2.14 Upper Basalt-Confined Aquifer

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The upper basalt-confined aquifer system, which extends well beyond the limits of the Hanford Site, lies within sedimentary interbeds and hydraulically conductive portions of basalt flows immediately below the Hanford/Ringold aquifer system. Monitoring the upper basalt-confined aquifer system is important because of the potential for contamination to migrate off the Hanford Site. The most recent and comprehensive investigation of the upper basalt-confined aquifer system is presented in PNL-10817, which examines the hydraulic, hydrochemical, and isotopic characteristics of this groundwater system. Approximately 40 wells are located within the upper basalt-confined aquifer system and are used to monitor water levels or water quality (PNNL-13021). Water levels in several of these wells are measured at least annually, but samples for chemical or radiological analyses are taken on a triennial basis. The frequency of sampling was higher in the past, but recent work (PNL-10817) has indicated a relatively low probability that contamination could migrate off the site. Thus, sample frequency has been progressively reduced since 1995.

2.14.1 Groundwater Flow

Groundwater occurs within basalt fractures and joints, interflow contacts, and intercalated sedimentary interbeds within the upper Saddle Mountains Basalt. The thickest and most widespread sedimentary unit in the upper basalt-confined aquifer system is the Rattlesnake Ridge Interbed. Groundwater is confined by the dense, low-permeability, interior portions of basalt flows and in some places by Ringold Formation silt and clay units overlying the basalt. The groundwater project measures water levels annually in this aquifer system, and these data are used to prepare a potentiometric surface map. Beginning in fiscal year 1999, annual water level measurements are taken during March, instead of June, as in previous years.

Groundwater in the basalt-confined aquifer flows from west to east and discharges to the Columbia River. The water-level map has changed little in the past 7 years.

In 1993, hydraulic head distribution and flow dynamics of the upper basalt-confined aquifer system were evaluated and reported in PNL-8869, which identified the following prominent hydrologic features (Figure 2.14-1):

- a broad recharge mound extending northeastward from Yakima Ridge toward the 200 West Area
- a small recharge mound (now subsiding) immediately east of the 200 East Area in the vicinity of B Pond
- a subsurface hydrogeologic barrier (i.e., an impediment to groundwater flow), believed to be related to faulting, near the mouth of Cold Creek Valley
- a region of low hydraulic head (potential discharge) in the Umtanum Ridge-Gable Mountain structural area
- a region of high hydraulic head to the north and east of the Columbia River associated with artificial recharge attributed to agricultural activities.

Recharge to the upper basalt-confined aquifer system is believed to result from precipitation and surface water infiltration where the basalt and interbeds are exposed at ground surface. Recharge also may occur through the Hanford/Ringold aquifer system, where a downward hydraulic gradient exists between the Ringold Formation confined and upper basalt-confined aquifers. Hydraulic communication with overlying and underlying aquifers is believed to cause the region of low hydraulic head found in the Umtanum Ridge-Gable Mountain structural area (these relationships are given in more detail in PNL-8869). Water-table

and potentiometric surface maps of the upper basalt-confined aquifer system (see Figure 2.14-1), the unconfined aquifer (see Figure 2.1-1 and Plate 2), and the Ringold Formation confined aquifer (see Figure 2.9-33) indicate that a downward hydraulic gradient from the Hanford/Ringold aquifer system to the upper basalt-confined aquifer occurs in the western portion of the Hanford Site, in the vicinity of the B Pond recharge mound, as well as in the regions north and east of the Columbia River (PNL-6313, PNL-8869, PNL-10082, PNNL-11470, PNNL-12067, WHC-EP-0142-3, WHC-EP-0142-4, WHC-EP-0394-3). In the vicinity of B Pond, however, head decline within the Hanford/Ringold aquifer system may soon lead to a reversal of the vertical hydraulic gradient. In other areas of the Hanford Site, the hydraulic gradient is upward from the upper basalt-confined aquifer to the Hanford/Ringold aquifer system.

Figure 2.14-1, constructed by manual contouring, presents a regional approximation of the potentiometric surface for the upper basalt-confined aquifer system based on water-level measurements taken during March 1999. Measurements in the Rattlesnake Ridge Interbed (23 wells), the Levey Interbed (2 wells), and the Elephant Mountain Interflow zone (1 well) were primarily used to construct this map. Additional measurements in the upper Saddle Mountains Basalt (12 wells) were used for general contouring. The monitoring well network used for hydraulic head monitoring is presented in PNNL-13021.

With some exceptions, the major potentiometric map features shown in Figure 2.14-1 are nearly the same as those for 1993 (PNL-8869). The potentiometric map indicates that, south of the Umtanum Ridge-Gable Mountain structural area, groundwater generally flows from west to east across the site toward the Columbia River, which represents a regional discharge area for groundwater flow systems. In the region northeast of Gable Mountain, potentiometric contours, based on scant water-level data, suggest that groundwater flows southwest and discharges primarily to underlying confined aquifer systems in the Umtanum Ridge-Gable Mountain structural area (PNL-8869). This region of increased hydraulic head is associated with recharge from agricultural activities north and east of the Columbia River and is reinforced by observations from wells completed in deeper, confined aquifer systems. Therefore, the Columbia River does not represent a major discharge area for upper basalt-confined groundwater in the northern portion of the Hanford Site.

In the vicinity of the 200 East Area, the potentiometric surface in Figure 2.14-1 is similar to the potentiometric surface for the Ringold Formation confined aquifer (compare with Figure 2.9-33). It is known that the basalt in this area was significantly eroded by late Pleistocene catastrophic flooding (RHO-BWI-LD-5), which facilitates aquifer intercommunication in this area and probably explains the similarity. In the vicinity of the 200 East Area and to the immediate north, the vertical hydraulic gradient between the upper basalt-confined aquifer system and the overlying Hanford/Ringold aquifer system is upward (compare the water-level elevations on Figure 2.14-1 with those on Plate 2). Therefore, it is likely the upper basalt-confined aquifer system discharges to the overlying Hanford/Ringold aquifer system in this region.

Water levels in the central and western portion of the Hanford Site declined over the 9-month period from June 1998 to March 1999, whereas water levels in the eastern portion of the site increased during this period. Water levels in the 200 East Area and to the immediate north and east (near B Pond) continue to show a decline; falling in the range of 0.13 to 0.33 meter over the 9-month period (0.17 to 0.35 meter per year). Water levels near the 200 West Area also continue to show a decline with a range of 0.11 to 0.18 meter (0.15 to 0.24 meter per year). These declines are a response to curtailed effluent disposal activities in the 200 Areas and are consistent with water-level declines in the overlying Hanford/Ringold aquifer system.

The center of the groundwater mound associated with B Pond has migrated to the northeast since periodic monitoring of the upper basalt-confined aquifer system began in 1991. Figure 2.14-2 shows a trend plot of hydraulic head at wells 699-42-40C (located at

B Pond and formerly the approximate center of the groundwater mound) and 699-51-36B (the current approximate center of the groundwater mound). This figure shows that water levels beneath B Pond peaked higher and earlier and are now declining more rapidly than the water level at 699-51-36B. This more rapid decline beneath B Pond is related to the apparent shift in the groundwater mound. Comparison of heads between well 699-42-40C and adjacent wells completed in the unconfined aquifer indicate that the vertical head gradient between this aquifer and the upper basalt-confined aquifer system has diminished in recent years and is now virtually nil. This is in contrast to historical conditions that indicated a pronounced downward gradient between these two aquifers, presumably due to the effects of the B Pond mound.

The greatest measured increase in water levels for the upper basalt-confined aquifer system was 1.11 meters in well 199-H4-2, which is near the Columbia River in the 100 H Area. For other wells in the eastern portion of the Hanford Site, the increase in water levels ranged from 0.05 to 0.26 meter over the 9-month period from June 1998 to March 1999. Between March 1991 and March 1993, water levels were measured quarterly in a selected set of upper basalt-confined aquifer system wells (PNL-8869). These data showed a trend of rising water levels for the eastern portion of the Hanford Site, at a rate of 0.2 to 0.4 meter per year. PNL-8869 also demonstrated that river stage fluctuations are most likely superimposed on this trend, at least for wells adjacent to the Columbia River. The rising water levels are attributed to large-scale irrigation activities in areas off the site and east of the Columbia River. The increase in water levels in the eastern portion of the site from June 1998 to March 1999 is consistent with this long-term trend.

2.14.2 Groundwater Quality

The upper basalt-confined aquifer system is affected far less by Hanford Site contamination than the unconfined system. Prior to 1995, several Hanford Site wells in the confined aquifer were sampled annually for radionuclides and hazardous waste constituents. Over approximately the last 10 years, results of sampling and analyses from these sites indicated that of the wells monitored, there were very few areas of concern that warranted continued annual monitoring. Consequently, the number of wells sampled annually has been progressively reduced since 1995. Most wells have been reduced to a triennial sampling frequency. Figure 2.14-3 shows the locations of wells used for monitoring upper basalt-confined aquifer groundwater chemistry. Only one well, 699-42-E9B, was sampled during fiscal year 1999. Hence, this section will briefly review some of the more prominent historical concerns of groundwater quality in the upper basalt-confined system.

Radionuclides have been detected in the upper basalt-confined aquifer, generally at low levels. Confined-aquifer wells are sampled infrequently because groundwater chemistry does not change rapidly in these wells.

Geochemical studies indicate that the major ionic composition of groundwater in the upper basalt-confined system is dominantly magnesium and calcium bicarbonate in the western portions of the Hanford Site, becoming more sodium bicarbonate dominant in the eastern portions as residence time increases from west to east (WHC-EP-0595; PNNL-10817). Total dissolved solids content is considerably less (mostly less than 250 mg/L) than in the Hanford/Ringold aquifer on the Hanford Site. Tritium activities are naturally low in the upper basalt-confined aquifer (averaging less than 3.2 pCi/L) compared with surface water (e.g., Columbia River) and unconfined aquifer groundwater, except in areas of intercommunication with the Hanford/Ringold aquifer or areas affected by deep drilling operations that used surface water. Well 699-42-40C, near B Pond, is probably located in such an area of intercommunication (RHO-RE-ST-12P), and has produced tritium activities as high as 8,000 pCi/L as recently as 1996. Activities have decreased to ~6,500 pCi/L in subsequent measurements (latest in fiscal year 1998).

Some wells near the northern border of the 200 East Area have historically produced elevated results for radionuclides and nonradiogenic constituents. The most notable of these, well 299-E33-12, has been monitored since the mid 1950s and has produced elevated results for cobalt-60, cyanide, technetium-99, and tritium. The most recent results for these constituents in this well, from August 1998 are: 21.8 pCi/L cobalt-60, 30 µg/L cyanide, 1,810 pCi/L technetium-99, and 630 pCi/L tritium. During the 1950s, this well produced cobalt-60 results as high as 450,000 pCi/L, though the accuracy of these results may be questionable (PNL-10817). The fiscal year 1998 results were generally on trend with declining or unchanging concentrations of all four of these constituents in this well. Slightly elevated levels of nitrate, gross beta, and tritium have occurred in other wells in this general vicinity, but no significant trends have been observed that would warrant more frequent sampling efforts (see PNNL-12086).

Well 699-42-E9B is located on the eastern shore of the Columbia River, just inside the Hanford Site boundary. Since sample collection from this well began in 1991, pH values have risen steadily from ~8.5 in 1992 to 9.52 in fiscal year 1999. The reason for this trend is unknown. Tritium concentration declined from 73.1 pCi/L in fiscal year 1998 to 26.9 pCi/L in fiscal year 1999. Cobalt-60 was reported at a maximum of 7.73 pCi/L in 1993, but results of the last 4 years have been below detection. A result of 9.33 pCi/L of cesium-137 was reported in 1993, but since 1996 this radionuclide has been reported below detection (minimum detectable concentration ~0.56 pCi/L in fiscal year 1999). Counting errors are a high percentage of the results for cobalt-60 and cesium-137 in the 1999 samples from well 699-42-E9B.

Because of the prolonged travel times for groundwater, the limited degree of contamination observed in wells, and the hydraulic head distribution in the upper basalt-confined aquifer, there is probably little risk of contamination from this aquifer affecting surface waters or near-surface aquifers. The area where groundwater from the upper basalt-confined aquifer may discharge is essentially limited to the southeast portion of the Hanford Site and along the southern contiguous reaches of the Columbia River where an upward hydraulic potential exists.

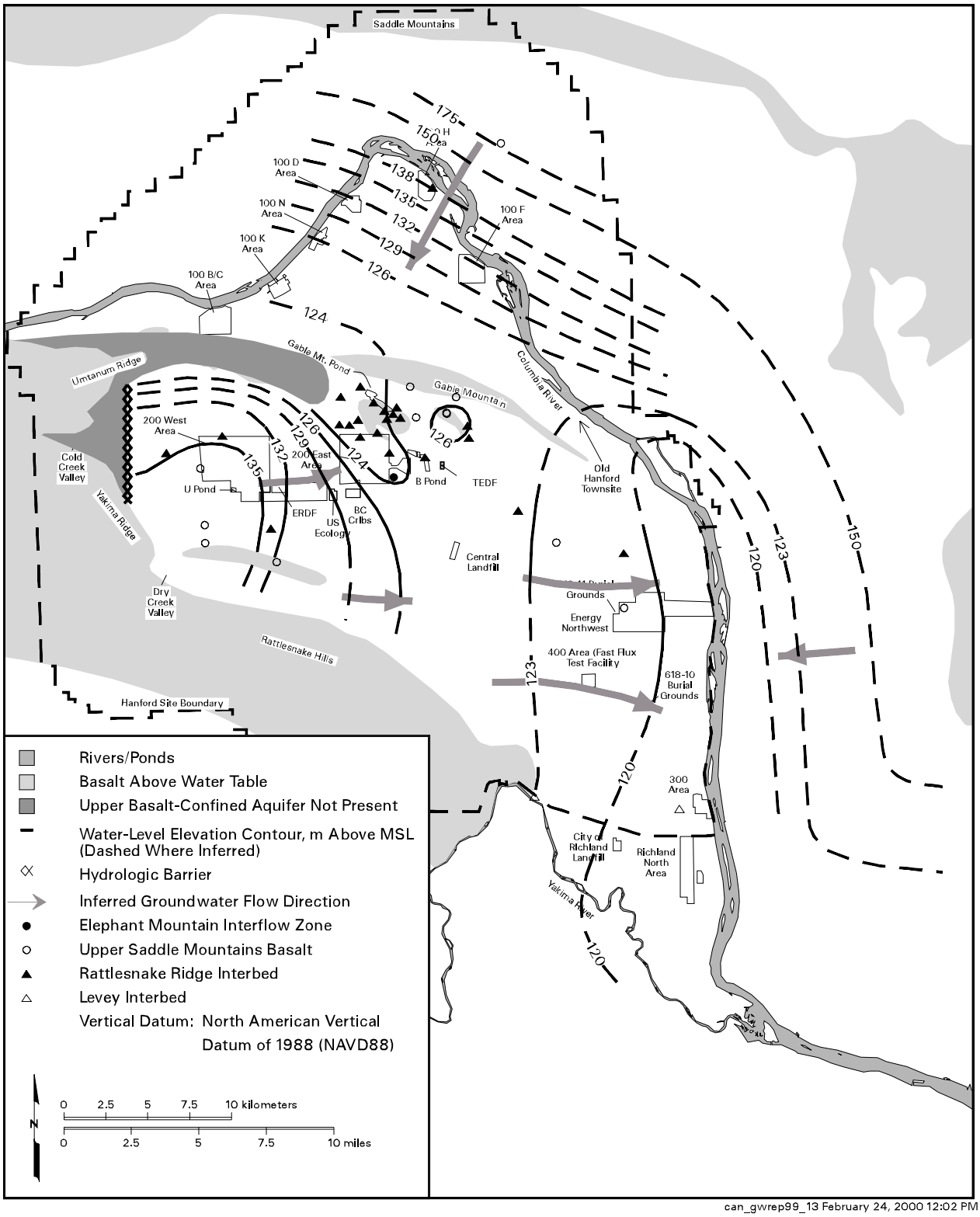

Figure 2.14-1. Potentiometric Map of Upper Basalt-Confined Aquifer System, March 1999

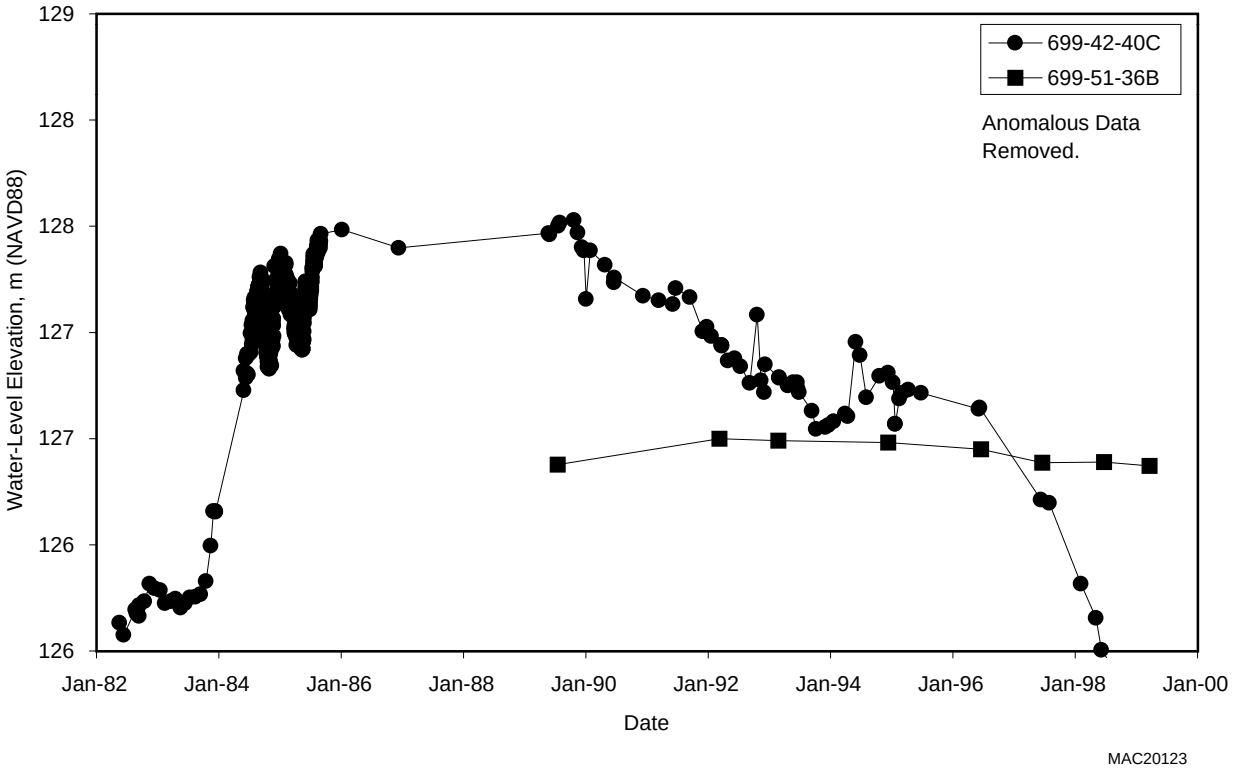

Figure 2.14-2. Upper Basalt-Confined Aquifer System Hydraulic Head in Wells Near B Pond

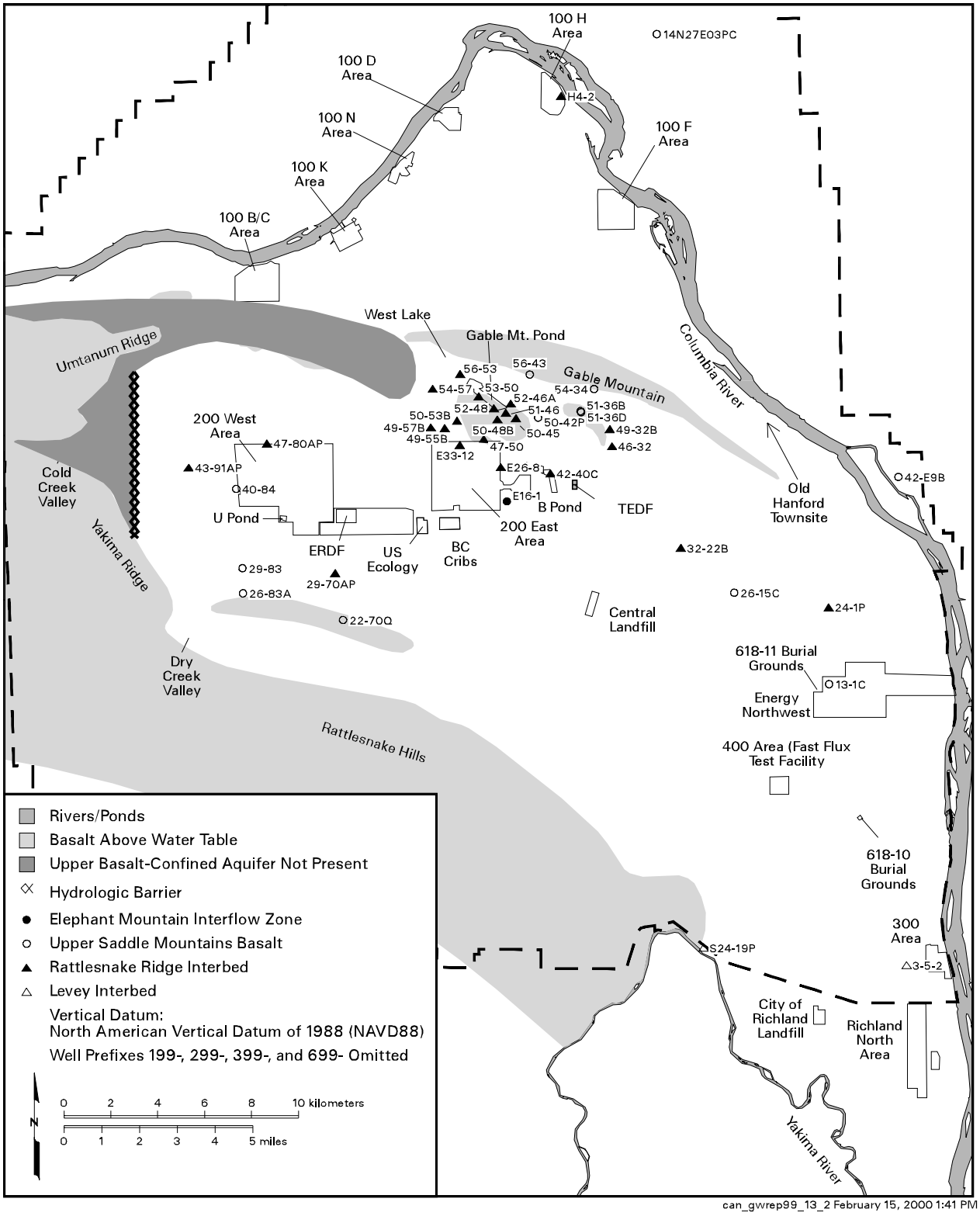

Figure 2.14-3. Hanford Site Map Showing Upper Basalt-Confined Aquifer Wells