15.0 Confined Aquifers

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This chapter describes groundwater flow and groundwater quality in confined aquifers within the Ringold Formation and in confined aquifers present in the upper portion of the Columbia River Basalt Group. The information provided in this chapter covers the period from January 1, 2010, through December 31, 2010.

A confined aquifer in the Ringold Formation exists beneath much of the Hanford Site, including the 100 and 300 Areas, but it has been described only for the 200 Area of the Central Plateau because only a few wells are completed in this aquifer outside of the Central Plateau. The upper basalt-confined aquifer system has also been identified beneath much of the Hanford Site, but it is monitored only in the area where intercommunication with the unconfined aquifer has been shown to occur, primarily south of Gable Butte and Gable Mountain. Figure 2-2 in Chapter 2.0 depicts the stratigraphy associated with the various aquifers beneath the Hanford Site.

Intercommunication between the unconfined aquifer and the underlying confined aquifers is an important consideration for environmental cleanup activities at the Hanford Site. To develop Records of Decision for final action in the various groundwater operable units (OUs), the nature and extent of groundwater contamination in all aquifers potentially impacted must be characterized sufficiently (1) to evaluate risk to human health and the environment; and (2) to identify, evaluate, and select a remedial action alternative. This necessarily includes assessing the degree to which the upper basalt-confined aquifer system may have been affected by groundwater plumes in the unconfined aquifer. Several studies have been conducted regarding communication between these aquifers, and the following discussion briefly summarizes the current conceptual model. *Hanford Site Groundwater Monitoring for Fiscal Year 2007* (DOE/RL-2008-01) discusses this topic in detail and provides an analysis of the potential for aquifer intercommunication on the Hanford Site.

Intercommunication between the upper basalt-confined aquifer and the overlying unconfined aquifer systems may occur where a pathway exists for movement of water, as well as a difference in hydraulic head between the two systems. An area of intercommunication between the unconfined and upper basalt-confined aquifer systems was first identified in the northern portion of the 200 East Area (RHO-BWI-ST-5, *Hydrologic Studies Within the Columbia Plateau, Washington: An Integration of Current Knowledge*). Intercommunication between the unconfined and confined aquifers in this region is attributed to erosion of the upper Saddle Mountains Basalt and a downward hydraulic gradient resulting from groundwater mounding associated with past wastewater disposal to receiver ponds in the area (e.g., 216-B-3 Pond and Gable Mountain Pond). However, since 1984, the groundwater mound beneath Gable Mountain Pond has dissipated completely, and the mound beneath the 216-B-3 Pond has diminished significantly, decreasing more than 3 meters since discharges ceased.

Additional studies (including PNNL-19702, *Hydrogeologic Model for the Gable Gap Area, Hanford Site*; PNL-10817, *Hydrochemistry and Hydrogeologic Conditions Within the Hanford Site Upper Basalt Confined Aquifer System*; RHO-ST-38, *Geohydrology of the Rattlesnake Ridge Interbed in the Gable Mountain Pond Area*; and RHO-RE-ST-12P, *An Assessment of Aquifer Intercommunication in the B Pond-Gable Mountain Pond Area of the Hanford Site*) delineated areas of erosion in the basalt extending from Gable Gap across the northern portion of the

200 East Area to B Pond. The extent of this area of erosion does not encompass Gable Mountain Pond, but the western lobe of B Pond does overlie the area where the Elephant Mountain Basalt has been partially removed by erosion (Figure 15-1).

Another location where intercommunication between aquifers is known to have occurred is centered on well 299-E33-12 in the northwestern portion of the 200 East Area. This well was drilled in 1953 into the Pomona Basalt underlying the Rattlesnake Ridge interbed and was uncased from just above the bottom of the unconfined aquifer through the Rattlesnake Ridge interbed. Contamination is believed to have migrated from the unconfined aquifer, down the open borehole, to the Rattlesnake Ridge interbed (DOE/RL-2008-1). The well was sealed from the unconfined aquifer in the early 1980s, with an additional seal placed in the well in 1990 to shorten the open interval. Concentrations of waste indicators cyanide, nitrate, technetium-99, and tritium continue to be elevated in samples from this well (see Section 15.2.2).

15.1 Ringold Formation Confined Aquifer

Confined water-bearing units are present in the Ringold Formation at various locations beneath the Hanford Site. The most widespread Ringold confined aquifer is where the lowermost sediments of Ringold Formation hydrologic unit 9 are overlain by the Ringold lower mud unit (see Figure 2-8 in Chapter 2.0). In the 100-HR-3 OU, a locally confined aquifer that occurs beneath the Ringold upper mud unit is being studied (see Chapter 7.0). In the 300 Area, several wells are completed in a confined transmissive unit within the Ringold lower mud unit (see Chapter 13.0).

In the 200 East Area, another locally confined aquifer occurs within fluvial sand and gravel comprising the lowest sedimentary unit of Ringold Formation hydrologic unit 9. This aquifer is confined between the bottom of the lower mud unit and the top of the uppermost basalt. Where hydrologic unit 9 is overlain by fine-grained units, confined conditions generally exist. Where hydrologic unit 9 is absent beneath the lower mud unit, limited vertical groundwater flow may occur. This confined aquifer is of concern because of its location relative to contamination sources in the 200 East Area. Wells completed in the lower portion of the unconfined aquifer above the lower mud unit in regions where hydrologic unit 9 is absent provide information on the distribution of contaminants in the lowermost portion of the unconfined aquifer system.

Approximately 36 wells/piezometers are currently available to monitor the Ringold confined aquifer on the Hanford Site. Of these wells/piezometers, 13 are used for water-level monitoring and have either one or no chemical analysis results; the remaining 23 have regular analytical results. Seven of the 23 wells/piezometers were sampled in calendar year (CY) 2010. Of these seven, four were also sampled in CY 2009.

15.1.1 Groundwater Flow in the Ringold Confined Aquifer

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Figure 15-2 presents the interpreted potentiometric surface for a portion of the Ringold confined aquifer for March 2010. This map is subject to uncertainty because only a few wells monitor this aquifer. However, generalized flow patterns can be inferred from available data when the hydrogeologic framework (i.e., extent of the confined unit, presence of basalt subcrops, and influence of the May Junction Fault) is considered.

Groundwater flow in the Ringold confined aquifer is generally west to east near the 200 West Area and along the southern boundary of the aquifer near the Rattlesnake Hills. This flow pattern indicates that recharge occurs west of the 200 West Area in upgradient areas within the Cold Creek Valley, as well as in the Dry Creek Valley and possibly the Rattlesnake Hills. Near the 200 East Area, flow in the Ringold confined aquifer converges from the west, south, and east before discharging to the unconfined aquifer where the lower mud unit is absent (PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*, Section 4.2.3). This water is thought to flow southeast over the top of the confining unit (PNNL-15479*, Groundwater Monitoring Plan for the Hanford Site 216-B-3 Pond RCRA Facility*, Section 2.3). Near the 200 East Area, water-level elevation data from piezometers 299-E25-32P and 299-E25-32Q (used to monitor different depths in the unconfined aquifer) indicate a slight upward gradient along the confined unit boundary. This upward gradient is consistent with discharge of groundwater from the confined aquifer to the overlying unconfined aquifer.

As a remnant of past wastewater discharges to the 216-B-3 Pond (B Pond), artificially elevated water levels are present in the Ringold confined aquifer to the northeast of this facility, which causes a southwest flow beneath B Pond to the 200 East Area. Eastward flow away from the region of elevated water levels does not occur; the May Junction Fault, located east of the B Pond area, is thought to be a hydrologic barrier preventing flow to the east (PNNL-15479, Section 3.1). South of the B Pond area, the flow of water divides, with some flow moving northwest toward the 200 East Area and some moving east or southeast. The exact location of the flow divide is not known due to a lack of water-level data in this area and a need to define the southward extent of the May Junction Fault.

The potentiometric contours for the Ringold confined aquifer (Figure 15-2) are similar to the potentiometric surface contours for the upper basalt-confined aquifer system, indicating that flow patterns in the central portion of the Hanford Site are similar in both aquifers. Basalt bedrock from the topographic low at Gable Gap near the 200 East Area was eroded significantly by late Pleistocene catastrophic flooding (PNNL-19702, Section 7.0), which facilitates intercommunication between the unconfined and confined aquifers. The 200 East Area is a discharge area for both of the confined aquifers, which explains the similar flow patterns.

Water levels declined throughout much of the Ringold confined aquifer from March 2009 to March 2010. The decline in individual wells ranged from 0.04 to 0.23 meters. The potentiometric surface is responding to the reduction of liquid effluent discharges to the ground since discharge volumes peaked in the mid-1980s.

15.1.2 Groundwater Quality in the Ringold Confined Aquifer

The 200 Area of the Central Plateau and the area near the inactive B Pond system are two known areas where conditions may allow contamination to migrate from the unconfined aquifer into the Ringold confined aquifer. Groundwater chemistry data for the Ringold confined aquifer are limited to wells north of the 200 Area and near B Pond, and in the 300 Area. During CY 2010, seven wells completed in the Ringold confined aquifer were sampled (Figure 15-3). Table 15-1 provides data for selected contaminants of interest from the sampled wells.

Tritium is the only constituent to exceed DWSs in the Ringold confined aquifer.

During CY 2010, only one waste indicator constituent, tritium, exceeded the drinking water standard (DWS) of 20,000 pCi/L for wells completed in the Ringold confined aquifer. Well 699-41-40 (located near the B-3 Pond) had a tritium concentration of 36,000 pCi/L. This well is sampled every 3 years and has shown a steadily declining trend since 1990.

Other detected contaminants potentially associated with Hanford Site operations include tritium in wells 699-28-40 and 699-31-31 downgradient of the 200 East Area; wells 699-41-40, 699-42-39B, and 699-42-42B near the B-3 Pond; and tritium and uranium in well 699-S28-E0 near the 300 Area. Concentrations measured during the reporting period were consistent with historical results. Tritium shows a long-term declining trend, while uranium concentrations increased in both wells. With the exception of tritium, which shows a decreasing trend in wells where it is detected, all other constituents show stable long-term trends, with only minor variations.

15.2 Upper Basalt-Confined Aquifer System

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Groundwater quality in the upper basalt-confined aquifer system is monitored due to the potential for downward migration of contaminants from the overlying unconfined aquifer. Contaminants that reach the upper basalt-confined aquifer system may have the potential to migrate through the aquifer to areas of exposure off the Hanford Site, such as the Columbia River downstream of the Tri-Cities (i.e., Richland, Kennewick, and Pasco). The upper basalt-confined aquifer system is also monitored to assess the potential migration of contaminants onto the Hanford Site from offsite sources. PNL-10817 and *Groundwater Chemistry and Hydrogeology of the Upper Saddle Mountains Basalt-Confined Aquifer South and Southeast of the Hanford Site* (PNNL-14107) provide additional information on the potential for contaminants to migrate off the Hanford Site. A large source of additional information is available through the reports of the Basalt Waste Isolation Project that was performed on the Hanford Site in the 1980s.

Within the upper basalt-confined aquifer system, groundwater occurs primarily within sedimentary interbeds and at interflow contacts but is also present in basalt fractures and joints (see Figure 2-2 in Chapter 2.0). The thickest and most widespread upper sedimentary unit in this system is the Rattlesnake Ridge interbed, which is present beneath a large portion of the Hanford Site. Groundwater also occurs within the Levey interbed, which is present only in the southern portion of the Hanford Site. An interflow zone occurs within the Elephant Mountain Member of the upper Saddle Mountains Basalt and may be significant to the lateral transmission of water where it occurs. Overall, this system is confined by the dense, low-permeability, interior portions of basalt flows and, in some places, by Ringold Formation silts and clays (lower mud unit) overlying the basalt.

Approximately seventy wells have been completed in the Columbia River Basalt Group. Of this total, 32 wells are completed in deeper interbeds/basalts or are screened across multiple intervals, 16 wells are completed in the Rattlesnake Ridge interbed, 9 wells are completed in the Elephant Mountain Basalt, and 7 wells have completion intervals that include both the Elephant Mountain Basalt and the Rattlesnake Ridge interbed. During CY 2010, fifteen wells were sampled, with analyses for at least one constituent. Figure 15-3 shows the location of the upper basalt-confined aquifer system monitoring wells on the Hanford Site. Of the fifteen wells sampled, seven wells are in the Rattlesnake Ridge interbed, three wells are across the Elephant Mountain Basalt/Rattlesnake Ridge interbed, two wells are in the Elephant Mountain Basalt, and one well is open across multiple deep intervals. The exact unit monitored by the two remaining wells is unclear, but these two wells are likely completed in the Rattlesnake Ridge interbed based on well depth.

15.2.1 Groundwater Flow in the Upper Basalt-Confined Aquifer System

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Figure 15-4 presents the interpreted March 2010 potentiometric surface for the upper basalt-confined aquifer system south of Gable Butte and Gable Mountain. The region to the north of Gable Butte and Gable Mountain was not contoured due to insufficient well control. *Preliminary Potentiometric Map and Flow Dynamic Characteristics for the Upper-Basalt Confined Aquifer System* (PNL-8869, Plate 1) provides a generalized potentiometric surface map of this area. The upper basalt-confined aquifer system does not exist in the Cold Creek Valley and along the west portion of the Gable Mountain/Gable Butte structural area due to the absence of the Rattlesnake Ridge interbed.

Recharge to the upper basalt-confined aquifer system likely occurs from upland areas along the margins of the Pasco Basin and results from the infiltration of precipitation and surface water where the basalt and interbeds are exposed at or near ground surface. Recharge may also occur from the overlying aquifers (i.e., the unconfined aquifer or Ringold confined aquifer) in areas where the hydraulic gradient is downward and from deeper basalt aquifers where an upward gradient is present. The Yakima River may also be a source of recharge to this aquifer system. The Columbia River represents a discharge area for this aquifer system in the southeastern portion of the Hanford Site where the river has a lower head than the upper basalt-confined aquifer, but not for the northern portion of the site where the river head is higher (PNL-8869, Section 3.2). Discharge also occurs to the overlying aquifers in areas where the hydraulic gradient is upward. Discharge to the overlying unconfined aquifer near the Gable Butte/Gable Mountain structural area is believed to occur through erosional windows in the basalt.

South of Gable Butte and Gable Mountain, groundwater in the upper basalt-confined aquifer system generally flows from west to east across the Hanford Site, toward the Columbia River. The north-south trending May Junction Fault, located east of B Pond, acts as a barrier to groundwater flow in the unconfined aquifer and the Ringold confined aquifer (PNNL-15479, Section 3.1). It may also impede the movement of water in the upper basalt-confined aquifer system by juxtaposing permeable units opposite impermeable units. As with the Ringold confined aquifer, a flow divide is interpreted to exist southeast of the 200 East Area and B Pond in the upper basalt-confined aquifer system, but the exact location of this divide is uncertain due to a lack of wells in the area.

Groundwater flow rates within the Rattlesnake Ridge interbed have been estimated between 0.7 and 2.9 meters per year (PNL-10817, Section 4.2), which is a considerably lower flow rate than most estimates for the overlying unconfined aquifer system. The sediment comprising the interbed consists mostly of sandstone, with some silts and clays, and is much less permeable than the sediments in the unconfined aquifer. Also, the magnitude of the hydraulic gradient is generally lower than in the unconfined aquifer.

The vertical hydraulic gradient between the upper basalt-confined aquifer system and the overlying aquifer varies spatially, as shown by comparison of observed heads (Figure 15-5). A downward gradient exists in the central portion of the Hanford Site, near the B Pond recharge mound, as well as in regions north and east of the Columbia River. Near the B Pond, the vertical head gradient between the unconfined aquifer system and the upper basalt-confined aquifer system has diminished in recent years but remains downward. In other areas of the Hanford Site, the hydraulic gradient is upward from the upper basalt-confined aquifer system to the overlying aquifer system.

In the 200 East Area, the potentiometric surface (Figure 15-4) is similar to the potentiometric surface for the Ringold confined aquifer (Figure 15-2). The basalt in this area was significantly eroded by late Pleistocene catastrophic flooding, which facilitates aquifer intercommunication (PNNL-19702, Section 7.0). In the 200 East Area and to the immediate north, the vertical hydraulic gradient between the upper basalt-confined aquifer system and the overlying aquifer is upward. It is likely that the upper basalt-confined aquifer system currently discharges to the overlying aquifer in this region.

Water levels in the upper basalt-confined aquifer system declined throughout the Hanford Site from March 2009 to March 2010. In the 200 East Area and to the immediate north and east (near B Pond), water-level declines in wells were up to 0.15 meters, and water levels declined up to 0.14 meters in wells near the 200 West Area. These declines are in response to reduced effluent disposal activities in the 200 Area and are consistent with water-level declines in the overlying unconfined aquifer and Ringold confined aquifer. The largest decline occurred in well 699-S24-19P (0.39 meters) near the Yakima River.

15.2.2 Groundwater Quality in the Upper Basalt-Confined Aquifer System

The upper basalt-confined aquifer system is not affected by contamination as much as the overlying unconfined aquifer system. Contamination found in the upper basalt-confined aquifer system is most likely to occur in areas where the basalt-confined units have been eroded away or were never deposited, and where past disposal of large amounts of wastewater resulted in downward hydraulic gradients. Although areas of intercommunication between the contaminated unconfined aquifer and the upper basalt-confined aquifer are well documented to date, groundwater monitoring data do not indicate that substantial contamination has migrated from the unconfined aquifer into the upper basalt-confined aquifer. In some areas, wells constructed prior to implementation of WAC 173-160 ("Minimum Standards for Construction and Maintenance of Wells") and penetrating the upper basalt-confined aquifer system lacked an impermeable seal between the well casing and the borehole wall. This provided a direct conduit between the upper unconfined and deeper confined aquifers. When this is discovered, the wells are either modified by installing an impermeable seal or are decommissioned using a method to isolate the aquifer. As a result of poor well seals, intercommunication between the aquifers permitted groundwater flow from the unconfined aquifer to the underlying confined aquifer, increasing the potential to spread contamination. Section 2.14.2.3 of DOE/RL-2008-01 discusses the communication between the upper basalt-confined aquifer system and the overlying aquifers.

Wells completed in the upper basalt-confined aquifer system are routinely sampled on the Hanford Site. Most of these wells are sampled every 3 years, but a few wells are sampled annually. During CY 2010, twenty wells were sampled and 348 analyses were performed for chemical and radiological constituents. Many of the samples were analyzed for tritium, iodine-129, and nitrate, which are the most widespread constituents in the overlying unconfined aquifer and are some of the most mobile constituents in groundwater. Detection of tritium, iodine-129, and nitrate provides an early warning for potential contamination in the upper basalt-confined aquifer system. Groundwater samples from the upper basalt-confined aquifer system were also analyzed for anions (other than nitrate), major cations, cyanide, gross alpha, gross beta, gamma emitters, strontium-90, technetium-99, and uranium isotopes. Data for selected contaminants of interest are provided in Table 15-2. A full data set is included in the data files accompanying this report.

Initially, high concentrations of contaminants (above DWSs) in new well 299-E33-340 declined significantly during the reporting period.

Well 299-E33-340 was installed as part of the 200-BP-5 OU remedial investigation in fiscal year 2008 within the upper basalt-confined aquifer system. The data reported in *Hanford Site Groundwater Monitoring for Fiscal Year 2008* (DOE/RL-2008-66) were collected shortly after the well was completed and, more importantly, prior to well development. The concentrations of cyanide, nitrate, nitrite, and technetium-99 were all well above their respective DWSs at that time. This well was developed on October 13, 2008, with the next samples collected January 12, 2009. Concentrations of cyanide, nitrate, nitrite, and technetium-99 (as well as elevated concentrations of chloride, sulfate, tritium, and uranium) all showed a significant decline (over 90% for cyanide, nitrate, nitrite, technetium-99, and tritium). For the remainder of the reporting period, this well showed constituent concentrations consistent with the nearby upper basalt-confined aquifer well 299-E33-50. Therefore, it is believed that the initial high values were not representative of true aquifer conditions.

15.2.2.1 Anions

Nitrate and cyanide remain elevated in the 200 East Area during the reporting period, but neither constituent exceeded the respective DWS.

Because of their negative charge, anions are more mobile than most other contaminants. The anions most related to contamination from Hanford Site operations are nitrate and cyanide. During the reporting period, neither of these constituents exceeded their respective DWS. Concentrations of cyanide and nitrate in well 299-E33-340 declined to levels consistent with other upper basalt-confined wells in CY 2009 and remained at those levels throughout CY 2010, further supporting the belief that the initial high concentrations were the result of contamination drawn down during the drilling process. Well 299-E33-12 was the only other well with elevated levels of cyanide and nitrate, which is consistent with previous years and is attributed to migration of contaminated groundwater from the unconfined aquifer moving down the borehole during well construction when it was open to both the unconfined and confined aquifers, as discussed in the intercommunication assessment report (RHO-RE-ST-12P).

As in previous years, the only anion to exceed a DWS was fluoride in well 699-S2-34B, which is located in the south-central portion of the Hanford Site. The concentration of fluoride in this well has always been reported above the DWS. Because this well is removed from any potential contamination source, the fluoride levels are likely naturally occurring in that portion of the aquifer. This is further supported based on its location near an area of known confined aquifer high fluoride water (e.g., near the Laser Interferometer Gravitational-Wave Observatory facility).

15.2.2.2 Metals

Iron and manganese are the only metals to exceed DWSs.

Contamination associated with metals from Hanford Site operations tends to be rapidly sorbed before reaching the unconfined aquifer. The major metal of concern is chromium, which is more prevalent along the River Corridor than in the Central Plateau area. Chromium concentrations in the upper basalt-confined aquifer wells were all below the detection limit during the reporting period, with the exception of well 699-50-53B. The chromium concentration in this well was 17 µg/L, just above the reporting limit of 14 µg/L. This well is located north of the 200 East Area and has previously had positive detections.

The concentrations of the major soil elements (i.e., calcium, magnesium, potassium, and sodium) and most trace elements (e.g., barium, strontium, vanadium, and zinc) remained at levels similar to those of previous years.

Two metals, iron and manganese, exceeded their secondary DWS concentrations in filtered samples from several wells in the upper basalt-confined aquifer. Iron was above the secondary DWS of 300 µg/L in well 699-54-34 at 965 µg/L (adjacent to Gable Mountain). The concentration of 1,650 µg/L in well 699-49-55B is out of trend and likely an artifact of contamination in the sample. This is supported by the fact that the August 2010 sample was back in trend and an order of magnitude lower at only 133 µg/L.

The manganese secondary DWS of 50 µg/L was exceeded in four wells: 299-E33-50, 299-E33-340, 699-49-55B, and 699-54-34. The maximum concentration measured during CY 2010 (in March sampling) was 128 µg/L in well 699-49-55B. As stated above for the iron result, this value is likely nonrepresentative, as the August value had decreased to 16 µg/L. Concentrations in the other three wells are consistent with previous results.

Two possible reasons for the elevated levels of manganese and iron in upper-basalt-confined aquifer wells are (1) natural variation related to the breakdown of basalt minerals high in manganese and iron, or (2) degradation of the well casing releasing these metals to the groundwater. The latter reason seems unlikely at two locations, however, because wells 299-E33-340 and 299-E33-50 were installed less than 4 years ago.

15.2.2.3 Radionuclides

No radionuclides exceeded DWSs during the reporting period.

Radionuclide contamination is a concern in the upper basalt-confined aquifer system due to the large amounts released to the subsurface during Hanford Site operations. Radionuclides are also of concern due to their mobility (e.g., tritium and technetium-99) and/or their long half-lives (e.g., iodine-129 at 15.7 million years).

None of the wells exceeded the DWS for tritium (20,000 pCi/L) during CY 2010. The maximum concentration measured during the reporting period was 3,500 pCi/L in well 699-42-40C, which is located near the 216-B-3 Pond east of the 200 East Area. Low levels of tritium (less than 1,000 pCi/L) were measured in the basalt-confined aquifer near the center of the Hanford Site in CY 2010. Most of the positive tritium results are in the 200 East Area/Gable Mountain region, which is in an area of intercommunication with the overlying contaminated unconfined aquifer. Nearby wells completed in the unconfined aquifer in the Ringold Formation (e.g., well 699-43-41G) show elevated but declining trends. A slight downward hydraulic gradient continues to exist at this location.

In the northern portion of the 200 East Area, technetium-99 continued to be elevated in the upper basalt-confined aquifer system in wells 299-E33-12, 299-E33-50, and 299-E33-340. These wells are located within the technetium-99 plume in the overlying unconfined aquifer (see discussion in Chapter 9.0). The maximum technetium-99 concentration during the reporting period was 1,300 pCi/L in well 299-E33-12. This well is known to have contamination that resulted from flow down along the unsealed borehole. Concentrations in well 299-E33-340 continued to decline significantly, from a concentration of 26.6 pCi/L in January 2010 to 12.9 pCi/L in August 2010. These concentrations are more representative of the basalt-confined aquifer and are consistent with the technetium-99 concentration in well 299-E33-50.

Samples collected from upper basalt-confined aquifer system wells were also analyzed for iodine-129. Iodine-129 was detected in wells 699-42-40C and 699-49-55B in the upper basalt-confined aquifer system during CY 2010 (Table 15-2). The maximum concentration reported was 0.32 pCi/L in well 699-49-55B. Concentrations in well 299-E33-340 decreased to below the DWS of 1 pCi/L in June 2009 and remained below the detection limit throughout CY 2010.

Groundwater samples from upper basalt-confined aquifer system wells were also analyzed for gamma-emitting radionuclides and uranium isotopes. During CY 2009, gamma-emitting radionuclides were not detected in the upper basalt-confined aquifer system on the Hanford Site, including the Gable Mountain/200 East Area.

No uranium isotopes (uranium-234, uranium-235, or uranium-238) were observed in the upper basalt-confined aquifer in CY 2010. The only other radionuclides detected were naturally occurring carbon-14, at 34.7 pCi/L in well 299-E33-50 in January 2010, and potassium-40 in August in wells 699-42-40C and 699-42-E9B at concentrations of 30.4 pCi/L and 36 pCi/L, respectively

15.2.2.4 Field Parameters

A series of general water quality parameter measurements were obtained in CY 2010. The parameters for dissolved oxygen, oxygen-reduction potential, pH, specific conductance, temperature, and turbidity are collected in the field at the time of sampling, while other parameters (e.g., alkalinity) are measured in the laboratory. These parameters provide information on the overall character of the upper basalt-confined aquifer system. There are no regulatory guidelines for the values of these parameters, and the value ranges tend to be very narrow. The ranges, as well as minimum and maximum values, are presented in Table 15-3.

15.3 Conclusions and Recommendations

No significant changes occurred in contaminant concentrations in the confined aquifers. The naturally occurring trace metals iron and manganese continue to exceed their respective DWSs in some wells near and northwest of the 200 East Area. Radionuclides are also found in measurable concentrations in this area. Since the reduction of wastewater discharges to the ground surface, the hydraulic gradient in the confined aquifers has returned to its pre-Hanford condition of flowing from the confined aquifers into the unconfined aquifer over much of the site. A localized area with a downward hydraulic gradient still exists near the 216-B-3 Pond and 200 East Area. The zone of downward flow in the western portion of the site is likely natural and related to recharge of the upper basalt-confined aquifer.

The single largest recommendation for these aquifers is to continue monitoring on a regular basis. A revised groundwater monitoring plan covering monitoring of the confined aquifers throughout the Hanford Site was issued for review in late 2010 and is planned for issuance by late 2011.

Table 15-1. Potential Contaminants of Interest in Ringold Confined Aquifer, 2008 Through 2010

Well	Sample Date	Specific Conductance (µS/cm)	Nitrate (mg/L)		Uranium (µg/L)		Tritium (pCi/L)		Chromium (Filtered) (µg/L)		Iron (Filtered) (µg/L)		Manganese (Filtered) (µg/L)	
199-H4-15CQ	11/24/08	244	--		--		--		--		--		--	
199-H4-15CQ	6/9/09	281	--		--		--		--		--		--	
199-H4-15CQ	11/9/09	306	--		--		--		--		--		--	
199-H4-15CQ	5/16/10	279	--		--		--		--		--		--	
199-H4-15CR	1/3/08	249	2.7	D	--		--		49.9		17.6	C	4	U
199-H4-15CR	11/24/08	342	--		--		--		--		--		--	
199-H4-15CR	6/9/09	270	--		--		--		--		--		--	
199-H4-15CR	11/9/09	345	--		--		--		--		--		--	
199-H4-15CR	5/16/10	271	--		--		--		--		--		--	
199-H4-15CS	1/3/08	253	5.18	D	120	U	2.51		100		9	U	4	U
199-H4-15CS	5/29/08	249	--		--		--		--		--		--	
199-H4-15CS	11/24/08	252	--		--		--		--		--		--	
199-H4-15CS	6/10/09	252	--		--		--		--		--		--	
199-H4-15CS	11/9/09	268	--		--		--		--		--		--	
199-H4-15CS	5/16/10	257	--		--		--		--		--		--	
399-1-9	1/18/08	370	0.44	UD	0.05	U	--		4	U	173		**65.6**	
399-1-9	1/6/09	361	0.089	UD	0.05	U	--		13	U	164		**60.9**	
399-1-9	12/28/09	371	0.274		1.41	D	--		13	U	116	C	**62.2**	
399-1-16C	1/31/08	367	0.25	U	0.05	U	--		4	U	77.6		**50.4**	
399-1-16C	12/31/08	380	0.106	UD	0.05	U	--		13	U	80.9	B	49.6	
399-1-16C	12/14/09	377	0.274		0.1	UD	--		13	U	85.7	B	49.5	
399-1-17C	1/17/08	381	0.047	BDX	0.05	U	--		4	U	52.7		17.7	
399-1-17C	12/30/08	384	0.173	BD	0.0885	B	--		10	U	46.2	B	17.9	
399-1-17C	12/28/09	392	0.274		0.698	D	--		13	U	60.5	BC	23.1	
699-43-69	3/12/08	499	38.0		1.13		33.7	U	--		--		--	
699-43-69	3/14/08	1,195	39.0		0.94		25.6	U	--		--		--	
699-43-69	3/18/08	490	42.0		1.05		-35.6	U	--		--		--	
699-43-69	3/26/08	486	31.0		1.48		113	U	--		--		--	
699-43-69	4/1/08	499	30.0		1.24		9.36	U	--		--		32.1	
699-43-69	4/2/08	449	35.0		1.08		0	U	--		--		--	
699-43-69	4/4/08	498	26.0		0.6		-94.6	U	--		--		--	
699-43-69	4/9/08	415	23.0		1.12		-85.5	U	--		--		--	
699-43-69	6/10/08	515	32.4	D	--		--		--		--		--	
699-43-69	9/28/08	506	31.5	D	--		--		--		--		--	
699-43-69	11/23/08	497	32.0	D	--		--		--		--		--	
699-43-69	3/4/09	517	30.6	D	--		--		--		--		--	
699-43-69	11/23/09	517	31.9	D	--		--		--		--		--	
699-43-69	6/02/10	519	30.4	D	--		--		--		--		--	
699-45-42	10/26/09	281	4.47	D	--		7,000		--		--		--	
699-45-42	12/20/10	284	4.78	D	--		6,500		--		--		--	
699-S22-E9C	2/28/08	367	0.044	UD	--		18.8	U	4	U	204	C	**65.1**	
699-S27-E9C	2/11/08	381	0.044	UD	0.05	U	13.1	U	95.1		202	C	**95**	
699-S28-E0	6/10/10	371	16.4	D	4.16	D	10	U	1.76	BD	18	U	4	U
699-S28-E0	6/10/10	--	--		--		--		13	U	--		--	
699-S28-E0	8/02/10	371	17.2	D	1.32	D	-39	U	1	UD	18		4	U
699-S28-E0	8/02/10	--	--		--		--		13	U	--		--	
699-S28-E0	12/14/10	395	17.4	D	4.05	D	84	U	1.76	BD	51		12	B

Table 15-1. (Cont.)

Well	Sample Date	Specific Conductance (µS/cm)	Nitrate (mg/L)		Uranium (µg/L)		Tritium (pCi/L)		Chromium (Filtered) (µg/L)		Iron (Filtered) (µg/L)	Manganese (Filtered) (µg/L)
699-S28-E0	12/14/10	--	--		--		--		14	U	--	--
699-S29-E16C	8/19/08	381	0.107	UD	0.05	U	-23.1	U	13	U	**3,290**	**139**
699-S29-E16C	4/16/09	383	--		--		--		--		--	--

Notes:

1. Cells with "--" notation indicate not analyzed during the reporting period.
2. Shaded cells with **bold type** indicate values above secondary DWS (iron = 300 µg/L, manganese = 50 µg/L).
3. Laboratory qualifiers are as follows:

B = analyte detected at a value less than contract required detection limit but greater than or equal to the instrument or method detection limit

C = analyte detected in both the sample and the associated quality control blank, and the sample concentration was less than or equal to five times the blank concentration

D = analyte reported at a secondary dilution factor

U = not detected in sample; value shown is the detection limit

X = additional result-specific information is available

Table 15-2. Potential Contaminants of Interest in the Upper Basalt-Confined Aquifer, Calendar Year 2008 Through Calendar Year 2010

Well Name	Date	Specific Conduc-tance (µS/cm)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Tc-99 (pCi/L)	Tritium (pCi/L)	Uranium (µg/L)	Cesium-137 (pCi/L)	Cobalt-60 (pCi/L)	Iodine-129 (pCi/L)	Sr-90 (pCi/L)	Nitrate (mg/L)	Cyanide (µg/L)
199-H4-2	8/25/09	262	0.78 U	9.6	--	-25.6 U	--	--	--	--	--	1.27 D	--
199-H4-15CP	5/16/10	369	--	--	--	--	--	--	--	--	--	--	--
299-E16-1	6/24/09	293	0.63 U	22	--	-5.4 U	--	--	--	0.04 U	--	0.27 UD	--
	3/28/10	301	-0.66 U	9.2	-10 U	29 U	0.121 BD	-0.695 U	0.314 U	--	--	0.27 UD	--
	6/09/10	296	--	12.9	--	--	--	--	--	--	--	--	--
	6/09/10	--	--	11	--	--	--	--	--	--	--	--	--
	8/03/10	320	-0.15 U	11	2.8 U	-120 U	0.182 BD	-0.967 U	1.56 U	-0.03 U	-1.8 U	0.27 UD	--
299-E26-8	7/9/09	292	1.8	9.8	--	-1.73 U	--	--	--	0.35	--	2.13 D	--
299-E33-12	6/25/08	351	1.0 U	**690**	**1,300**	140 U	3.2	-3.18 U	4.27 U	0.09 U	--	40.20 D	31.3
	3/28/10	315	0.12 U	**800**	**1,180**	189	3.15 D	0.483 U	3.55 U	-0.05 U	-5.8 U	41.3 D	26.9
	7/06/10	346	0.84 U	**790**	**1,200**	--	--	--	--	--	--	--	--
299-E33-50	1/12/09	260	0.187 U	17.8	43	50 U	2.29	-0.27 U	-1.49 U	0.11 U	-2.8 U	1.36 D	4 U
	6/25/09	263	0.006 U	**52**	250 Y	-100 U	2.35	-0.65 U	-0.481 U	0.18	-1.6 U	1.93 D	4 UX
	1/06/10	265	1.5 U	36	46.1	-6.3 U	2.25 DC	0.407 U	2.47 U	0.08 U	-5.3 U	2.31 D	4 U
	6/29/10	261	1.8	38	--	-94 U	2.29 D	0.446 U	1.66 U	0.01 U	-2.8 U	2.03 D	4 U
299-E33-340	4/2/09	319	2.20	31	23	52 UJ	3.05	0.739 U	-0.51 U	0.24	-3.4 U	3.46 D	4.40 J
	6/26/09	310	0.48 U	30	28	86 U	3.27	-1.42 U	1.53 U	0.07 U	0.48 U	3.05 D	4 UX
	9/3/09	318	2.3	28 Q	20	120 U	3.05	-0.203 U	-1.04 U	0.07 U	-1.2 U	2.92 D	5.04 B
	1/15/10	304	1.8 U	28	26.6	-23 U	3.02 D	-0.516 U	0.782 U	0.03 U	-2.8 U	2.71 D	4 U
	1/15/10		0.97 U	30	22.9	-19 U	2.99 D	-1.09 U	0.0414 U	-0.1 U	-3.9 U	2.86 D	4 U
	3/28/10	280	2.1 U	18	15.8	70 U	2.97 D	--	--	--	--	2.09 D	4 U
	6/29/10	303	2.5	25	19.2	-33 U	2.93 D	-1.42 U	1.88 U	0.11 U	-3 U	2.82 D	4 U
	8/26/10	297	0.91 U	7.3	12.9	-51 U	2.83 D	--	--	--	--	1.29 D	4 U
	12/28/10	306	0.37 U	8.5	10.9	100 U	2.8 D	-9.3 U	1.3 U	--	--	1.95 D	4 U
	12/28/10	305	0.98 U	8.8	12	71 U	2.86 D	-0.16 U	0.0019 U	--	--	2.02 D	4 U
399-5-2	6/29/07	349	0.28 U	11	--	5.74 U	--	--	--	--	--	0.02 U	--
	6/06/10	348	0.48 U	7.9	-10 U	-6.8 U	0.1 UD	-1.34 U	-0.813 U	0.01 U	-0.73 U	0.27 UD	--
699-2-E14	8/25/09	427	0.73 U	6.8	-3.9 U	-110 U	0.05 U	--	0.23 U	-0.07 U	-0.61 U	0.27 UD	--
	10/26/09	435	4.0	8.9	-6.7 U	-50.3 U	0.1 UD	-0.14 U	--	--	--	0.27 UD	--
699-13-1C	7/24/09	375	0.4 U	8.7	--	120 U	--	--	--	--	--	0.27 UD	--
699-32-22B	9/24/09	380	0.009 U	5.5 U	--	220 U	--	--	--	0.06 U	--	0.27 UD	--
	12/19/10	376	0.72 U	9.7	-4.5 U	25.1 U	0.17 BD	--	--	--	--	0.841 UD	--

Table 15-2. (Cont.)

Well Name	Date	Specific Conduc-tance (µS/cm)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Tc-99 (pCi/L)	Tritium (pCi/L)	Uranium (µg/L)	Cesium-137 (pCi/L)	Cobalt-60 (pCi/L)	Iodine-129 (pCi/L)	Sr-90 (pCi/L)	Nitrate (mg/L)	Cyanide (µg/L)
699-42-40C	7/8/09	341	2.2	14	--	3,900	--	--	--	0.25	--	6.24 D	--
	8/18/10	342	0.006 U	12	-0.5 U	3,500	2.49 D	-0.165 U	0.826 U	0.29	-- U	6.15 D	4 U
699-42-E9B	9/27/09	392	-0.19 U	13	--	78 U	--	0.575 U	-0.132 U	0.04 U	--	0.27 UD	--
	8/23/10	420	6.6 Y	6.4	-0.5 U	-6.3 U	0.1 UD	-0.416 U	0.057 U	0.04 U	--	0.08 UD	--
699-49-55B	2/6/08	278	2.96	7.97	1.23 U	-170 U	3.32	-0.278 U	0.96 U	-0.26 U	--	0.66 BD	4 U
	3/21/10	281	1 U	7.2	-6.5 U	-6.75 U	0.995 DC	0.514 U	0.321 U	0.32	-0.31 U	0.28 BDX	--
	8/17/10	286	2 U	7.4	-2.1 U	-0.004 U	4.09 D	-0.535 U	-1.46 U	--	--	0.69 BD	--
699-49-57B	4/1/09	305	--	--	-7.1 U	-9.0 U	--	1.61 U	-1.04 U	-0.02 U	--	1.23 D	2 UDN
	3/21/10	311	--	--	-10 U	-39 U	--	-1.89 U	0.49 U	0.01 U	--	1.11 DX	4 U
699-50-53B	9/20/09	372	--	--	-5.7 U	-0.83 U	--	--	--	-0.09 U	--	11.82 D	--
	4/06/10	370	1.8 U	7.4	-8.7 U	-37.3 U	2.18 D	--	--	--	--	12.3 D	--
	8/18/10	386	1.3 U	6.3	-2.5 U	-11.1 U	1.94 D	--	--	--	--	11.9 D	--
699-52-46A	6/30/07	326	3.6	7.6	--	7.92	--	--	--	--	0.22 U	1.84	--
	9/22/10	339	2.7	9.8	-5.4 U	10.7 U	5.76 D	0.207 U	0.369 U	0.02 U	-1.3 U	2.13 D	--
699-52-55B	01/13/09	339	0.823 U	8.55	-8 U	31 U	2.21	-1.33 U	1.01 U	0.0719 U	-0.42 U	0.39 BD	4 U
	04/01/09	383	0.51 U	11	-12 U	-60 U	3.11	-0.476 U	-0.648 U	-0.0141 U	1.2 U	1.45 D	2 UDN
	08/27/09	315	1.6 U	10	-3.5 U	31 U	3.02	0.578 U	0.533 U	-0.0287 U	-3.2 U	1.9 D	4 U
	09/20/09	339	3.6	7.6	-6.5 U	-18 U	3	0.664 U	-0.69 U	-0.0539 U	-5 U	2.14 D	4 U
	02/19/10	324	1 U	12	7.4	-78.2 U	2.92 D	0.113 U	-0.917 U	0.0146 U	-2 U	1.89 D	4 U
	09/22/10	326	5.2	13	-6 U	81 U	3.57 D	-0.248 U	0.803 U	0.0335 U	-4.7 U	2.41 D	4 U
699-54-34	7/18/10	335	1.5	5.7	6.7	-13.4 U	1.97	0.302 U	0.538 U	-0.039 U	-5.4 U	18.5 DN	--
699-54-57	11/117/10	306	2.2 U	3.4	-2.8 U	110 U	2.39 D	1.3 U	-3.3 U	-0.09 U	-1.4 U	1.37 D	4 U
699-56-43	9/24/09	322	2.0 U	6.9		-18.1 U	--	--	--	--	--	5.05 D	--
699-66-91	9/21/10	324	-2.3 U	1.3 U	-2.9 U	12.2 U	1.87 D	-1.42 U	2.71 U	-0.067 U	-2 U	4.21 D	--
699-S2-34B	2/4/09	624	2.7 U	10	--	-110 U	--	--	--	--	--	0.11 UD	--
	2/21/10	596	-0.23 U	13	-1.4 U	41.1	0.1 UD	0.57 U	-0.31 U	0.15 U	--	0.27 UD	--
699-S11-E12AP	8/25/09	356	0.87 U	8.8	--	-54 U	--	--	--	--	--	0.27 UD	--
	2/21/10	356	-0.62 U	8.4	-6.2 U	33.8	0.1 UD	-0.972 U	0.025 U	0.032 U	-2.9 U	0.27 UD	--
699-S24-19P	2/28/08	201	--	--	--	19.9 U	--	--	--	--	--	2.05 D	--
	7/23/10	267	-0.76 U	2 U	-2.6 U	0.53 U	0.788 D	-0.298 U	-0.574 U	0.03 U	-2.9 U	3.3 D	--

Table 15-2. (Cont.)

Well Name	Date	Specific Conduc-tance (µS/cm)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Tc-99 (pCi/L)	Tritium (pCi/L)	Uranium (µg/L)	Cesium-137 (pCi/L)	Cobalt-60 (pCi/L)	Iodine-129 (pCi/L)	Sr-90 (pCi/L)	Nitrate (mg/L)	Cyanide (µg/L)

Notes:

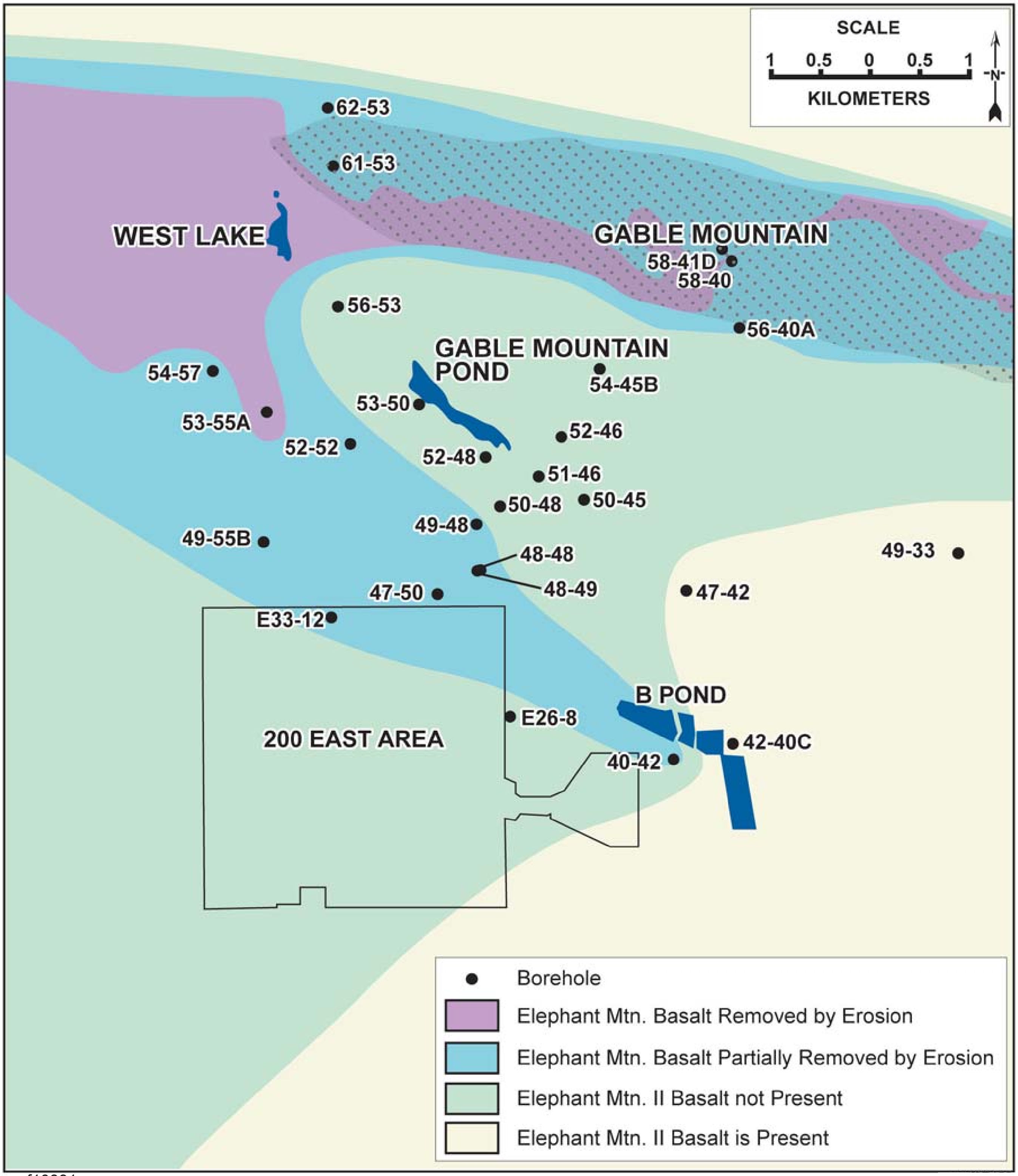
1. Cells with "--" notation indicate not analyzed between October 1, 2007, and December 31, 2010.
2. Shaded cells with **bold type** indicate values greater than drinking water standards (technetium-99 = 900 pCi/L, cobalt-60 = 100 pCi/L, iodine-129 = 1 pCi/L, nitrate = 45,000 µg/L, and cyanide = 200 µg/L).
3. Laboratory qualifiers are as follows:

B = analyte detected at a value less than contract required detection limit but greater than or equal to the instrument or method detection limit
C = analyte detected in both the sample and the associated quality control blank, and the sample concentration was less than or equal to five times the blank concentration
D = analyte reported at a secondary dilution factor
H = laboratory holding time exceeded before sample was analyzed
J = estimated value; constituent detected at a level less than the contract required detection limit and greater than or equal to the method detection limit
N = spike and/or spike duplicate sample recovery is outside control limits
Q = associated quality control sample is out of limits
U = not detected in sample; value shown is the detection limit
X = additional result-specific information is available
Y = result is suspect; review had insufficient data to show result valid or invalid

Table 15-3. Upper Basalt-Confined Aquifer Field Parameters for Calendar Year 2010

Parameter	Unit	Range	Minimum	Well	Maximum	Well
Dissolved oxygen	mg/L	8.83	0.04	699-S11-E12AP	8.87	699-S24-19P
Oxidation-reduction potential	mV	68	230	299-E33-340	298	699-49-57B
pH	Standard units	2.24	7.36	699-S24-19P	9.6	699-42-E9B
Specific conductivity	µS/cm	335	261	299-E33-50	596	699-S2-34B
Temperature	°C	6.4	16.4	699-S24-19P	22.8	299-E16-1
Turbidity	NTU	40.94	0.16	199-H4-15CP	41.1	699-49-55B

Figure 15-1. Extent of Partial or Complete Erosion of the Elephant Mountain Basalt in the 200 East Area/Gable Mountain Region (from DOE/RL-2008-01)



gwf10391

Figure 15-2. Potentiometric Surface Map of Ringold Formation Confined Aquifer (Unit 9), Central Hanford Site, March 2010

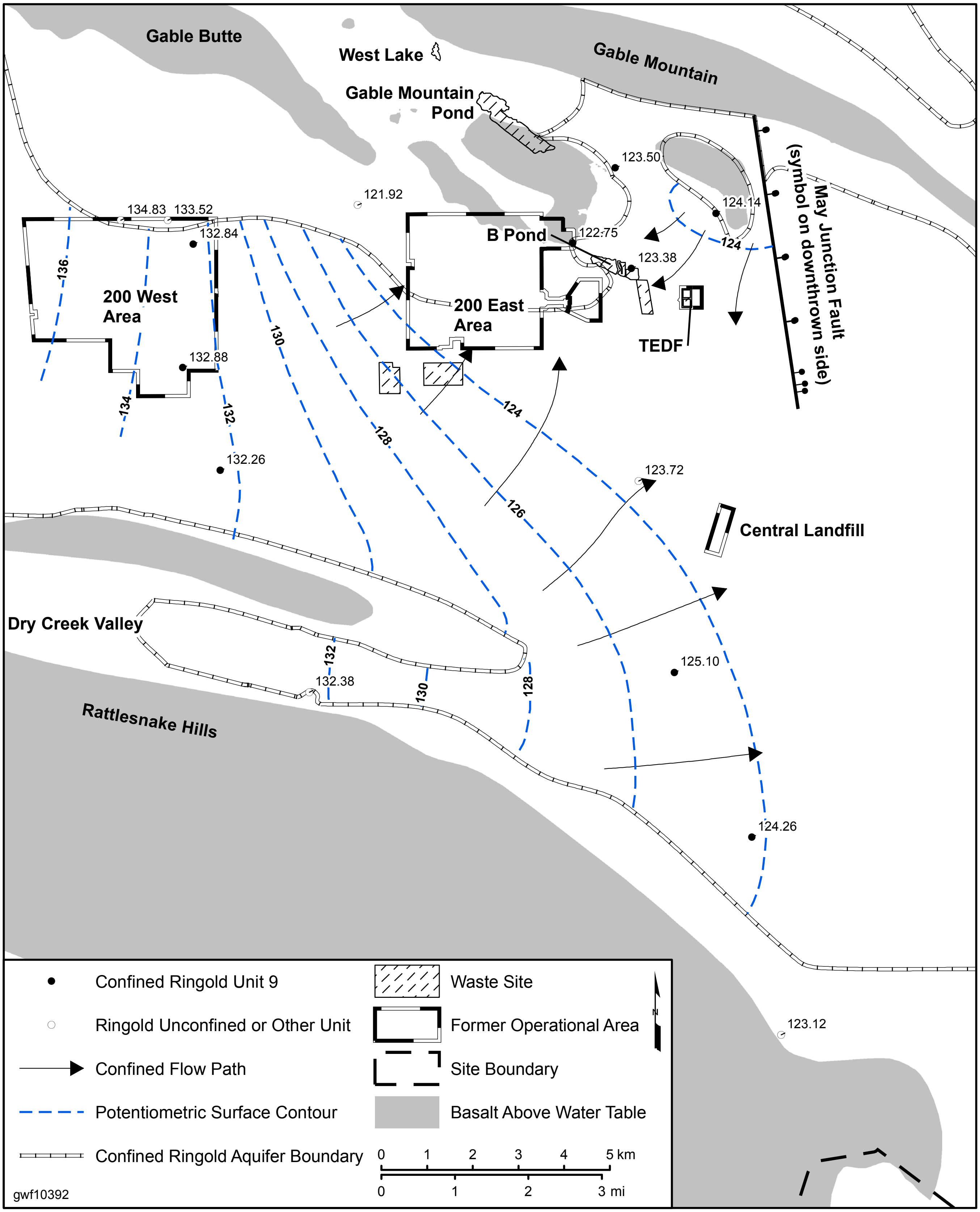


Figure 15-3. Groundwater Monitoring Wells Sampled in Ringold Formation Confined and Upper Basalt-Confined Aquifers, Fiscal Year 2007 Through Calendar Year 2010

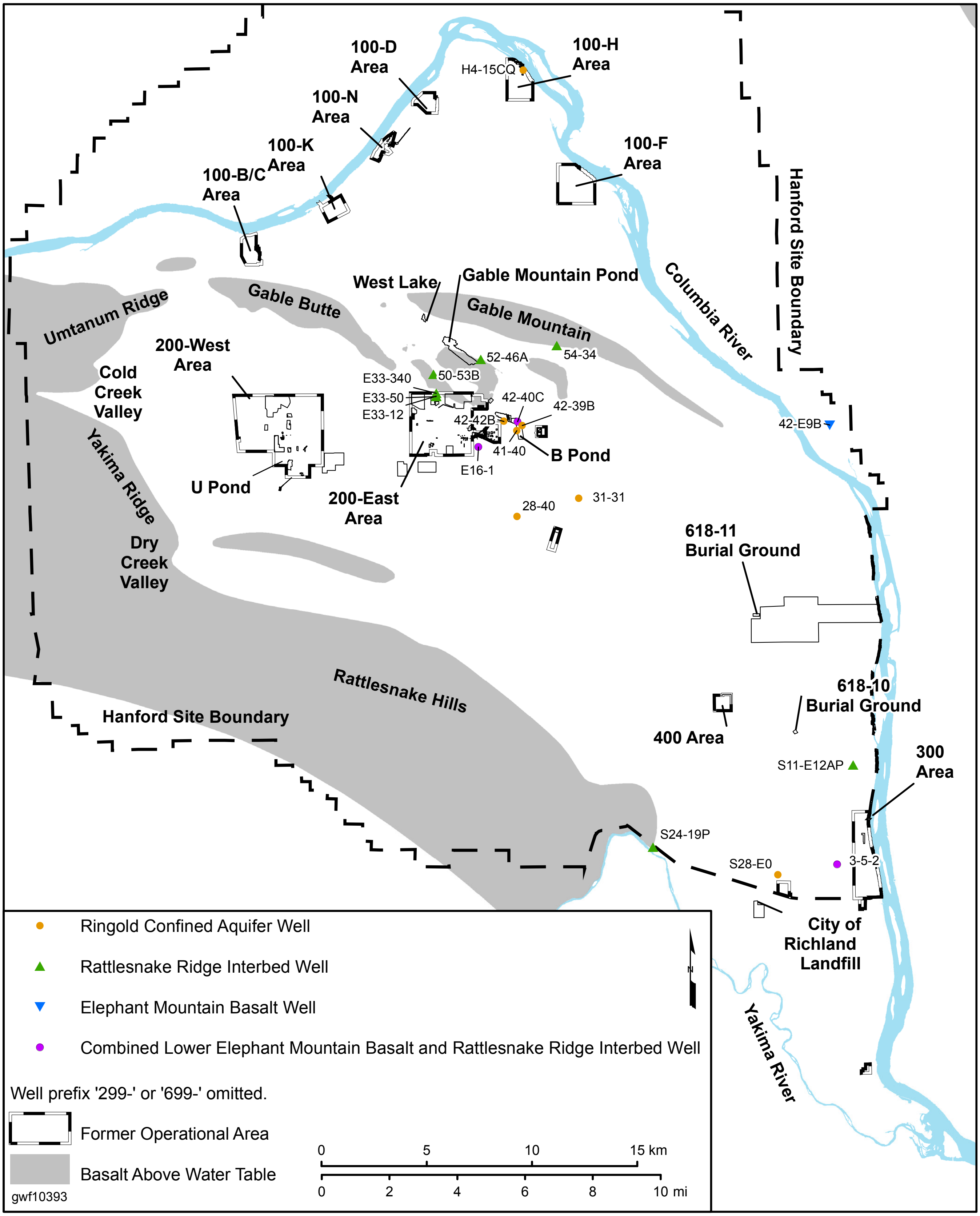


Figure 15-4. Potentiometric Surface Map of Upper Basalt-Confined Aquifer System, March 2010

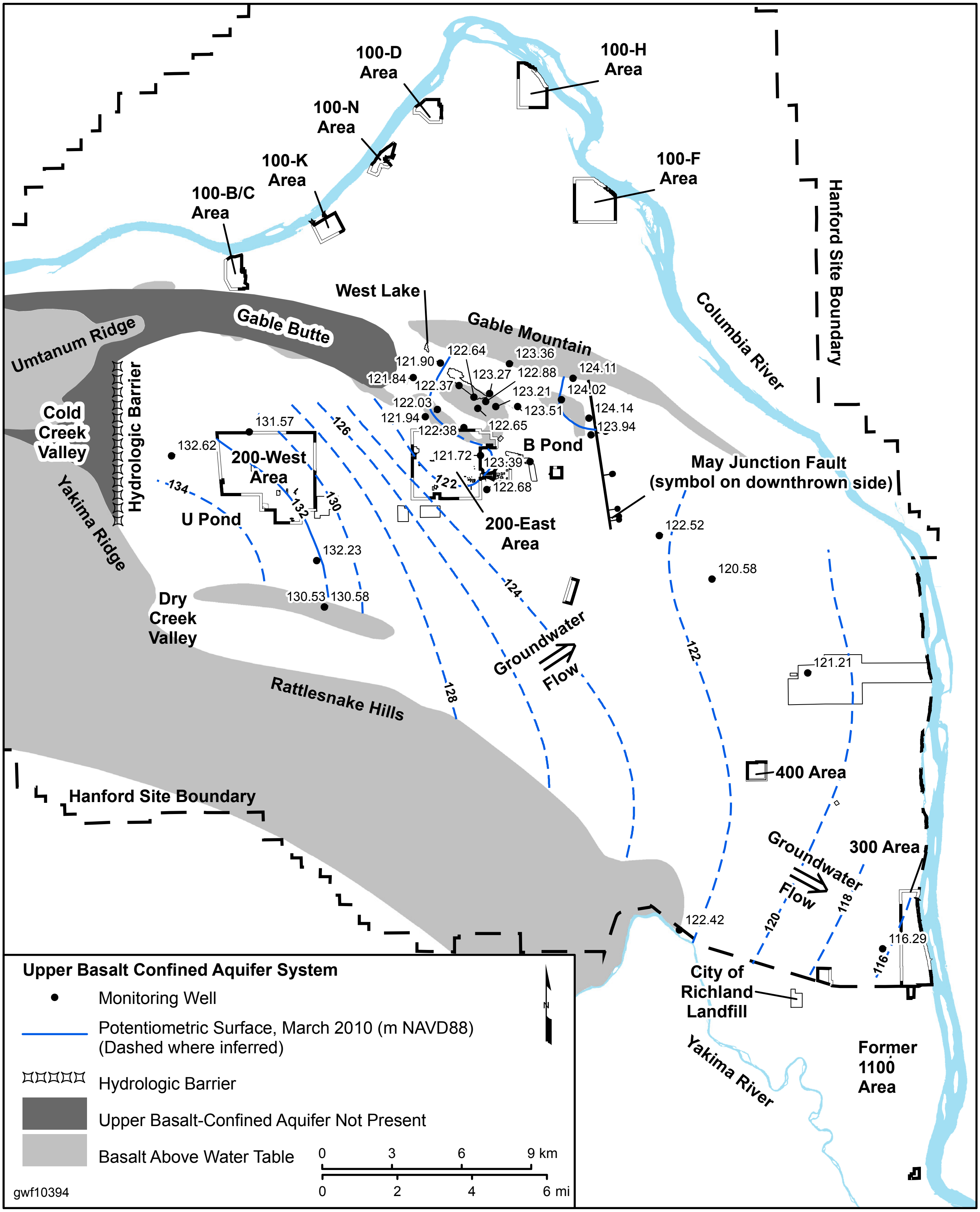


Figure 15-5. Comparison of Observed Heads for Upper Basalt-Confined Aquifer and Overlying Unconfined Aquifer