-15. 200-PO Iodine-129 Data for Well 699-31-31
10.5 Nitrate

The highest historical concentrations of nitrate in 200-PO have been detected near the PUREX cribs and trenches. The extent of nitrate at concentrations greater than the 45 mg/L DWS equivalent is limited to the near-field area (Figure 10-16). Historically, the nitrate plume was larger, but concentrations within the far-field area have decreased to below the 45 mg/L DWS equivalent, other than near the 618-11 Burial Ground (see 300-FF discussion in Chapter 7). Comparing the 2016 plume (Figure 10-16) to the 2015 plume reveals the following notable changes:


- Nitrate levels in wells 299-E24-22 and 299-E24-33 along the western margin of WMA A-AX continue to rise as the result of the migration of a nitrate plume from WMA C. Nitrate concentrations in 299-E24-20 also along the western margin of WMA A-AX have been rising since 2008, but showed a decline in 2016.

The highest nitrate concentrations in 200-PO in 2016 were 146 mg/L at well 299-E17-19 (located downgradient of the 216-A-10 Crib) and 120 mg/L from well 299-E17-14 (located downgradient of the 216-A-36B Crib) (Figure 10-17). Some of the wells near the PUREX cribs, including 299-E24-16, 299-E17-19, 299-E17-1, 299-E17-18 (near the 216-A-10 and 216-A-36B Cibs), 299-E25-17, 299-E25-18, and 299-E25-20 (near the 216-A-37-1 Crib), have exhibited increasing nitrate concentrations since early 2000.

The southeastern portion of the 200 East Area has exhibited increasing nitrate concentrations since approximately 2002. Migration of the leading edge of the nitrate plume to the south and southeast is indicated by the increasing concentrations in wells 299-E17-26 and 299-E17-23 (Figure 10-18). The cause of the increase in nitrate concentrations in this portion of the 200 East Area may be related to changes in gradient and groundwater flow direction and/or a vadose zone source(s) contribution associated with the PUREX cribs.

During 2016 in the near-field area in wells monitoring the middle to lower portions of the unconfined aquifer (299-E25-28, 299-E25-29Q, and 299-E25-32Q), nitrate exceeded 45 mg/L in well 299-E25-32Q (48.7 mg/L). Nitrate concentrations in well 299-E25-29Q have been increasing since 2011, and 2016 represents the first exceedance since sampling began in 1996. In the far-field area, the maximum nitrate concentration in the deeper portion of the aquifer was 32.8 mg/L in near-river well 699-37-E4 in 2016. Nitrate levels have been stable in this well since 1991.

Only one well in the far-field area had a concentration above the 45 mg/L DWS equivalent in 2016. A maximum concentration of 57.5 mg/L was detected in well 699-13-3A. The source of the nitrate in this well is the 618-11 Burial Ground (see 300-FF discussion in Chapter 7). The nitrate concentration (0.133 mg/L) was near the detection limits in the main water supply well for the 400 Area (499-S1-8J), which is screened in the deep portion of the unconfined aquifer.
Figure 10-16. 200-PO Nitrate Plume, 2016
Figure 10-17. 200-PO Nitrate Data for Wells 299-E17-14 and 299-E17-19

Figure 10-18. 200-PO Nitrate Data for Wells 299-E17-23, 299-E17-25, 299-E17-26, and 699-37-47A
Nitrate was detected in 2016 in one well within the Ringold Formation confined aquifer above 45 mg/L. A concentration of 79.7 mg/L was measured in well 699-39-39. Beginning in 1995, nitrate concentrations increased as the water table elevation in the area decreased (Figure 10-19). It is suspected that the well completion may have permitted groundwater from the unconfined aquifer to be driven downward by hydrostatic head associated with B Pond discharges and groundwater mounding. Nitrate in groundwater may have entered through the upper screened interval and/or borehole annulus and was then forced into the surrounding sediments by the downward gradient associated with the B Pond groundwater mound. The saturated portion of the well screen now occurs entirely within the RLM. It is suspected that thin silty or sandy sequences may be present within the RLM adjacent to the well screen, which has permitted continued low-rate pumping and sampling of this well. This situation is unique, and the estimated nitrate distribution is assumed to be within a limited region adjacent to this well. None of the other wells completed in sand intervals below the RLM in this area show elevated nitrate concentrations.

![Figure 10-19. 200-PO Historical Changes in Nitrate Concentration and Hydraulic Head in Well 699-39-39](image)

Nitrate concentrations in the basalt-confined aquifer range from not detected to 9.30 mg/L, much lower than in the unconfined aquifer because the groundwater is less oxygenated.

### 10.6 Technetium-99

Technetium-99 has historically been detected in one relatively small area in the 200-PO near-field region around WMA A-AX (Figure 10-20). This plume appears to have sources both in WMA C (in 200-BP) and in WMA A-AX (in 200-PO). WMA A-AX is hydraulically downgradient of WMA C.
Figure 10-20. 200-PO Technetium-99 Plume, 2016
Wells 299-E24-22 and 299-E24-33 have previously been sampled for technetium-99 during groundwater monitoring for WMA A-AX and in 2015 showed annual average concentrations of 2,570 pCi/L and 1,128 pCi/L respectively (Figures 10-20 and 10-21). In 2016, a revised RCRA groundwater monitoring plan was implemented that removed the non-RCRA constituents, including technetium-99. These wells and downgradient well 299-E25-237 are scheduled for sampling every other year under the AEA SAP (DOE/RL-2015-56) and were not scheduled for sampling in 2016.

Until June 2014, the highest concentrations detected at WMA A-AX generally occurred in downgradient well 299-E25-93. Concentrations were elevated when the well was drilled in 2003 and have declined over time (Figure 10-22). Concentrations of technetium-99 in upgradient well 299-E24-22 (Figure 10-21) have been increasing since 2011. The leading edge of the technetium-99 plume migrating from WMA C is projected to extend beneath the central portion of WMA A-AX. The detections above the 900 pCi/L DWS southeast and downgradient of WMA A-AX in wells 299-E25-93 and 299-E25-94 are inferred to be primarily associated with WMA A-AX, although there may be some contribution of technetium-99 from the leading edge of the WMA C plume in this area. This interpretation is supported by different characteristics in the historical technetium-99 concentration trends in upgradient wells 299-E24-33 and 299-E24-22 (Figure 10-21) in comparison to downgradient wells 299-E25-94, 299-E25-93, 299-E25-236, and 299-E25-237 (Figure 10-22). The increasing concentration trend in the WMA A-AX upgradient wells is expected to continue as the technetium-99 plume emanating from WMA C continues migration to the southeast toward WMA A-AX.
The calculated migration rate of technetium-99 from WMA C is discussed most recently within quarterly groundwater assessment reports including SGW-60494, WMA C July through September 2016 Quarterly Groundwater Monitoring Report. Groundwater flow rates at WMA C were interpreted to be 0.52 m/day towards the south-southeast, based on gradient and hydraulic conductivity. Based on a flow rate of 0.52 m/day and a distance of 290 m, the estimated minimum travel time between downgradient WMA C well 299-E27-21 and upgradient WMA A-AX well 299-E24-22 is 1.5 years. Technetium-99 to nitrate concentration ratios discussed and presented in SGW-60494 depict an increasing trend in well 299-E27-21 beginning in June 2007, and a corresponding increasing trend in well 299-E24-22 beginning in December 2011, indicating a travel time of 3.5 years.

In 2016, in the far-field area southeast and east of the 200 East Area, technetium-99 was reported at 531 pCi/L in well 699-37-47A. Well 699-37-47A, located near the southeast corner of the 200 East Area, has been showing steadily increasing levels of technetium-99 since consistent sampling of the well began in 2009 (Figure 10-23).

Technetium-99 continued to be detected at low levels in some aquifer tubes in 200-PO used to monitor groundwater adjacent to the Columbia River. In September 2016, a concentration of 69.9 pCi/L was detected in aquifer tube C6353 (Figure 10-2), showing an increase from a nondetect level of 5.88 pCi/L in January 2015. However, the 2016 results are consistent with concentrations identified between 2008 and 2012, ranging from 26 to 85 pCi/L.

Wells monitoring the Ringold-confined and basalt-confined aquifers historically had little or no detectable technetium-99 and are no longer monitored for this analyte.
10.7 Uranium

Uranium has been identified historically as a small plume near the PUREX cribs and trenches in the near-field area (Figure 10-24) and adjacent to the 618-10 Burial Ground (which is part of 300-FF) located in the far-field area. Due to severe winter weather, one of the wells in the near-field plume (299-E24-23) was not sampled in 2016. Uranium declined from 42.4 µg/L to 6.2 µg/L in well 299-E25-36 in 2016 (Figure 10-25).

Uranium concentrations at well 299-E17-14 near the 216-A-36B Crib and well 299-E24-16 near the 216-A-10 Crib remained slightly below the 30 µg/L DWS in 2016 (Figures 10-24 and 10-25). Uranium remains somewhat mobile in groundwater at 200-PO, and the concentration changes observed are consistent with continued slow migration of uranium away from source areas.

During 2016, uranium within far-field unconfined, Ringold-confined, and basalt-confined aquifers ranged remained well below the DWS. Concentrations ranged from not detected to 7.53 µg/L in well 699-26-33A.
Figure 10-24. 200-PO Uranium Plume, 2016
Figure 10-25. 200-PO Uranium Data for Wells 299-E17-14 (216-A-36B Crib), 299-E24-23 (216-A-4 Crib), 299-E24-16 (216-A-10 Crib), and 299-E25-36

10.8 Strontium-90

Strontium-90 has historically been detected in relatively small areas at concentrations greater than the DWS of 8 pCi/L near the 216-A-5, 216-A-10, and 216-A-36B Cribs. In 2016, a small plume was present near the 216-A-10 Crib and 216-A-36B Crib (Figure 10-26).

The only well in 200-PO with strontium-90 above the DWS in 2016 was 299-E17-14 near the 216-A-10 Crib, with an annual average of 11.6 pCi/L. Since sampling was started for strontium-90 in this well, the general concentration trend has been relatively stable (Figure 10-27), suggesting a potential for continuing contribution from the vadose zone.

Historically, concentrations of strontium-90 near the 216-A-10 Crib have only exceeded the 8 pCi/L DWS in one sampling event in one well (299-E24-16 at a concentration of 8.19 pCi/L in 2004). Concentrations in the well have generally ranged from 5.2 to 7.8 pCi/L (Figure 10-27). Strontium-90 was detected in well 299-E24-16 near the 216-A-10 Crib at 4.67 pCi/L in 2016, consistent with the 2015 concentration of 4.21 pCi/L. In 2016, strontium-90 was not detected in any far-field wells.

Strontium-90 is typically not detected in the middle or deep unconfined aquifer, Ringold-confined, or basalt-confined aquifer. Wells screened in these units are no longer required to be monitored for this analyte.
Figure 10-26. 200-PO Strontium-90 Plume, 2016
Concentrations of PCE are near or below detection limits in 200-PO. In 2016, PCE was detected at a maximum concentration of 1.11 (J) µg/L in well 299-E17-14 and below the 5 µg/L DWS. The laboratory “J” flag indicates that the value is estimated, the detection is uncertain, and the value reported is less than the practical quantitation limit but greater than or equal to the MDL. Low-level detections of PCE were common in a few wells near NRDWL and the SWL used for RCRA and WAC monitoring before about 2007, but most results since then have been near or below detection limits. Additional information concerning VOC results from wells used for RCRA monitoring are presented in Section 10.12 and in Section 10.13 for WAC monitoring at the SWL.

10.10 Trichloroethene

In the near-field area, TCE was detected at levels below the 5 µg/L DWS in 2016 near the 216-A-10 and 216-A-36B Cribs. TCE was detected in wells 299-E17-19 (1.3[J] µg/L) and 299-E17-14 (0.94[J] µg/L). Monitoring for VOCs at the 216-A-36B Crib is part of the RCRA monitoring program (Section 10.12). CERCLA monitoring for VOCs is also performed in conjunction with RCRA monitoring at NRDWL and WAC monitoring at the SWL. TCE concentrations at the SWL in CERCLA network well 699-26-33A ranged from 0.16(J) to 0.33(J) µg/L in 2016.
10.11 CERCLA Monitoring

Groundwater monitoring in the 200-PO-1 OU under CERCLA is described in the SAP (DOE/RL-2003-04, Sampling and Analysis Plan for the 200-PO-1 Groundwater Operable Unit, as amended by TPA-CN-205) and DOE/RL-2007-31, Remedial Investigation/Feasibility Study Work Plan for the 200-PO-1 Groundwater Operable Unit, as amended by TPA-CN-2-253. Groundwater is monitored within the unconfined aquifer, Ringold-confined aquifers, and the basalt-confined aquifer. Wells and aquifer tubes (Figure 10-2) are generally sampled annually or triennially (every 3 years). Additional aquifer tube sampling within 200-PO is also conducted as defined in the SAP for aquifer sampling tubes (DOE/RL-2000-59, Sampling and Analysis Plan for Aquifer Sampling Tubes).

Tables A-11 and A-12 in Appendix A list monitoring wells, constituents, and sampling status for 2016. For purposes of CERCLA groundwater monitoring, the 200-PO-1 OU is informally divided into the near-field area (includes the former operational areas within and near the 200 East Area) and the far-field area (includes wells downgradient of the near-field area, and aquifer tubes along the Columbia River, and generally comprises areas where site operations did not occur). The river area is generally within 1 km (0.6 mi) of the west shore of the Columbia River. CERCLA sampling wells within the far-field area have been grouped into several sub-areas, including the BC Cribs, southeast transect, river transect, basalt-confined aquifer, and the general far-field area (DOE/RL-2003-04; TPA-CN-205).

The results of the RI are provided in DOE/RL-2009-85. The report recommended that the OU should advance to the next step in the CERCLA process, which is an FS to develop alternatives to remediate the groundwater contamination. The RI identified tritium, iodine-129, nitrate, strontium-90, technetium-99, PCE, TCE, and uranium as final COPCs. PCE and/or TCE were detected at very low (laboratory-estimated) concentrations (below the 5 µg/L DWS) in far-field area wells near the 216-A-10 Crib, 216-A-36B Crib, NRDWL, and SWL.

An RI addendum (DOE/RL-2009-85-ADD1, Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit Addendum 1) was submitted to Ecology in 2015. The addendum was completed to address Ecology comments to update the baseline risk assessment to be consistent with the same time frame as used for the 200-BP-5 OU and to update the fate and transport model presented in the 200-PO-1 RI report (DOE/RL-2009-85).

Monitoring well 699-30-57 was installed in the boundaries of the 200-PO interest area in 2016 to monitor contamination from the 200-UP-1 groundwater OU (Chapter 11).

10.12 RCRA Monitoring

The following subsections, taken from DOE/RL-2016-66, describe the results of monitoring at seven individual waste management areas within the 200-PO interest area conducted in accordance with RCRA regulations: 216-A-29, 216-A-36B, 216-A-37-1, B Pond, IDF, NRDWL, and WMA A-AX. Interim status groundwater quality assessment monitoring is conducted at WMA A-AX (40 CFR 265.93(d), as referenced by WAC 173-303-400). Interim status facility standards detection monitoring for indicator parameter evaluation is conducted at five sites: 216-A-29, 216-A-36B, 216-A-37-1, B Pond, and NRDWL (40 CFR 265.92, as referenced by WAC 173-303-400). The IDF is not operational but is monitored as incorporated into the Hanford RCRA Permit to obtain baseline information.
10.12.1 Waste Management Area A-AX

WMA A-AX is located in the southeast quarter of the 200 East Area (Figure 10-28) and consists of 10 underground storage tanks, 2 of which are confirmed or assumed leakers (HNF-EP-0182, Waste Tank Summary Report for Month Ending November 30, 2016). Leaks were reassessed in the 2014 revision of RPP-ENV-37956, Hanford A and AX-Farm Leak Assessments Report: 241-A-103, 241-A-104, 241-A-105, 241-AX-102, 241-AX-104 and Unplanned Waste Releases. To minimize the probability and severity of future leaks, most of the drainable liquid in each tank has been removed and transferred to DSTs. The extent of vadose zone contaminant migration from the tanks is uncertain. Although no dangerous waste groundwater contamination has been attributed to the tank releases, the WMA is in an interim status assessment program because an indicator parameter (specific conductance) exceeded the critical mean value in 2005. WMA A-AX remained in assessment monitoring in accordance with 40 CFR 265.93(d) (as referenced by WAC 173-303-400) during 2016.

A revised assessment plan (DOE/RL-2015-49, Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area A-AX) was drafted in 2015 and implemented in 2016. The new plan is a continuation of the first determination process of the previous plan (PNNL-15315, RCRA Assessment Plan for Single-Shell Tank Waste Management Area A-AX at the Hanford Site) and includes a comprehensive list of dangerous waste constituents for assessment. The new plan reviews conditions that may have contributed to the casing corrosion in well 299-E25-236 and removes technetium-99 as a RCRA constituent.

The monitoring network includes three upgradient and six downgradient wells (Table B-69 in Appendix B) and includes well 299-E25-237, which replaced corroded well 299-E25-236. The depth of the water column in the monitoring wells ranges from 1.2 to 11.8 m (3.8 to 38.6 ft). These wells all have adequate water in the screened interval for continued sampling. Wells are screened across the water table and monitor the upper portion of the unconfined aquifer. The estimated thickness of the unconfined aquifer is from 15 to 24 m (50 to 80 ft) in the vicinity of WMA A-AX.

In 2016, groundwater near WMA A-AX was interpreted to flow to the south-southeast based on trend surface analysis results. Supporting evidence for the flow orientation included water-level measurements with slightly higher hydraulic heads to the northwest, as well as the distribution and migration of the nitrate contamination plumes in this area. This flow direction also corresponds to the orientation of a southeast-trending paleochannel in the area (Appendix E of DOE/RL-2011-118). Based on the 2016 trend surface analysis and low-gradient groundwater contour map for this area, the estimated hydraulic gradient is $4.61 \times 10^{-6}$ m/m, with an estimated groundwater flow rate of 0.091 m/day (0.30 ft/day) (Table B-70). Water-level measurements using the low-gradient monitoring well network near WMA A-AX support greater certainty in calculating groundwater gradient and flow in this area (SGW-54165; SGW-58828).

The revised monitoring plan initially included a semiannual sampling frequency, implemented with the March 2016 event. However, sampling was revised to a quarterly frequency beginning in September 2016 for consistency with other assessment monitoring plans. The monitoring network was sampled in December 2016 and will continue to be sampled quarterly to assess whether dangerous waste or dangerous waste constituents are present in the groundwater, their extent, and their rate of migration (Tables B-71 and B-72). The assessment concerning whether dangerous waste constituents have impacted groundwater from WMA A-AX as the result of tank releases has not been completed. Assessment data will be evaluated in detail in the first determination report.

Figure 10-28. WMA A-AX
The results for the March 2016 sampling event identified nitrate exceeding 45 mg/L in wells 299-E24-20 (57.5 mg/L) and 299-E25-93 (62.0 mg/L). An anomalous total iron result of 3,640 µg/L was measured in well 299-E25-40 in March, exceeding the 300 µg/L secondary DWS; however, subsequent sampling in September and December showed concentrations of 38.6 and 96.8 µg/L. The high iron was likely caused by particles of aquifer sediment. Dissolved iron concentrations were below the detection limit (30 µg/L), consistent with all other network wells. Associated increases in manganese, nickel, and chromium, which would indicate well casing corrosion, were not observed in well 299-E25-40 in the March, September, or December sampling events.

Well 299-E25-236 was decommissioned in June 2013 due to casing corrosion. It was replaced by well 299-E25-237 in January 2015. Indications of corrosion were identified in well 299-E25-41 and were confirmed with an inspection video logging based on the December 2016 sample results. Sampling of this well will continue as a portion of the monitoring network, with elevated unfiltered chromium, iron, and nickel attributed to corrosion. Well 299-E25-41 will be evaluated for decommissioning and replacement.

10.12.2 216-A-36B Crib

The 216-A-36B Crib is a TSD unit located in the southeastern portion of the 200 East Area (Figure 10-29). It was 7 m (23 ft) deep, 150 m (490 ft) long, and 2.3 to 3.4 m (7.5 to 11.2 ft) wide at the base; the sides sloped at 1:1.5. The crib construction includes 7 m (23 ft) of naturally revegetated clean backfill soil. The crib was originally part of the 180 m (590 ft) long 216-A-36 Crib, which received PUREX effluent from September 1965 to March 1966. In March 1966, the northernmost 30 m (98 ft) of the crib was isolated, with a grout barrier established between it and the southern portion of the crib, now known as 216-A-36B. The 216-A-36B Crib operated from March 1966 to October 1972 and was reactivated in November 1982 for the PUREX restart. It received 290 million L (76.6 million gal) of PUREX ammonia scrubber distillate and was permanently removed from service in September 1987. In May 2010, 15 cm (6 in.) of gravel was added to the surface of the 216-A-36B Crib.

The 216-A-36B, 216-A-10, and 216-A-37-1 Cribs were monitored in a RCRA interim status groundwater quality assessment program before 2011. The 216-A-10 Crib was officially closed and removed from the Hanford RCRA Permit on March 30, 2010. Since January 2011, the two remaining cribs (216-A-36B and 216-A-37-1) continue in RCRA interim status monitoring, but they are under indicator evaluation programs because the groundwater constituent detected (i.e., nitrate) is not a dangerous waste or dangerous waste constituent. In 2016, one upgradient well and three downgradient wells were monitored for the 216-A-36B Crib (Figure 10-29 and Table B-17).

The low-gradient groundwater contour maps for 2016 indicated groundwater flow to the southeast near the 216-A-36B Crib (Figure 10-29). The calculated groundwater flow rate is 0.0006 to 0.10 m/day (0.002 to 0.34 ft/day) (Table B-18). In 2015, the estimated flow direction was toward the east-southeast.

Based on the current groundwater flow interpretations, the 216-A-36B Crib monitoring well network is capable of meeting the objective of determining if groundwater has been affected by dangerous waste constituents. Additional upgradient and downgradient wells are proposed for the current network when the updated monitoring plan for 216-A-36B is implemented. Table B-17 summarizes water-level information for the 216-A-36B monitoring network.

The 216-A-36B Crib groundwater wells were monitored semiannually in 2016 for RCRA indicator parameters (TOC, TOX, pH, and specific conductance) and annually for water quality parameters (Table B-19). There were no exceedances of the 2016 critical mean values for pH, specific conductance, TOC, or TOX.
Figure 10-29. 216-A-36B Crib
Groundwater quality parameters monitored for the site include chloride, iron, manganese, nitrate, phenols, sodium, and sulfate. Samples for analyses of alkalinity, calcium, magnesium, and potassium are collected to support charge balance calculations for the calcium-bicarbonate-type groundwater (Table B-20). In 2016, nitrate continued to be above the DWS in all the network wells, and these levels are associated with a Central Plateau nitrate plume. Nitrate is a constituent of interest at the 216-A-36B Crib because it is a breakdown product of nitric acid, which was disposed to the nearby 216-A-10 Crib.

VOCs were monitored at the 216-A-36B Crib in 2016 to determine if previous historical intermittent low-level detections of TCE were still occurring. No statistical comparisons of upgradient and downgradient concentrations of TCE are required under the current monitoring plan. During 2016, three network wells had TCE detections: upgradient well 299-E17-19 (1.33 µg/L) and downgradient wells 299-E17-14 (0.24 µg/L to 0.94 µg/L) and 299-E17-16 (1.29 µg/L).

DOE published a revised RCRA groundwater monitoring plan for the 216-A-36B Crib in 2016 (DOE/RL-2010-93, Interim Status Groundwater Monitoring Plan for the 216-A-36B PUREX Plant Crib). The plan incorporates the current groundwater flow direction obtained from the low-gradient monitoring network, presents new geologic cross sections derived from data incorporated in the Hanford South Geoframework Model (ECF-HANFORD-13-0029, Development of the Hanford South Geologic Framework Model, Hanford Site, Washington), reviews and summarizes historical monitoring results with the relationship to changing flow directions, and updates the CSM. The updated monitoring includes adding one upgradient and one downgradient well to the current monitoring network to document variations in upgradient and downgradient constituent concentrations near the crib. The new plan will be implemented in 2017.

10.12.3 216-A-37-1 Crib

The 216-A-37-1 Crib TSD unit was located east of the 200 East Area (Figure 10-30) and was 5.2 m (17.1 ft) deep, 213 m (699 ft) long, and 33 m (108 ft) wide at the base with sides sloped at 1:1. The crib operated from March 1977 through April 1989 and was used to percolate 242-A Evaporator process condensate to the soil column. It received spent halogenated and nonhalogenated solvents and ammonia. During its operational life, this crib received 380 million L (98 million gal) of process condensate. Discharge of the evaporator process condensate to the crib continued through April 1989, when it was removed from service. In 1994, the bottom of the diversion box was filled with grout to preclude the potential for inadvertent discharges to the crib. In July 2000, vent risers from the crib were sealed to prevent potential passive radioactive emissions.

The 216-A-36B, 216-A-10, and 216-A-37-1 Cribs were monitored in a RCRA interim status groundwater quality assessment program before 2011. The 216-A-10 Crib was officially closed and removed from the Hanford RCRA Permit on March 30, 2010. Since January 2011, the two remaining cribs (216-A-36B and 216-A-37-1) continue in RCRA interim status monitoring, but under indicator evaluation programs because the groundwater constituent detected (i.e., nitrate) is not a dangerous waste or dangerous waste constituent. In 2016, one upgradient well and three downgradient wells are monitored for the 216-A-37-1 Crib (Table B-21 in Appendix B).

Figure 10-30. 216-A-37-1 Crib
Near the 216-A-37-1 Crib, the estimated groundwater flow was toward the southeast in 2016. Flow directions are influenced by a northwest-southeast-trending paleochannel with high-permeability Hanford formation sediments near the crib, the RLM at the water table east of the 200 East Area, and the higher water table elevations to the west and north. These interpretations of flow directions are supported mainly by the distribution of plumes emanating from near the crib and recent efforts to improve the accuracy of water-level measurements in the southeastern portion of the 200 East Area. The gradient magnitude for 2016 was calculated to be $6.35 \times 10^{-6}$ m/m. The estimated groundwater flow rate is between 0.0004 and 0.19 m/day (0.001 and 0.64 ft/day) (Table B-22). Ongoing gradient network evaluation near the crib will provide greater certainty in calculations of groundwater flow in this area.

Based on current groundwater flow interpretations, a revised RCRA monitoring plan for the crib was initiated in 2015 and is expected to be implemented in 2017. The revised plan incorporates the current groundwater flow direction interpreted from the low-gradient monitoring network, presents new geologic cross sections from data added to the Hanford South Geoframework Model (ECF-HANFORD-13-0029), reviews and summarizes historical monitoring results with the relationship to changing flow directions, and updates the CSM. To improve monitoring capabilities upgradient and downgradient of the crib, the updated monitoring plan includes adding an existing upgradient well and installing a new downgradient well. Although not directly downgradient, use of existing network well 299-E25-20 will continue until the new downgradient well is installed because of its proximity to the crib and its use in delineating the nitrate plume associated with 216-A-37-1. The new downgradient well is scheduled for installation in 2017.

The 216-A-37-1 Crib network wells are monitored semiannually for RCRA indicator parameters (TOC, TOX, pH, and specific conductance), temperature, and turbidity. They are also monitored annually for water quality parameters. Water-level measurements are collected semiannually. The network wells were sampled as scheduled in 2016 (Table B-23).

Analytical results for RCRA indicator parameters obtained from the 216-A-37-1 Crib network downgradient wells did not exceed the 2016 critical mean values, so the site remains in interim status indicator evaluation monitoring. A pH critical mean exceedance for upgradient well 299-E25-47 occurred during January 2016; the pH declined in July.

The groundwater quality constituents monitored include chloride, iron, manganese, phenol, sodium, and sulfate (Table B-23). Samples for analyses of alkalinity, calcium, magnesium, and potassium also are collected (Table B-24). Manganese was detected above the 50 µg/L secondary DWS in filtered and unfiltered samples from wells 299-E25-19 and 299-E25-20 in 2013 through 2016. Unfiltered iron samples for downgradient wells 299-E25-17 and 299-E25-19 were above the 300 µg/L secondary DWS in 2014 through 2016.

Elevated concentrations of iron in well 299-E25-19 correspond with increased unfiltered chromium and nickel in 2015 and 2016, associated with high turbidity and potential well casing corrosion. Chromium and nickel analysis is not a requirement of the monitoring plan, but was available from the required metals analysis. A video log of well 299-E25-19 in November 2016 documented significant well incrustation. The well was cleaned and the post-cleaning video revealed damaged well pump debris within the sump. Sampling will continue in 2017 but if the debris cannot be removed, the well will be evaluated for decommissioning and replacement.
The 216-A-29 Ditch TSD unit is just east of the 200 East Area fence line (Figure 10-31) and is planned for closure. DOE submitted an updated closure plan (DOE/RL-2008-53, Hanford Facility Dangerous Waste Closure/Postclosure Plan for the 216-A-29 Ditch) to Ecology in 2014. The site is designated a surface impoundment according to WAC 173-303-040, “Definitions.” It was placed in service in November 1955 to convey liquid effluent from the PUREX Plant chemical sewer to B Pond. Flow from the chemical sewer (low-level contaminants) was continuous, with an average volume of 3,700 L/min (970 gal/min). The 216-A-29 Ditch received continuous discharge of corrosive waste and potentially hazardous spilled chemical materials from PUREX. The most significant chemical discharges included acidic and caustic effluents from backwashing during the regeneration of demineralizer columns. From 1955 to 1986, there were daily discharges of sodium hydroxide and sulfuric acid solutions. Treatment of this waste involved the successive addition of acidic and caustic waste, which neutralized waste in the ditch. The ditch also received spills from the PUREX chemical sewer (low-level contamination).


The 216-A-29 Ditch was removed from service in 1991, partly backfilled with material from the ditch sides, and the portion of the ditch inside the 200 East Area security fence was brought to grade with clean material. The ditch outside the 200 East Area security fence was topped with clean material in a series of 11 terraces progressing down the length of the ditch. Both areas were revegetated and posted as an underground radioactive material areas.

DOE submitted an updated draft RCRA interim status detection groundwater monitoring plan for the 216-A-29 Ditch (DOE/RL-2008-58, Interim Status Groundwater Monitoring Plan for the 216-A-29 Ditch) in 2015. The new plan incorporates current groundwater flow direction data from the low-gradient monitoring network; presents new geologic cross sections derived from data incorporated in ECF-HANFORD-13-0029; reviews and summarizes historical monitoring results with regard to changing flow directions; and updates the CSM. However, this plan has not been finalized and implemented due to the site entering an assessment monitoring program.

In January 2016, the 216-A-29 Ditch was placed into a groundwater assessment program because specific conductance in wells 299-E25-32P, 299-E25-35, and 299-E25-48 exceeded the critical mean value in 2015. Initial semiannual assessment sampling was completed in April 2016 for the wells with exceedances under the assessment monitoring plan (DOE/RL-2016-23, Interim Status Groundwater Quality Assessment Monitoring Plan). Following the April sampling event, the plan was revised to include all network wells on a quarterly sampling frequency beginning in October 2016. The draft plan is undergoing Ecology review.

The current monitoring network includes three upgradient wells and seven downgradient wells (Table B-13). One additional well (299-E25-43) was sampled in October 2016 in conjunction with the network for added groundwater characterization purposes, but is not required under the monitoring plan. The average rate of water-level decline over the last 5 years for network wells was 0.030 m/yr (0.098 ft/yr). Network groundwater wells all have adequate water columns in the screened interval for representative sampling over the next decade.

Figure 10-31. 216-A-29 Ditch
Historically, when the flow direction was affected by the B Pond groundwater mound, well 699-43-45 served as an upgradient well for the 216-A-29 Ditch. With the continual flow direction shift from southwestward groundwater flow to southward and southeastward flow, this well is no longer upgradient from the ditch. Wells 299-E26-12 and 299-E26-13, which have always been included in the network, became the new network upgradient wells starting in 2011. Current 216-A-29 Ditch groundwater flow directions (Figure 10-31) were determined using the low-gradient monitoring well network, comparing upgradient and downgradient well water chemistry along different ditch segments, using fate and transport modeling (including particle tracking), and reviewing historical migration patterns of 200 East Area nitrate and sulfate plumes (specifically near the ditch from 2000 to 2015). This analysis showed that near the north end of the ditch, flow in the unconfined aquifer is to the south. At the south end of the 216-A-29 Ditch, groundwater flows to the south-southeast. Based on the most recent groundwater flow interpretation, the existing monitoring network configuration for the 216-A-29 Ditch has been updated in the current groundwater monitoring plan.

Trend surface analysis using the low-gradient well network near the 216-A-29 Ditch indicates a water table gradient of $6.11 \times 10^{-6} \text{ m/m}$ (Table B-14). The calculated average flow velocity is 0.0011 m/day (0.0036 ft/day). Influences from the Columbia River and large-volume effluent discharges at TEDF influence the gradient in the vicinity of the 216-A-29 Ditch and other 200 East Area locations (Section 9.10.3).

The network was sampled as planned in 2016 under the assessment monitoring plan (DOE/RL-2016-23). The monitoring network was sampled in April for assessment parameters at select wells and in October 2016 for assessment parameters at all network wells (Tables B-15 and B-16). The full network will be sampled quarterly for assessment parameters to assess whether dangerous waste or dangerous waste constituents are present in the groundwater and their extent and rate of migration. The assessment concerning whether dangerous waste constituents have influenced groundwater from the 219-A-29 Ditch as the result of TSD releases has not been completed. A detailed evaluation of assessment data will be included in the first determination report. In October 2016, nitrate exceeded the DWS in well 299-E25-32P and iron exceeded the secondary DWS in an unfiltered sample from well 299-E25-2.

### 10.12.5 216-B-3 Pond

The inactive 216-B-3 Pond, also known as B Pond, was located east of the 200 East Area (Figure 10-32) in a natural topographic depression. The TSD unit includes the main pond and an adjoining portion of the 216-B-3-3 Ditch. During operations, the pond covered about 14.2 ha (35 ac) with a depth up to 6.1 m (20 ft). The total estimated discharge to the pond since 1945 exceeded 10 billion L (2.6 billion gal) (PNNL-15479, *Groundwater Monitoring Plan for the Hanford Site 216-B-3 Pond RCRA Facility*).

The dangerous waste received came from three primary sources: corrosive and dangerous waste resulting from regeneration of demineralizer columns at PUREX, spills of dangerous or mixed waste from PUREX and other facilities, and off-specification chemical makeups at PUREX. The last known reportable discharge of chemical waste (sodium nitrite) occurred in 1987. In 1994, B Pond was backfilled with coarse-grained material and then covered with fine-grained material.

Figure 10-32. 216-B-3 Pond (B Pond)
DOE/RL-2008-59, Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond, provides a detailed description of the geology and hydrogeology at B Pond. In summary, because of the dipping beds of the Ringold Formation in this area and the erosional contact with the overlying Hanford formation, groundwater beneath B Pond can occur in both confined and unconfined states, depending on the location. The uppermost aquifer is unconfined west, southwest, and northwest of the main pond where the Ringold Formation confining units 8 and 9B are absent. The aquifer becomes progressively more confined to the east and southeast of the main pond. Confinement of the Ringold unit 9 aquifers to the east is supported by the fact that no hydrologic response to TEDF discharges has been observed in the TEDF wells completed in unit 9A since the facility began operating in 1995 (DOE/RL-2008-59). Figure 10-32 presents the approximate boundary of the Ringold Formation mud above the water table within the vicinity of B Pond.

Groundwater flow directions beneath B Pond range from southwest to west within the confined Ringold Formation and southwest to south within the unconfined Hanford Formation. The monitoring network defined in DOE/RL-2008-59 consists of one upgradient well and three downgradient wells, based on a groundwater flow direction to the southwest (Table B-25). The network wells are screened across the top 1.2 to 6.3 m (3.9 to 21 ft) of the aquifer. The average rate of water-level decline over the last 5 years for network wells ranged from 0.02 m/yr (0.07 ft/yr) for well 699-43-45 to 0.08 m/yr (0.25 ft/yr) for well 699-44-39B. The rate of decline varies across the network because of differences in hydrogeology. The network wells have adequate water in the screened interval for representative sampling over the next decade. The 2016 estimated flow rate in the Ringold Formation is 0.0056 m/day (0.018 ft/day) to the southwest (Table B-26).

In accordance with WAC 173-303-400 and 40 CFR 265.92, the B Pond network wells are monitored semiannually for RCRA indicator parameters (TOC, TOX, pH, and specific conductance). TOC, pH, and specific conductance did not exceed their critical means in 2016 (Table B-27). TOC was detected at 1,300 μg/L in well 699-43-44 in July 2016, but the quadruplicate sample average was below the 1,126 μg/L critical mean. All other individual TOC results for the network during 2016 were below the critical mean value. Due to the number of nondetects in upgradient well 699-44-39B, no 2016 TOX critical mean was calculated. In lieu of a TOX critical mean, sampling results were compared to the laboratory TOX LOQs, and no TOX concentrations exceeded the LOQs.

Groundwater quality constituents monitored for the site include chloride, iron (unfiltered), manganese (unfiltered), phenols, sodium (unfiltered), and sulfate (Table B-27). These constituents were below their DWSs in 2016. Table B-28 lists other required monitoring plan (DOE/RL-2008-59) constituents.

A draft, updated RCRA groundwater monitoring plan for B Pond was prepared in 2015. The new plan incorporates current groundwater flow direction data, presents new geologic cross sections derived from data incorporated in the Hanford South Geoframework Model (ECF-HANFORD-13-0029), reviews and summarizes historical monitoring results with respect to changing flow directions, updates the CSM, and adds existing upgradient well 699-45-42. The new monitoring plan proposes a new well near the upgradient facility boundary in 2017. The proposed upgradient well will replace well 699-45-42. This new monitoring plan is scheduled for implementation in 2017.

10.12.6 Integrated Disposal Facility

The IDF is an expandable, double-lined landfill with 0.07 km² (0.027 mi²) of liner. It includes two distinct cells: an east cell for low-level radioactive waste and a west cell for mixed waste. It is not yet in use.
Construction of the first phase for IDF was completed in April 2006. DOE submitted a Part B RCRA Permit application to Ecology, which was incorporated into the Hanford RCRA Permit on April 9, 2006. The start date for IDF operations has not been determined, but it is monitored as part of a detection monitoring program described in Section III.11.E.1.b of 10-EMD-0080, Enclosure 1, “Class 1 Modifications to the Hanford Facility Resource Conservation and Recovery Act Permit, Quarter Ending June 30, 2010.”

Based on the current southeast groundwater flow direction, the monitoring network consists of one upgradient well, two cross-gradient wells, and four downgradient wells (Figure 10-33; Table B-40 in Appendix B). Since IDF is not operational, the current monitoring objective is to collect baseline groundwater information. All network wells were sampled as scheduled during 2016.

Groundwater modeling was conducted in 2000 (PNNL-13400, Groundwater Flow and Transport Calculations Supporting the Immobilized Low-Activity Waste Disposal Facility Performance Assessment) to support an assessment of flow and transport conditions during future IDF use and to assist in positioning wells for the monitoring network. The early modeling results indicated a southeast flow direction. Beginning in 2008, data collection efforts were started to improve the accuracy of water-level measurements, so flow direction beneath the PUREX cribs and IDF could be evaluated in greater detail (Section 3.2 of DOE/RL-2011-01).

The groundwater flow direction in 2016 was east-southeast with an estimated flow rate of 0.0021 to 0.0023 m/day (0.0069 to 0.0077 ft/day) (Table B-41). In recent years, the flow direction has varied from east-northeast (2008-2011) to southeast (2013-2014). Based on current groundwater flow interpretations, the monitoring network is considered adequate.

The wells are monitored annually for indicator parameters chromium (filtered), pH, specific conductance, TOC, and TOX (Table B-42). In addition, monitoring includes supplemental constituents alkalinity, anions, metals, and turbidity (Tables B-43 and B-44). No upgradient/downgradient comparisons of indicator parameters are required because IDF is not in use. Concentrations of the indicator parameters in 2016 were within historical ranges. An increase of unfiltered chromium, nickel, and iron were detected in well 299-E18-1, consistent with well casing corrosion products. The well is scheduled for video logging, cleaning, and continued sampling in 2017. If indications of corrosion persist, the well will be evaluated for decommissioning and replacement. Ecology, DOE, and EPA negotiate replacement wells annually under Tri-Party Agreement Milestone M-24-00. Beginning in 2017, RCRA monitoring networks, including IDF, will be assessed for adequacy of TSD monitoring. The assessment will be completed via engineering evaluation processes, and conclusions of the assessments will guide selection of new and replacement well locations.

Nitrate concentrations in 2016 were above 45 mg/L in five IDF wells, consistent with the 2015 monitoring results. Changes in the plume configuration and trends at individual wells indicate nitrate is slowly migrating to the southeast, consistent with the flow direction calculated from trend surface analyses of water level measurements. The maximum 2016 nitrate concentration was 66.4 mg/L in well 299-E17-22 (Table B-43). Wells that monitor IDF are within the regional 200 East Area nitrate plume.

Figure 10-33. IDF
10.12.7 Nonradioactive Dangerous Waste Landfill

The NRDWL is a TSD unit southeast of the 200 East Area next to the Solid Waste Landfill (SWL) (Figure 10-34). This landfill has an area of 0.045 km² (0.017 mi²) and consists of 19 parallel unlined trenches, each about 122 m (400 ft) long, 4.9 m (16 ft) wide at the base, and 4.6 m (15 ft) deep. It received chemical, asbestos, and nonhazardous waste from 1975 to 1985.

The objective of RCRA monitoring at NRDWL is to determine if dangerous waste constituents from the landfill have contaminated groundwater (40 CFR 265.92, as referenced by WAC 173-303-400) through an interim status indicator evaluation monitoring program. The well network and associated monitoring constituents for the first 2016 semiannual event are described in PNNL-12227, Groundwater Monitoring Plan for the Nonradioactive Dangerous Waste Landfill, and associated interim change notice (PNNL-12227-ICN-1, Interim Change Notice to the Groundwater Monitoring Plan for the Nonradioactive Dangerous Waste Landfill).

Several years ago, DOE began to install additional monitoring wells at NRDWL to replace wells that were predicted to go dry. New far-field upgradient well 699-26-38 was completed in 2014 and downgradient replacement wells 699-26-33A and 699-25-34F were installed in 2015. The original and replacement wells were co-sampled beginning in October 2015, but the new wells were not formally incorporated into the network until October 2016 when a revised monitoring plan (DOE/RL-2015-32, Groundwater Monitoring Plan for the Nonradioactive Dangerous Waste Landfill) was implemented. This revised plan added the newly installed wells, incorporated the most current groundwater flow direction data obtained from the low-gradient monitoring network, presented new geologic cross sections derived from data incorporated in the Hanford South Geoframework Model (ECF-HANFORD-13-0029), reviewed and summarized historical monitoring results with the relationship to changing flow directions, and updated the CSM. DOE/RL-2015-32 was the applicable monitoring plan for the October 2016 sampling event. Table B-64 in Appendix B lists the current NRDWL monitoring network wells.

Data compiled in 2016 and used for trend surface analysis indicate an east-southeast flow direction and a hydraulic gradient of $3.1 \times 10^{-5}$ m/m (Table B-65). This flow direction generally agrees with the southeast flow direction inferred from historical plume migration in this area and hydraulic head differences in the NRDWL/SWL area compared to the 200 East Area. The NRDWL well network continues to be located appropriately to accomplish the objectives of the interim status indicator evaluation program.

NRDWL wells were monitored semiannually for RCRA indicator parameters (TOC, TOX, pH, and specific conductance) and site-specific contaminants (VOCs and nitrate) under the PNNL-12227 plan through April 2016. The wells were also monitored annually for water quality parameters chloride, iron, manganese, phenols, sodium, and sulfate (Table B-66). Changes to the required analytical suite under the new monitoring plan include removing 1,4-dichloroethane and adding alkalinity, calcium, magnesium, and potassium as site-specific parameters (Table B-67).

Critical mean values for both the new and old monitoring networks were calculated and presented in ECF-Hanford-16-0015, Calculation of Critical Means for Calendar Year 2016 RCRA Groundwater Monitoring. New upgradient well 699-26-38 was used for the 2016 data evaluation.

Figure 10-34. NRDWL
The new upgradient well 699-26-38 and downgradient wells 699-25-34F and 699-26-33A have been sampled semiannually since installation. The sampling requirements were updated to include 40 CFR 265.92 Appendix III drinking water quality parameters in addition to indicator parameters and site-specific contaminants for quarterly sampling for 1 year while incorporating the wells into the network (Table B-68). Quarterly sampling of new well 699-26-38 began in April 2016, and quarterly sampling of 699-25-34F and 699-26-33A began in October 2016. These three new network wells will be sampled quarterly for the required analysis until data from four consecutive quarters of analysis are collected.

Iron and manganese exceeded secondary DWSs in 2016 unfiltered samples from some wells (Table B-66). These constituents are associated with iron-reducing bacteria growth and well casing corrosion.

The NRDWL wells were sampled as scheduled in 2016. The April 2016 TOC results indicated an exceedance of the critical mean value for replacement wells 699-25-34F and 699-26-33A. Confirmation sampling results documented the absence of a TOC exceedance, but follow-up well inspection activities identified the presence of iron-reducing bacteria in the wells. The well casings and pump system components were subsequently cleaned. The well cleaning activities corresponded with scheduled gyroscopic survey of the NRDWL wells, which included the replacement wells and wells 699-24-34D, 699-24-34E, 699-24-36, 699-26-38, and 699-26-35C. These wells were additionally cleaned after the gyroscopic surveys were complete. The October 2016 event documented background concentrations of TOC within the cleaned wells including the replacement wells.

Specific conductance initially exceeded the critical mean value at NRDWL in February and March 2001 in wells 699-25-34A and 699-25-34B. A groundwater assessment evaluation was completed in June 2001 (01-GWVZ-025, “Results of Assessment at the Non-Radioactive Dangerous Waste Landfill [NRDWL]”). The assessment attributed the increase of specific conductance to nondangerous waste constituents bicarbonate (alkalinity), sulfate, calcium, and magnesium, which were interpreted to be a result of documented disposal of sewage at the adjacent SWL. The sewage disposal caused an increase of carbon dioxide vapor in the vadose zone from the breakdown of the organic carbon, affecting groundwater chemistry and increasing specific conductance.

In October 2016, TOC exceeded its critical mean in wells 699-25-34B and 699-26-38, and specific conductance exceeded the critical mean in well 699-25-34B. Because iron-reducing bacterial growth can affect TOC and specific conductance, the wells were cleaned prior to confirmation sampling to reduce the potential for false-positive results. The wells were resampled, and TOC was at background concentrations in both wells. Results for specific conductance were above the critical mean and consistent with historic values. DOE notified Ecology of the exceedance on January 31, 2017 (17-AMRP-0089, “Notification of Exceedance of Critical Mean Values for Specific Conductance”).

The 2016 groundwater monitoring results for NRDWL and SWL continue to indicate the area of highest specific conductance to be within the southern portion of SWL. The area of impact extends upgradient and downgradient of the landfills (Figure 10-35).

Deep, upgradient well 699-26-35C had elevated concentrations of TOC in April 2015 (up to 2,000 µg/L) consistent with a trending increase since 2012. Subsequent to cleaning, the October 2016 event documented concentrations of TOC in well 699-26-35C consistent with background for the network (532 µg/L).
Figure 10-35. October 2016 Specific Conductance Plume at NRDWL and SWL
Low-level detections of PCE, 1,1,1-trichloroethane, TCE, and chloroform, which are site-specific constituents of concern required in the groundwater monitoring plan, were noted in 2016. Low-level detections of acetone, methylene chloride, and toluene were noted in 2016 and are supplementary data reviewed and provided through laboratory method based analysis of volatile organic compounds. The following tentatively identified compounds (TICs) were identified in October 2016: 2-butanol, 2-propanol, acrolein, hexamethyldisiloxane, methyl methacrylate, octamethylcyclotetrasiloxane, trans-1,3-dichloropropene, and trichloromonofluoromethane. All detected constituent concentrations were “J” qualified by the analytical laboratories, except for acetone (699-26-33A), toluene (wells 699-26-35A and 699-26-35C), and the TIC 2-propanol (wells 699-26-33A and 699-26-34B). The laboratory “J” flag indicates that the value is estimated, the detection is uncertain, and the value reported is less than the practical quantitation limit but greater than or equal to the method detection limit.


The SWL is located south of and adjacent to the NRDWL (Figure 10-36). The landfill is regulated by Ecology in accordance with WAC 173-350, which requires monitoring of leachate, soil gas, and groundwater. Annual reporting for the SWL is additionally presented by MSA in DOE/RL-2015-21, Hanford Site Solid Waste Landfill Annual Monitoring Report October 2015 through September 2016). The information presented in this subsection is derived from DOE/RL-2015-21 and is modified to provide groundwater sampling data for CY 2016.

In 2016, sampling events were completed in January and April under the monitoring plan (PNNL-13014, Groundwater Monitoring Plan for the Solid Waste Landfill) issued in 2000. Sampling was completed quarterly, as required by WAC 173-304, “Minimum Functional Standards for Solid Waste Handling,” as part of the overall Hanford Site groundwater monitoring project. During 2016 and following the April event, a revised groundwater monitoring plan was implemented for the SWL. The new groundwater monitoring plan (DOE/RL-2015-33, Groundwater Monitoring Plan for the Solid Waste Landfill) is designed to meet the current governing regulation WAC 173-350. Compliance is determined by comparing results from downgradient monitoring wells with statistically derived background threshold values (BTVs) from upgradient wells.

Table 10-2 provides a summary of current network wells. Changes to the network have occurred in 2016 due to installation of replacement wells and revisions incorporated in the revised groundwater monitoring plan (Table 10-3). Figure 10-36 shows the SWL groundwater monitoring wells and network wells that have been replaced during the last few years.
Figure 10-36. 200-PO WAC Facility SWL Monitoring Well Locations
### Table 10-2. SWL Monitoring Well Network Changes

<table>
<thead>
<tr>
<th>Well Number</th>
<th>Monitoring Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upgradient Groundwater Monitoring Wells</strong></td>
<td></td>
</tr>
<tr>
<td>699-24-35</td>
<td>Active</td>
</tr>
<tr>
<td>699-26-35A</td>
<td>Active (removed under <a href="#">DOE/RL-2015-33</a>)</td>
</tr>
<tr>
<td>699-24-36a</td>
<td>Active</td>
</tr>
<tr>
<td><strong>Downgradient Groundwater Monitoring Wells</strong></td>
<td></td>
</tr>
<tr>
<td>699-22-35</td>
<td>Active</td>
</tr>
<tr>
<td>699-23-34B</td>
<td>Active</td>
</tr>
<tr>
<td>699-23-34A</td>
<td>Inactive – sample dry&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>699-24-34A</td>
<td>Active – going sample dry&lt;sup&gt;b&lt;/sup&gt; (removed under <a href="#">DOE/RL-2015-33</a>)</td>
</tr>
<tr>
<td>699-24-34D&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Active – replaces 699-24-34A</td>
</tr>
<tr>
<td>699-24-34B</td>
<td>Inactive – going sample dry&lt;sup&gt;b&lt;/sup&gt; (removed under <a href="#">DOE/RL-2015-33</a>)</td>
</tr>
<tr>
<td>699-24-34E&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Active – replaces 699-24-34B</td>
</tr>
<tr>
<td>699-24-33 (deep well)</td>
<td>Active – nonstatistical use well</td>
</tr>
<tr>
<td>699-24-34C</td>
<td>Inactive – sample dry&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>699-25-34C</td>
<td>Inactive – sample dry&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>699-25-34E</td>
<td>Active – replaces 699-24-34C and 699-25-34C</td>
</tr>
</tbody>
</table>


- b. Sample dry means insufficient water available in well to permit sample collection.
# Table 10-3. Main Differences between DOE/RL-2015-33 and PNNL-13014

<table>
<thead>
<tr>
<th>Type of Change</th>
<th>PNNL-13014 Plan</th>
<th>DOE/RL-2015-33 Revised Plan</th>
<th>Summary of Plan Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constituents</td>
<td>WAC 173-304-490 constituents and site-specific constituents</td>
<td>WAC 173-350-500(4)(h)(i) and (ii) constituents and site-specific constituents</td>
<td>Constituents updated to requirements in WAC 173-350-500</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total coliform is retained as a site-specific constituent due to previous sewage disposal at SWL.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Chloroform is added as a site-specific constituent based on past leachate and groundwater detections.</td>
</tr>
<tr>
<td>Sampling frequency</td>
<td>Quarterly for WAC 173-304-490 required parameters and site-specific parameters</td>
<td>Semiannually for WAC 173-350-500 required parameters and site-specific parameters</td>
<td>Semiannual sampling frequency for required parameters is appropriate as landfill operations ceased in 1996 and parameter concentrations are relatively stable.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Site-specific VOC concentrations have decreased over time and are now stable at nondetect or low concentrations.</td>
</tr>
<tr>
<td>Well network</td>
<td>Eight downgradient and two upgradient wells</td>
<td>Six downgradient and two upgradient wells</td>
<td>Wells 699-23-34A, 699-24-34C, and 699-25-34C are sample dry and are removed from the network; new downgradient well 699-25-34E added to the network.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Upgradient well 699-26-35A monitors NRDWL and is removed from the network; well 699-24-36 directly upgradient of SWL is added to the network.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Downgradient wells 699-24-34A and 699-24-34B are going dry and are replaced by wells 699-24-34D and 699-24-34E.</td>
</tr>
<tr>
<td>Groundwater flow direction</td>
<td>Southeast</td>
<td>No change</td>
<td>N/A</td>
</tr>
<tr>
<td>Type of groundwater monitoring program</td>
<td>Detection level</td>
<td>No change</td>
<td>N/A</td>
</tr>
<tr>
<td>Background summary statistics</td>
<td>Tolerance intervals</td>
<td>No change</td>
<td>N/A</td>
</tr>
</tbody>
</table>

References: [PNNL-13014](#), *Groundwater Monitoring Plan for the Solid Waste Landfill*.  
N/A = not applicable
10.13.1 Differences between Previous and Current Plans

An additional upgradient well (699-24-36) and a new well to replace the downgradient dry well 699-25-34C were initially proposed in DOE/RL-2010-28, *Groundwater Monitoring Plan for the Nonradioactive Dangerous Waste Landfill and Solid Waste Landfill*, as a portion of the final status closure plan. Subsequently, downgradient well 699-24-34C has also become sample dry. The additional upgradient well 699-24-36 and new downgradient well 699-25-34E, which replaces wells 699-24-34C and 699-25-34C, were completed in early 2014. Sampling of well 699-25-34E began in October 2014. Additional replacement wells 699-24-34E and 699-24-34D were drilled in 2015 in anticipation of wells 699-24-34B and 699-24-34A going sample dry. Replacement wells 699-24-34E and 699-24-34D were integrated into the network in October 2015 for comparative sampling and evaluation against the adjacent wells being replaced. The network changes were initiated under PNNL-13014 and have been incorporated into DOE/RL-2015-33. Tables 10-2 and 10-3 summarize changes to the network and the monitoring plans, respectively.

As presented in DOE/RL-2015-33, during the first year of use, field parameters and geochemical indicator parameters at the replacement wells (699-24-34D and 699-24-34E) and the new upgradient well (699-24-36) will be sampled quarterly until 1 year of consecutive quarterly analytical data are collected. Under the new plan, the remainder of the network wells have changed from quarterly to semiannual sampling. The semiannual frequency was implemented after the April 2016 event, with the first event completed in October 2016. Under this revised schedule, with the exception of the new wells, sampling for the network was not completed for the entire network during the third quarter of 2016. As upgradient well 699-24-36 and downgradient wells 699-24-34D and 699-24-34E have been added to the network, quarterly sampling was completed for geochemical indicator parameters, field parameters, and site-specific constituents as presented in DOE/RL-2015-33. Quarterly sampling of these three wells began in July 2016, with the exception of coliform, which began in October 2016.

10.13.2 Sampling Results

The results of the leachate, soil gas, and groundwater monitoring are reported annually in a separate report prepared by MSA (DOE/RL-2015-21). The following paragraphs provide a summary of groundwater monitoring results.

The results of groundwater sampling are evaluated to determine whether concentrations of any of the sampled constituents have increased significantly over established BTV and/or the groundwater quality criteria (GWQC) or MCL. BTVs have been calculated under PNNL-13014. Revised BTVs are additionally being calculated for applicable constituents under DOE/RL-2015-33 and will be presented in ECF-200PO1-16-0144, *Calculation of Background Threshold Values (BTVs) for the Solid Waste Landfill (SWL) through CY 2016*. Samples collected in July and October 2016 have been evaluated against published BTVs calculated under PNNL-13014 and/or the GWQC or MCL consistent with the January and April 2016 events.

Groundwater monitoring results for the analytes listed in the sampling plans are detailed in Tables B-94 through B-97 in Appendix B. The results are summarized below.

10.13.2.1 Ammonium

Ammonium is a WAC 173-304-490 requirement, but is not required under WAC 173-350 and has not been maintained as a sampled constituent under DOE/RL-2015-33. Ammonium was sampled only during the January and April events in 2016.
In 2016, ammonium exceeded the BTV of 90 µg/L established for ammonium ion during one sampling event in wells 699-24-34D, 699-24-34B, and 699-24-33. Concentrations at the SWL ranged from less than 10.7 µg/L (nondetect) to 236 µg/L (699-24-34D). Historically, ammonium has been detected intermittently and had previously exceeded the BTV one time in well 699-24-34A in 2009. Laboratory blank contamination was documented for the two elevated concentrations reported in well 699-24-33.

10.13.2.2 Chemical Oxygen Demand
Chemical oxygen demand (COD), a WAC 173-304-490, “Ground Water Monitoring Requirements,” requirement, is not required under WAC 173-350 and has not been maintained as a sampled constituent under DOE/RL-2015-33. Sampling for COD was completed only during the January and April events in 2016.

In 2016, COD ranged from less than 1.1 mg/L (nondetect) to less than 6.67 mg/L (nondetect) in downgradient wells. An anomalously high value of 100 mg/L was detected in downgradient well 699-24-34B during the January 2016 event, but has been flagged as a suspect data point. Results for well 699-24-34B during the subsequent April 2016 event were nondetect. Since sampling began per PNNL-13014 in January 2001, chemical oxygen demand has exceeded the BTV intermittently in all downgradient network wells and in both of the upgradient wells (699-24-35 and 699-26-35A).

10.13.2.3 Chloride
Chloride concentrations detected in 2016 ranged from 5.90 to 7.90 mg/L in downgradient wells. Well 699-25-34E exceeded the BTV of 7.82 mg/L in the April sampling event. Since the current sampling plan was implemented at the SWL in 2001, chloride has exceeded the BTV intermittently in all 10 of the network wells utilized prior to installation of new and replacement wells in 2014 and 2015.

10.13.2.4 Coliform Bacteria
Coliform bacteria concentrations in 2016 ranged from less than 1 colony/100 mL (nondetect) to 2,420 colonies/100 mL. Coliform bacteria were detected above the BTV (1 colony/100 mL) in downgradient wells 699-22-35, 699-23-34B, 699-24-34D, and 699-24-34E. Well 699-24-34E had the maximum detected concentration in 2016 of 2,420 colonies/100 mL.

10.13.2.5 Iron (Filtered)
In 2016, dissolved (filtered) iron concentrations ranged from less than 12.8 µg/L (nondetect) to a maximum of 65.5 µg/L in well 699-24-34B. All network wells were below the BTV of 160 µg/L.

10.13.2.6 Manganese (Filtered)
Dissolved (filtered) manganese concentrations ranged from less than 0.7 µg/L (nondetect) to 160 µg/L in the SWL wells. Wells exceeding the BTV of 18 µg/L included replacement wells 699-24-34D (160 µg/L) and 699-24-34E (19.8 µg/L), and new upgradient well 699-24-36 (41.2 µg/L) during the October 2016 event. Prior to the October 2016 event concentrations of dissolved manganese in the SWL, wells have never been detected above the BTV since implementation of PNNL-13014 in 2001. In September 2016 prior to sampling, the new SWL wells and additional wells at the adjacent NRDWL RCRA TSD unit were gyroscopically surveyed and cleaned with hydrogen peroxide. Treatment of the wells with hydrogen peroxide was completed to sterilize the well and reduce future bacterial growth. After the wells were treated with hydrogen peroxide, both the SWL and NRDWL networks were sampled in October 2016. All wells that had been treated at both networks were identified as having elevated dissolved manganese concentrations. In contrast, all wells at both the SWL and NRDWL networks that had not been treated were noted as having dissolved manganese concentrations on trend with historic values and at or near nondetect.
Manganese dioxide (pyrolusite) is a stable, insoluble, and naturally occurring mineral in the environment, including at the Hanford Site. Manganese dioxide is additionally a catalyst for the decomposition of hydrogen peroxide. The presence of dissolved manganese is directly correlated with the treatment of the wells with hydrogen peroxide and is not associated with a release of manganese from the SWL.

Dissolved manganese concentrations for the new SWL wells sampled in January 2017 were 3.39 µg/L at well 699-24-36, 12.8 µg/L at well 699-24-34D, and 5.64 µg/L at well 699-24-34E. These concentrations are below the BTV value and represent a return to concentrations consistent with historic data trends for the network.

10.13.2.7 Nitrate
In 2016, nitrate was detected at concentrations ranging from 12 to 20.4 mg/L. Since 2001, the highest nitrate concentration detected in the SWL well network has been 20.4 mg/L at well 699-24-34A during the January and April 2016 events. The detected concentrations have been below the BTV of 29.0 mg/L. The SWL is near the southwestern extent of the historical elevated nitrate concentrations that once emanated from 200 East Area sources into the 200-PO far-field area. Concentrations of nitrate detected in the SWL have been consistent with the far-field interpretation of nitrate groundwater impacts.

10.13.2.8 Nitrite
In 2016, nitrite was detected at concentrations ranging from nondetect to 154 µg/L and below the BTV of 266 µg/L. Results for all downgradient SWL wells in 2016 were nondetect. Nitrate was detected at 145 µg/L at well 699-24-35 and 154 µg/L at well 699-24-36 in October 2016. Since sampling began per the 2001 sampling plan, nitrite has exceeded the BTV intermittently in seven of the current eight network wells, including both of the upgradient wells (699-24-35 and 699-26-35A).

10.13.2.9 pH Measurements
In 2016, pH measurements ranged from 6.52 (699-24-34D) to 7.68 (699-24-36) in downgradient wells. The pH measurements did not exceed the upper-bound BTV of 7.84. The pH measurements were less than the lower-bound BTV of 6.68 in the January quarterly samples from wells 699-24-34A, 699-24-34B, 699-24-34D, and 699-24-34E. Historically, pH measurements have exceeded the lower bound of the BTV intermittently in 6 of the 10 historical network wells, including upgradient well 699-24-35, and have only been detected once above the upper-bound BTV in well 699-25-34C in 2003.

10.13.2.10 Specific Conductance
In 2016, specific conductance was field measured at concentrations ranging from 604 µS/cm (699-24-34D) to 767 µS/cm (699-22-35) in downgradient wells. In 2016 (as in 2013 through 2015), all six downgradient wells exceeded the specific conductance BTV of 583 µS/cm. Three downgradient wells in 2016 had measurements above the 700 µS/cm limit of WAC 246-290-310, “Maximum Contaminant Levels (MCLs) and Maximum Residual Disinfectant Levels (MRDLs).” Specific conductance measurements in upgradient wells were below the BTV. Elevated specific conductance is principally caused by an increase of bicarbonate concentration in the groundwater at the SWL (Section 3.4 of DOE/RL-94-143, Corrective Action Plan for the Hanford Site Solid Waste Landfill). Since sampling began per the current sampling plan in 2001, specific conductance has exceeded the BTV intermittently in eight of the nine historical and current downgradient network wells and two upgradient wells (699-24-35 and 699-26-35A).
10.13.2.11 Sulfate
Sulfate ranged in concentration from 39.0 to 46.0 mg/L during 2016. No exceedances to the sulfate BTV of 47.2 mg/L occurred in any network wells. Since 2000, sulfate has intermittently exceeded the BTV in 9 of 10 historical and current network wells.

10.13.2.12 Temperature
In 2016, temperature measurements exceeded the BTV of 20.7°C (69.3°F) in downgradient wells 699-24-33 (22.1°C), 699-24-34D (21.6°C), and 699-24-34E (21.2°C), as well as upgradient well 699-26-35A (21.9°C). Since 2000, the temperature has additionally been measured one time above the BTV in downgradient wells 699-24-33 and 699-24-34B, two times in 699-23-34B and 699-24-34A, and three times in 699-22-35.

10.13.2.13 Total Organic Carbon
TOC concentrations ranged from less than 155 (not detected) to 994 µg/L in 2016. TOC did not exceed the BTV of 1,200 µg/L. Since 2000, TOC has been detected multiple times above the BTV in both upgradient and downgradient network wells.

10.13.2.14 Zinc (Filtered)
In 2016, dissolved zinc concentrations ranged from less than 3 µg/L (not detected) to 40 µg/L, all below the BTV of 42.3 µg/L. Since 2000, dissolved (filtered) zinc has not been detected above the BTV of 42.3 µg/L.

10.13.2.15 Site-Specific Parameters
Additional site-specific parameters monitored for the SWL include filtered arsenic and VOCs (1,1-dichloroethane, 1,2-dichloroethane, 1,4-dioxan, 1,4-dichlorobenzene, 1,1,1-trichloroethane, carbon tetrachloride, PCE, and TCE). Subsequent to the April 2016 event and implementation of the revised groundwater monitoring plan, chloroform was added to the site-specific VOC analysis.

Filtered arsenic concentrations at the SWL in 2016 ranged from nondetect to 5.14 µg/L (699-24-36). The Hanford Site groundwater background value for arsenic is 11.8 µg/L (Table 1-5).

Four site-specific VOCs (PCE, TCE, chloroform, and 1,1,1-trichloroethane) were detected in samples at low concentrations that were “J”-qualified by the laboratory in 2016. Detected concentrations ranged from 0.15(J) to 1.11(J) µg/L. Detections occurred at both upgradient and downgradient wells. The laboratory “J” flag indicates that the value is estimated and the detection is uncertain, and the value reported is less than the practical quantitation limit but greater than or equal to the MDL.

Since 2000, a total of 20 VOCs have been detected in samples collected from the SWL monitoring network. Five of the VOCs (1,1,1-trichloroethane, 1,1-dichloroethane, chloroform, PCE, and TCE) have been detected most frequently. A large number of the detections were “J”-qualified values. Concentrations of these five primary VOCs have generally remained at low levels or decreased since sampling began in 2000 (e.g., 1,1,1-trichloroethane).

10.13.3 Water-Level and Well Network Evaluation
From 2011 to September 2016, efforts were undertaken to improve the accuracy of the water-level measurements and resulting estimates of groundwater gradient near the NRDWL and SWL. The efforts included vertical offset surveys of well casings, high-resolution water-level measurements, and consideration of barometric effects.
In 2016, vertical offset surveys were completed on additional SWL and adjacent NRDWL monitoring wells. As reported in Section 2.15 of DOE/RL-2016-66, data compiled in 2016 and used for trend surface analysis indicate an east-southeast flow direction and a hydraulic gradient of $3.1 \times 10^{-5}$ m/m. This flow direction generally agrees with the southeast flow direction inferred from historical plume migration in this area and hydraulic head differences in the NRDWL/SWL area compared to the 200 East Area.

### 10.14 Atomic Energy Act Monitoring

AEA monitoring for the 200-PO interest area is implemented through the AEA SAP (DOE/RL-2015-56). Additional AEA monitoring is described in RPP-PLAN-26534, Integrated Disposal Facility Operational Monitoring Plan to Meet DOE Order 435.1. AEA monitoring specific to 200-PO is additionally implemented by the CERCLA SAP (DOE/RL-2003-04) as amended by TPA-CN-205.

#### 10.14.1 Sitewide Sampling Plan

AEA groundwater monitoring was conducted at 26 groundwater wells and aquifer tubes in the 200-PO groundwater interest area in accordance with the SAP issued in December 2015 (DOE/RL-2015-56). The primary AEA constituents for 200-PO are tritium, iodine-129, nitrate, strontium-90, technetium-99, and uranium. Eight wells were not sampled in accordance with SAP requirements in 2016 (Table C-9 in Appendix C). Minor exceptions to planned monitoring occurred because of maintenance issues and scheduling constraints. Appendix C lists the sampling frequencies, types of laboratory analyses, and sample status for 2016 AEA monitoring of the 200-PO groundwater wells.

Concentrations of radionuclides in groundwater samples from 26 wells were used to estimate the cumulative TED and to compare the cumulative beta/photon emitters, alpha emitters, and uranium mass to DWSs, as described in Section 1.2.4. The estimated TED did not exceed the 100 mrem/yr standard at any locations in 200-PO. No DWSs for cumulative alpha emitters were exceeded, nor was the uranium mass DWS of 30 µg/L exceeded, but three locations exceeded the EPA activity level for net alpha of 15 pCi/L. The cumulative drinking water dose from beta/photon emitters exceeded the 4 mrem/yr standard at 67 locations in this interest area (Table 10-4). One of these locations, aquifer tube C6353, is adjacent to the Columbia River, which is the primary potential pathway for offsite exposure to Hanford Site contaminated groundwater. Members of the public are protected from exposure to groundwater in 200-PO through the implementation of institutional controls that restrict access to groundwater.

<table>
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<th>Monitoring Location/Well Name</th>
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Table 10-4. Cumulative Total Effective Doses and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 200-PO in 2016

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<th>Monitoring Location/Well Name</th>
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Source: ECF-HANFORD-17-0022, Calculation of Radiological Dose based on Calendar Year 2016 Atomic Energy Act Groundwater Monitoring at Hanford.

Notes: No wells in 200-PO had total effective dose $\geq 100$ mrem/yr, cumulative alpha activity $\geq 15$ pCi/L, or cumulative uranium mass $\geq 30$ µg/L.

Blank cells indicate no exceedances.

10.14.2 400 Area

The 400 Area is located 16.2 km (10.1 mi) southeast of the 200 East Area. The 400 Area includes the Fast Flux Test Facility, ancillary facilities, and waste sites. Monitoring is conducted to provide information on the potential impact of sitewide contamination (primarily tritium, nitrate, and iodine-129) on the water supply wells, which provide drinking water and emergency supply water for the 400 Area (Chapter 7 of DOE/RL-2014-52, Hanford Site Environmental Report for 2014). Specific AEA monitoring that is part of the CERCLA SAP (DOE/RL-2003-04; TPA-CN-205) includes monitoring of three water supply wells (499-S1-8J, 499-S0-7, and 499-S0-8) in the 400 Area (Figure 10-37). Well 499-S1-8J is the main water supply well, but occasionally wells 499-S0-7 and 499-S0-8 are used for water supply.

The wells have been sampled annually since 2009 for AEA monitoring, including gamma scan, gross alpha, gross beta, iodine-129, strontium-90, technetium-99, and tritium, as well as additional analytes including ammonium, anions, metals (including uranium), and VOCs. However, due to severe weather conditions, sampling of these three wells was delayed and not conducted as scheduled in 2016. The wells are scheduled for sampling in 2017.

10.14.3 Integrated Disposal Facility

The IDF consists of an expandable, double-lined landfill with approximately 0.07 km$^2$ (0.027 mi$^2$) of liner area. The landfill is divided into two distinct cells: (1) the east cell for the disposal of low-level radioactive waste, and (2) the west cell for the disposal of mixed waste. The landfill is not yet in use. It is a permitted RCRA facility (Section 10.12.6) and has additional groundwater sampling requirements under the AEA, as described in RPP-PLAN-26534. The plan describes sampling of two upgradient wells (299-E18-1 and 299-E24-24) and five downgradient wells (299-E17-22, 299-E17-23, 299-E17-25, 299-E17-26, and 299-E24-21) semiannually for gross alpha, gross beta, iodine-129, and technetium-99. Based on the current southeast groundwater flow direction, the monitoring network configuration includes one upgradient well (299-E24-24), two cross-gradient wells (299-E18-1 and 299-E24-21), and four downgradient wells (299-E17-22, 299-E17-23, 299-E17-25, and 299-E17-26).

Gross alpha was detected in wells 299-E17-22, 299-E17-23, 299-E17-26, 299-E24-21, and 299-E24-24 at concentrations ranging from 2.38 pCi/L at 299-E17-22 to 10.1 pCi/L at 299-E24-21. Gross beta was detected in all of the wells at concentrations ranging from 5.56 pCi/L (299-E18-1) to 50.1 pCi/L (299-E24-21) and corresponds to technetium-99 levels. Iodine-129 was undetected except in wells 299-E17-22 (0.541 pCi/L) and 299-E17-23 (0.733 pCi/L). Technetium-99 concentrations ranged from nondetect (299-E17-23, 299-E17-26, and 299-E18-1) to 78.1 pCi/L (299-E24-21).
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