Montana Bureau of Mines and Geology
A Department of Montana Tech of The University of Montana

Montana Ground-Water Assessment Atlas No. 1, Part B, Map 7
October 1998
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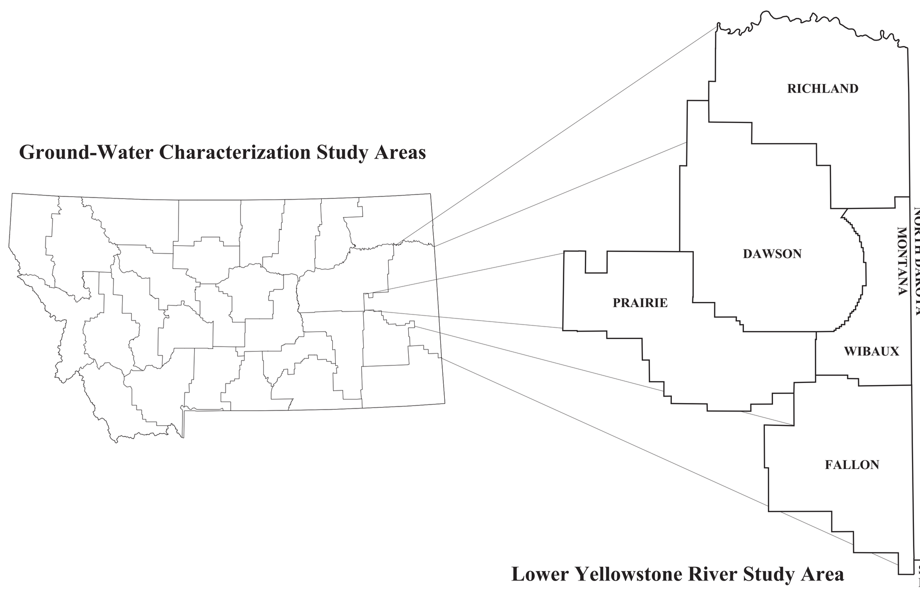
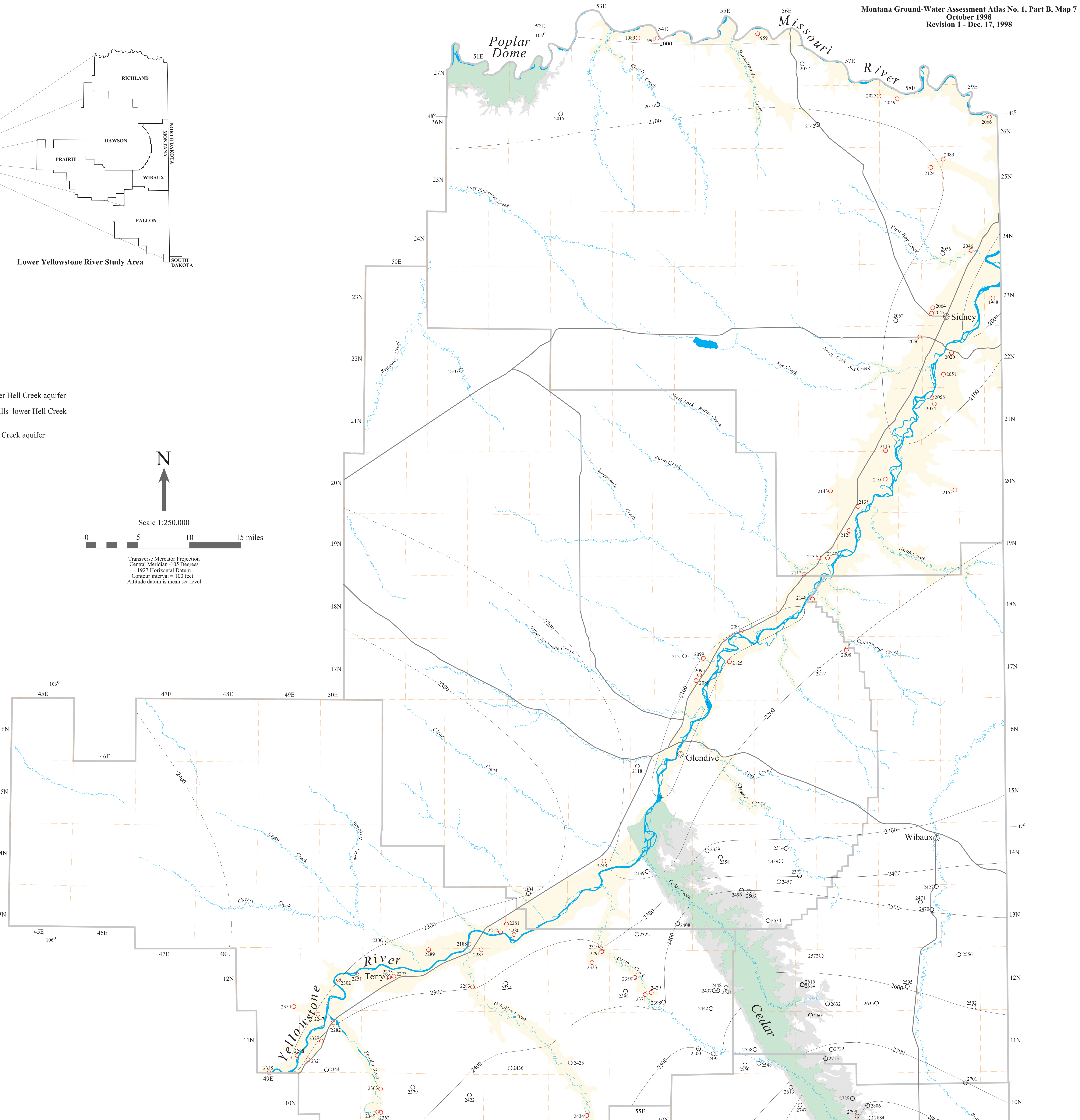
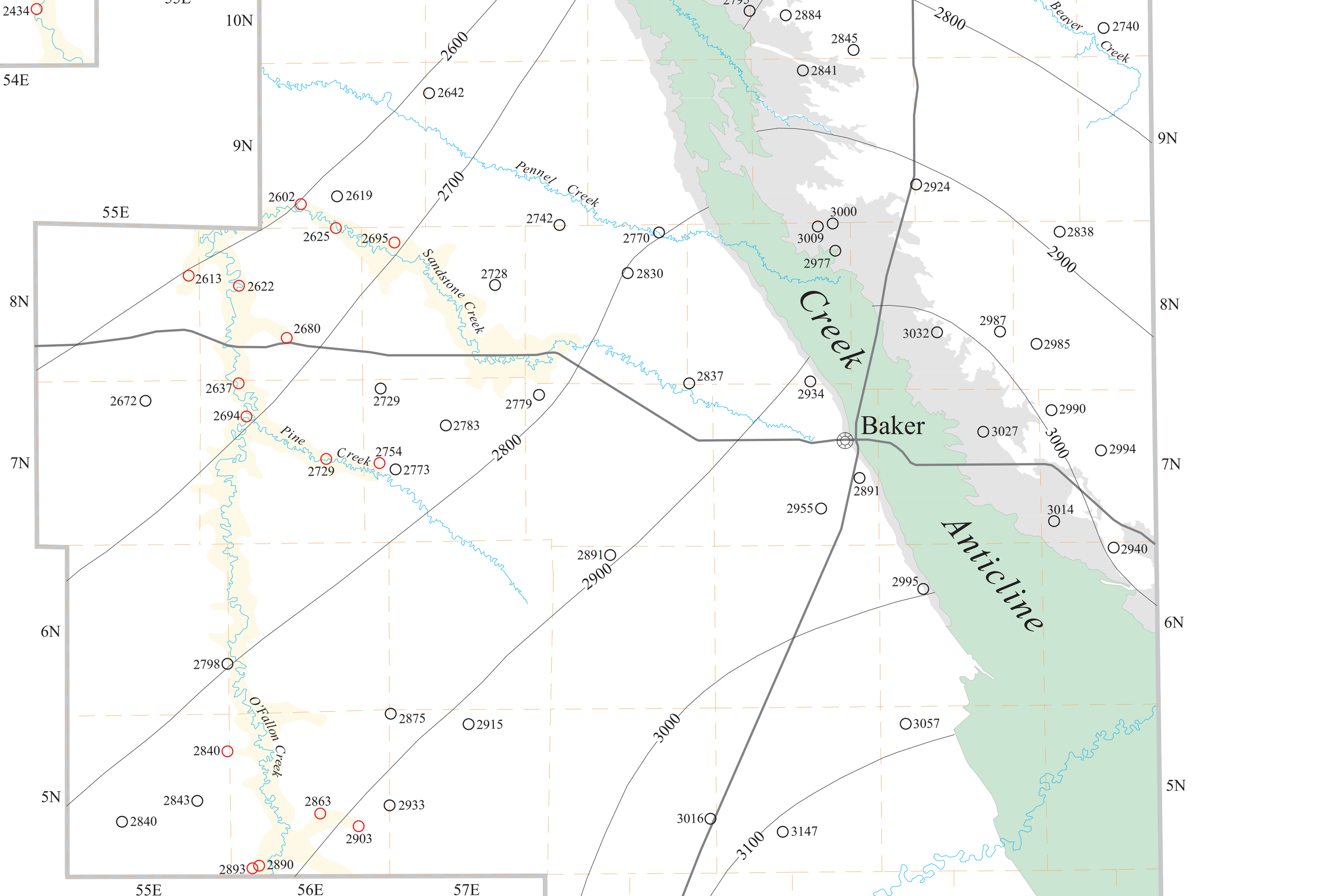






Explanation

- ○ Water-level altitude in well completed in the Fox Hills–lower Hell Creek aquifer
- ○ Water-level altitude in flowing well completed in the Fox Hills–lower Hell Creek aquifer
- 2200 Potentiometric surface contour for the Fox Hills–lower Hell Creek aquifer (dashed where inferred)
- Area of flowing artesian conditions
- County boundary
- Township boundary
- County seat
- Major road
- Principal stream
- Outcrop and subcrop of the Pierre Shale
- Outcrop of the Fox Hills Formation

N

Scale 1:250,000

0 5 10 15 miles

Transverse Mercator Projection
Central Meridian -105 Degrees
1927 Horizontal Datum
Contour interval = 100 feet
Altitude datum is mean sea level

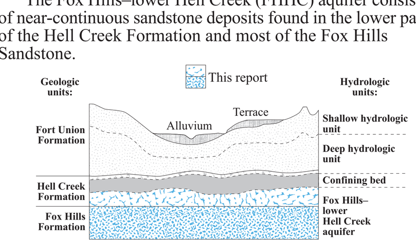
Potentiometric Surface Map of the Fox Hills–Lower Hell Creek Aquifer, Lower Yellowstone River Area: Dawson, Fallon, Prairie, Richland, and Wibaux Counties, Montana

by

John I. LaFave

Introduction

The Fox Hills–lower Hell Creek (FHHC) aquifer consists of near-continuous sandstone deposits found in the lower part of the Hell Creek Formation and most of the Fox Hills Sandstone.



Aquifers are saturated geologic materials that yield sufficient water to supply wells and springs. Non-aquifer materials (confining beds) also may be saturated but have low permeability and do not produce usable amounts of water to wells or springs. The sandstones that compose the FHHC aquifer are from 125 to 400 feet thick and are sandwiched between the Pierre Shale, which marks the basal confining layer, and overlying mudstone of the upper Hell Creek Formation. The aquifer occurs at depths from 600 to 1,600 feet below land surface throughout most of the study area, except along the Cedar Creek anticline and the Poplar Dome (Smith 1997). Typically the water level in wells completed in the aquifer will rise above the top of the aquifer due to the artesian pressure, and in low areas—such as the Yellowstone River Valley—flowing wells are common.

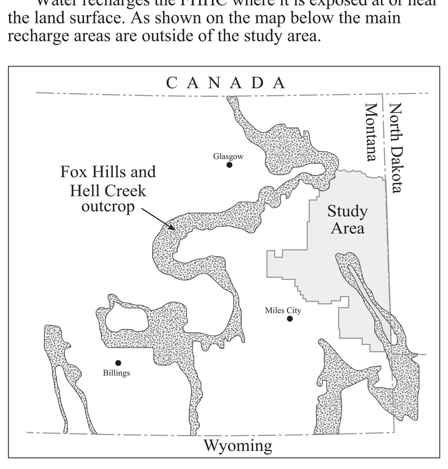
The FHHC is the deepest and most dependable potable-water aquifer in the five-county Lower Yellowstone Area. About 1,000 wells are completed in the aquifer (roughly 10 percent of the total wells). Ground water from the FHHC is used primarily for domestic and stock-water purposes; however, the cities of Baker, Lambert, and Richey rely on it for municipal water supply. Water from the FHHC is a sodium-bicarbonate type with dissolved-constituent concentrations typically ranging from about 1,000 to 2,500 mg/L. Reported well yields average less than 15 gallons per minute (gpm), but individual wells may yield as much as 100 gpm.

Ground-Water Flow

Ground water generally moves down the slope of the potentiometric surface, from higher altitude to lower altitude, perpendicular to the contours. This map shows the potentiometric surface of the FHHC aquifer based on water-level measurements performed between 1993 and 1995. The potentiometric surface represents the altitude to which water will rise in wells penetrating the aquifer. The shaded zone on the map shows areas where the potentiometric surface is higher than the land surface. In these areas, which coincide with the Yellowstone and Missouri River valleys and their major tributaries, flowing wells occur (red circles).

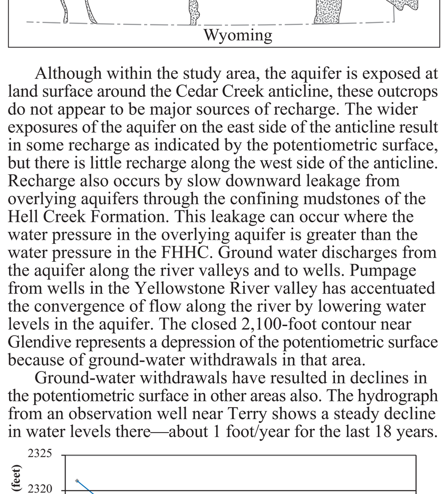
Across most of the study area ground water in the FHHC is flowing toward the Yellowstone River parallel to the trend of the Cedar Creek anticline. In the northern part of the study area flow is toward the Missouri River. The ground water moves slowly. Based on the hydraulic gradient and published aquifer transmissivities for the Fox Hills–lower Hell Creek aquifer (Henderson 1985; Groenewold et al. 1979; Taylor 1965) the rate of ground-water flow is estimated to be on the order of 2 to 10 feet/year in the study area. To put this flow estimate into perspective, if the ground water is moving at a rate of 5 feet/year it would take about 1,000 years for water to travel one mile.

Water recharges the FHHC where it is exposed at or near the land surface. As shown on the map below the main recharge areas are outside of the study area.



Although within the study area, the aquifer is exposed at land surface around the Cedar Creek anticline, these outcrops do not appear to be major sources of recharge. The wider exposures of the aquifer on the east side of the anticline result in some recharge as indicated by the potentiometric surface, but there is little recharge along the west side of the anticline. Recharge also occurs by slow downward leakage from overlying aquifers through the confining mudstones of the Hell Creek Formation. This leakage can occur where the water pressure in the overlying aquifer is greater than the water pressure in the FHHC. Ground water discharges from the aquifer along the river valleys and to wells. Pumpage from wells in the Yellowstone River valley has accentuated the convergence of flow along the river by lowering water levels in the aquifer. The closed 2,100-foot contour near Glendive represents a depression of the potentiometric surface because of ground-water withdrawals in that area.

Ground-water withdrawals have resulted in declines in the potentiometric surface in other areas also. The hydrograph from an observation well near Terry shows a steady decline in water levels there—about 1 foot/year for the last 18 years.



Long-term declines occur when more water is removed from the aquifer than is recharged. At some point these declines can create undesirable effects such as increased lift costs, decreased yields, and flowing wells ceasing to flow.

Map Use

This potentiometric surface map is useful for estimating the general direction of ground-water flow in the aquifer, identifying areas where flowing artesian wells may occur, and estimating the water-level altitude in a non-flowing well. The inset diagram to the right shows how to determine direction of ground-water flow from the map. Areas of flowing artesian conditions, where the water levels in wells completed in the FHHC will rise above the land surface, are shown in yellow on the map. In areas where the water levels are below the land surface, the map can be used to estimate the level to which water will rise in a well. If the approximate land-surface altitude at a location is known, the corresponding point on the potentiometric surface map can be found and the altitude of the potentiometric surface estimated. Subtraction of the potentiometric surface altitude from the land surface altitude yields the approximate depth below land surface at which water will stand in the well.

Map Construction

This map was constructed by hand-contouring 186 measured water-level altitudes. The water levels were measured in wells between October 1993 and November 1995. Map accuracy is affected by data distribution, field measurement errors, accuracy of well locations, and errors in interpretation. Points at which water levels have been measured are distributed unevenly across the map and map accuracy is greater near points of measurement. For example, the accuracy of the contours is greater along the Yellowstone River valley and south of the river where most of the measurements were made. There is more uncertainty associated with the contours north of the river were there are few wells, and therefore almost no measurements. Well locations are accurate to the 2.5-acre level. Land-surface altitudes at well locations were interpreted from U.S. Geological Survey 1:24,000 topographic maps and are generally accurate to ± 5 to 10 feet (based on 10- and 20-foot contour intervals). Land-surface altitudes used in contouring were obtained from U.S. Geological Survey 1:250,000 topographic maps with land-surface contour intervals of 100 feet. The contoured potentiometric surface is expected to be accurate to ± 50 feet at any given point, or ± 100 feet where the contours are dashed.

The flowing artesian zone was determined by subtracting the potentiometric surface from the land surface. The land surface topography was derived from the U.S. Geological Survey 1:250,000 digital elevation model (DEM) for the study area. Areas where the potentiometric surface is higher than the land surface show where flowing artesian conditions occur.

Acknowledgements

Well owners who allowed collection of the data necessary for this map, and the people who collected the data are all gratefully acknowledged. Reviews of this report by Tom Patton, Larry Smith, Wayne Van Voast, and Kate Miller improved its clarity.

Data Sources

Geographic features:

Population center locations and roads are from 1:100,000-scale U.S. Geological Survey (USGS) Digital Line Graph files available from the Natural Resources Information System (NRIS) at the Montana State Library, Helena, Montana. Hydrography has been simplified from the 1:100,000 Digital Line Graph files. Township boundaries are from 1:250,000-scale U.S. Geological Survey mapping and are available from NRIS.

Point data:

Well location and water-level altitude data were obtained by Ground-Water Characterization Program personnel, altitude of the points was determined from U.S. Geological Survey 7.5-min. quadrangles. All point data used on this map are available from the Ground-Water Information Center (GWIC) at the Montana Bureau of Mines and Geology, Montana Tech of The University of Montana, Butte.

References

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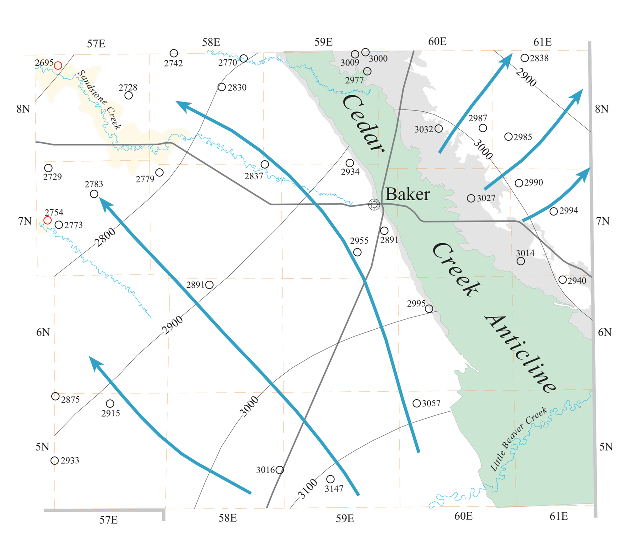

The area near Baker provides an example of how the potentiometric-surface map can be used to estimate general directions of ground-water flow. Flow arrows drawn perpendicular to the contours show that ground water in the Fox Hills–lower Hell Creek aquifer flows northeast, east of the Cedar Creek Anticline and northwest, west of the anticline.

Author's Note: This map is part of the Montana Bureau of Mines and Geology (MBMG) Ground-Water Assessment Atlas for the Lower Yellowstone River Area ground-water characterization. It is intended to stand alone and describe a single hydrogeologic aspect of the study area, although many of the area's hydrogeologic features are interrelated. For an integrated view of the hydrogeology of the Lower Yellowstone River Area the reader is referred to Part A (descriptive overview) and Part B (maps) of the Montana Ground-Water Assessment Atlas No. 1.

Geographic information system production by Joel Hall and Larry Smith. Digital cartography by Don Mason.