MBMG
Montana Bureau of Mines and Geology
Ground Water Assessment Program

Information Pamphlet 8

WATER LEVELS IN THE UPPER WEST BENCH ALLUVIAL AQUIFER, RED LODGE, MONTANA

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View of Remington Ranch, a development on the Upper West Bench, from the south, looking north.

Ground Water Assessment Program: Carbon–Stillwater Study Area

The community of Red Lodge, Montana, 63 miles south of Billings, is a gateway into the Beartooth Wilderness and Yellowstone National Park. Residential development around Red Lodge that relies on wells and individual septic systems has raised concern about the impact to groundwater quantity and quality. As part of the Carbon–Stillwater Ground Water Characterization Program, the Montana Bureau of Mines and Geology (MBMG) measured groundwater levels and water-quality parameters in 25 wells to assess groundwater conditions of the Upper West Bench alluvial aquifer, between October 2004 and November 2005.

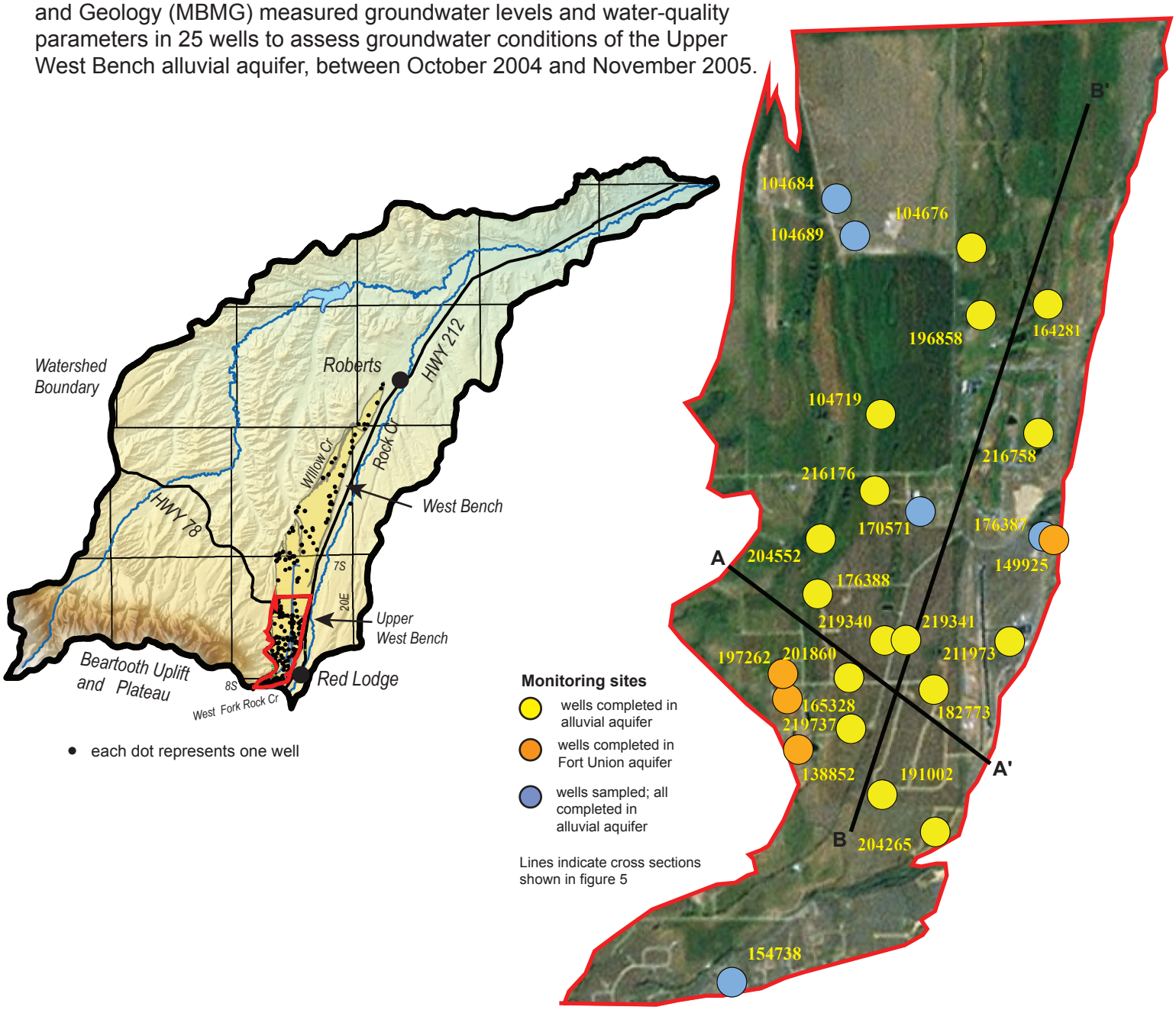

Figure 1. The West Bench is an alluvial terrace that stretches from Red Lodge to Roberts (Lopez, 2001, mapped this surface as Qat2). The Upper West Bench study area (air photo) is the part of the bench adjacent to Red Lodge; most of the groundwater development, as indicated by the number of wells, has occurred in this area. The West Bench is surrounded and underlain by the Tertiary Fort Union Formation. For this study, data were collected from 25 wells.

The Study Area

The West Bench is a prominent terrace that flanks Rock Creek near the town of Red Lodge, Montana and extends northward from the West Fork of Rock Creek about 15 miles to Roberts (fig. 1). It consists of glacio-fluvial sand and gravel up to 150 feet thick. The bench deposits overlie south-dipping beds of the Tongue River member of the Fort Union Formation (this relationship is best illustrated by outcrops on the exposed cut of the east bench, fig. 2). The edge of the bench is defined by the Willow Creek drainage to the west and Rock Creek to the east. The "upper" part of the West Bench covers about 5 square miles south of State Highway 78, just west of Red Lodge, where development density is the greatest (Township 7 S., Range 20 E., sections 15,16, 21, 22, 27, 28, and 34, and Township 8 S., Range 20 E., the northern half of sections 3 and 4). The West Bench is as much as 150 feet above the current Rock Creek floodplain. Residential development on the upper part of the bench has raised concern about impacts to groundwater quantity and quality. The number of wells on the Upper West Bench has more than tripled between 1995 and 2005 (from 61 to 191). According to records from the MBMG's Ground Water Information Center (GWIC), the number of wells on the Upper West Bench as of 2013 is approximately 320, or roughly 60 wells per square mile (fig. 3). Seventy percent of these are domestic wells, most with an associated individual septic system.

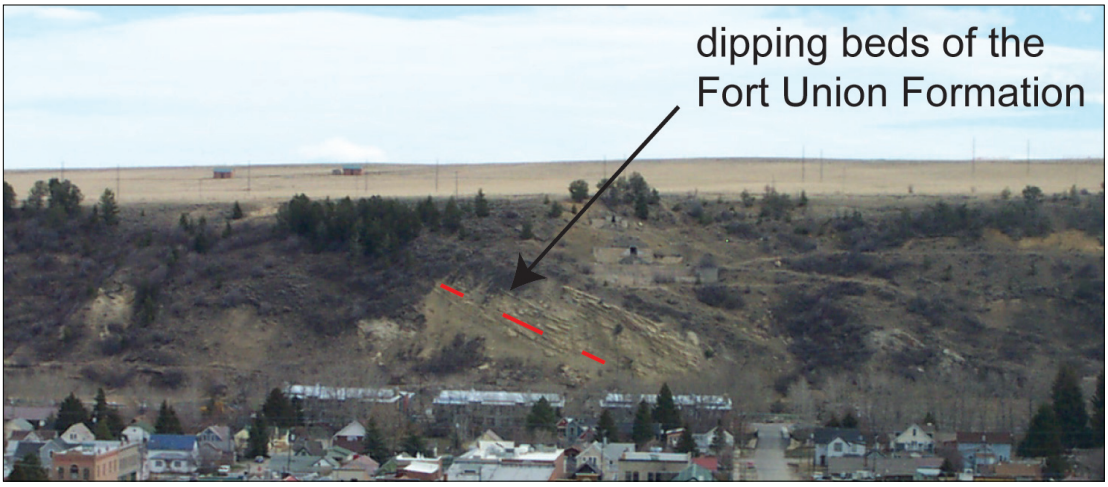

Figure 2. Looking east from the Upper West Bench, south-dipping beds of the Fort Union Formation are overlain by alluvium forming the gently sloping East Bench surface. Dashed line identifies southern dip and dip angle of Fort Union.

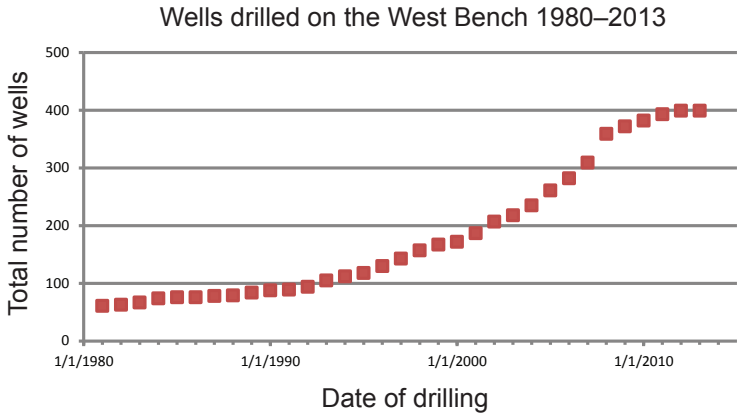

Figure 3. Groundwater development rate, as indicated by the number of wells drilled, increased around 2001. Most of the wells are located on the upper part of the West Bench.

Climate and Geology

The climate is semi-arid, and the landscape is open grassland with the exception of aspen-grove stringers that line drainages. Average annual precipitation for 1971–2000 was 23.77 inches (NOAA, 2000). Almost half the annual precipitation falls within the months of April, May, and June (NOAA, 2000). Elevations in the Upper West Bench study area range from about 6,000 feet at its southern end to about 5,520 feet near Highway 78 (fig. 4).

Lopez (2001, 2005) and Ritter (1967) mapped five separate terraces in the Rock Creek drainage near Red Lodge. The West Bench is one of the younger terraces in the area and mantles south-dipping beds of the Fort Union Formation (fig. 4). The Upper West Bench deposits cover the Tongue River and Linley Conglomerate members of the Fort Union Formation.

The Upper West Bench alluvial aquifer is unconfined and recharged by infiltration from precipitation, irrigation, and canal seepage. Groundwater is discharged by pumpage, spring discharge along the terrace edges (fig. 5), and stream baseflow. The aquifer is productive; reported well yields range up to 500 gallons per minute (gpm), with a median yield of 35 gpm.

Data

To understand the seasonal dynamics of groundwater recharge and storage, water levels were measured monthly in 25 wells between October 2004 and November 2005 across the Upper West Bench; 21 of those wells were completed in the Upper West Bench alluvial aquifer. Groundwater temperature, pH, and specific conductivity were measured in 18 wells; 5 wells were sampled for major cations, anions, trace metals, and nitrate.

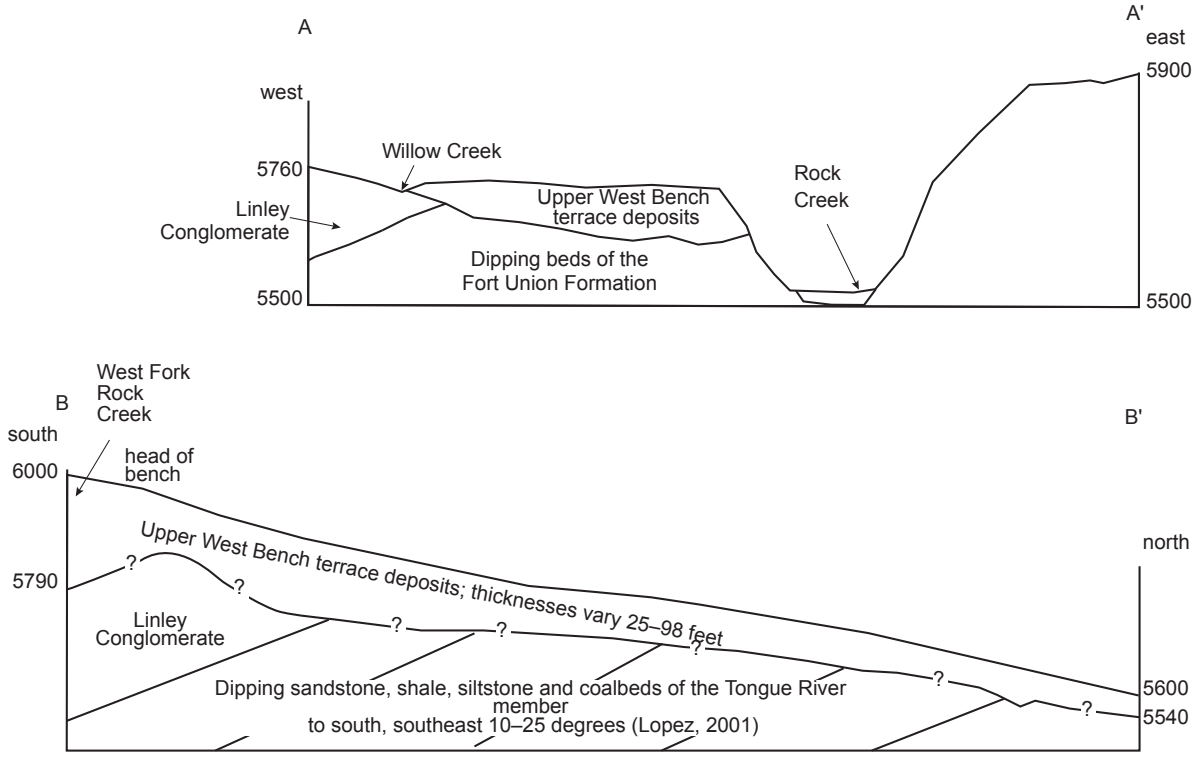

Figure 4. Schematic cross sections depict relationship between terrace gravels and underlying Tongue River and Linley Conglomerate members of the Fort Union Formation. These terrace gravels have been mapped by Lopez (2001) as Qat2. See figure 2 for lines of cross sections.

Figure 5. The contact between the underlying Fort Union and the capping alluvial deposits is marked by springs and associated vegetation.

Water Levels

The volume of water in storage varies with changes in groundwater level. Seasonal water-level fluctuations range from 5 to 30 ft (residual contours in fig. 6). Across the upper bench there are distinct seasonal water-level patterns that highlight the different sources of groundwater recharge. Irrigation-influenced wells (fig. 7a) typically have small seasonal fluctuation and an elevated water level from April through September.

Towards the upper end of the bench, where the alluvial aquifer is its thickest, peak water levels are of short duration and coincide with peak run-off discharge (fig. 7b). Water levels decline quickly after the peak run-off passes.

In addition to these two patterns, some wells show a peak water level associated with irrigation, and though the water level does not stay elevated, it does dissipate slowly throughout the summer. These profiles are referred to in the hydrographs as “leaky irrigation” (fig. 7c).

Even though annual fluctuations can be dynamic, no long-term declining water-level trends were observed during the 9-year record for well 170571 (fig. 8).

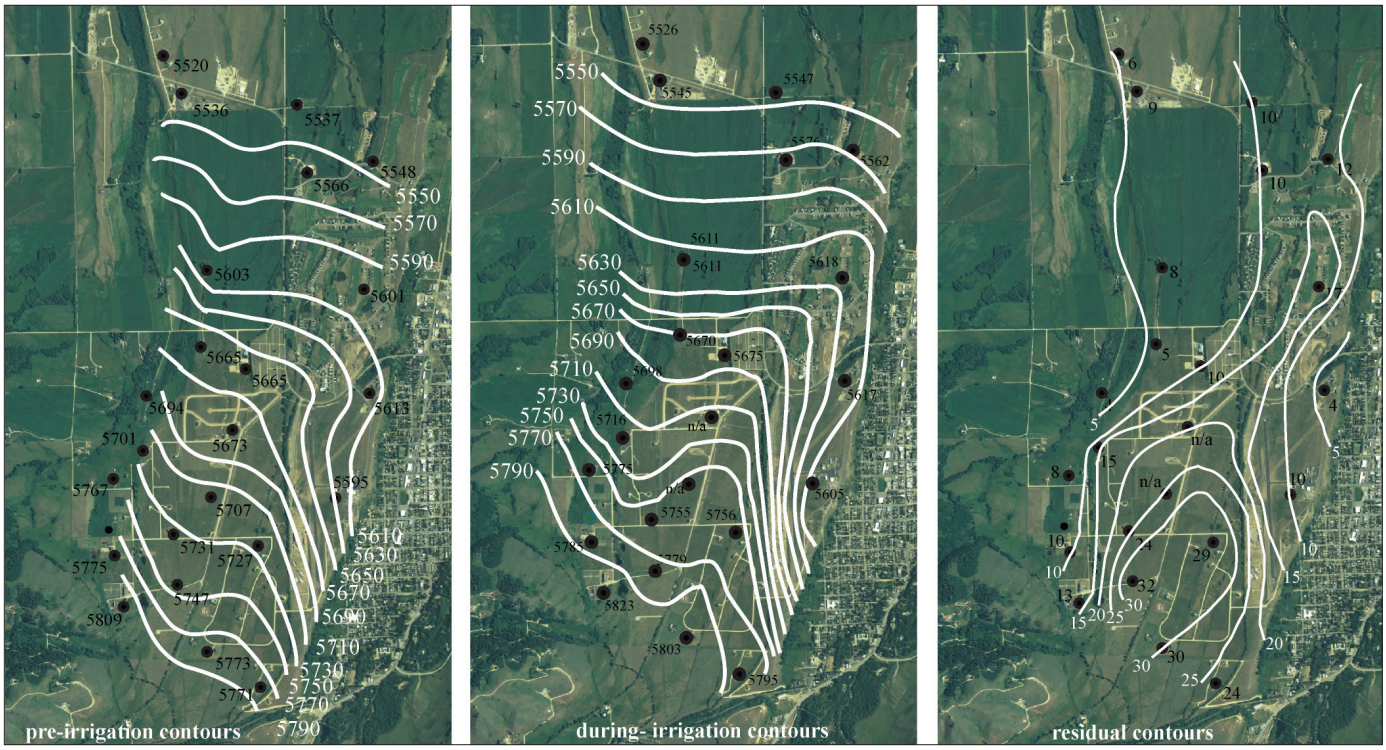

Figure 6. Based on March and July water-level measurements, the northward groundwater flow shows little change in direction between pre-irrigation and irrigation conditions. Seasonal water-level changes show that the glacio-fluvial deposits receive recharge at the head of the bench during high flows from the West Fork of Rock Creek (just south of the map extent), and from irrigation canals throughout the upper bench. Residual contours (July’s altitude minus March’s altitude) illustrate the “mounding” of recharge that occurs near the head of the bench.

a

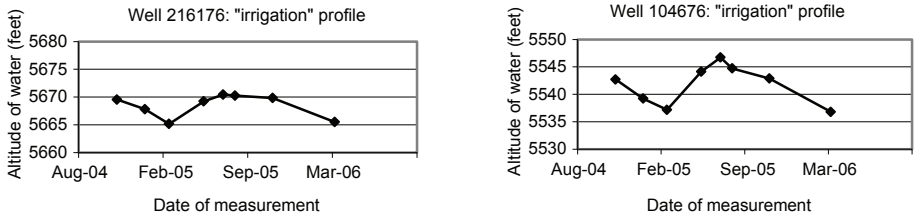

Figure 7a. Wells with this profile have water levels that rise and stay suspended through summer.

b

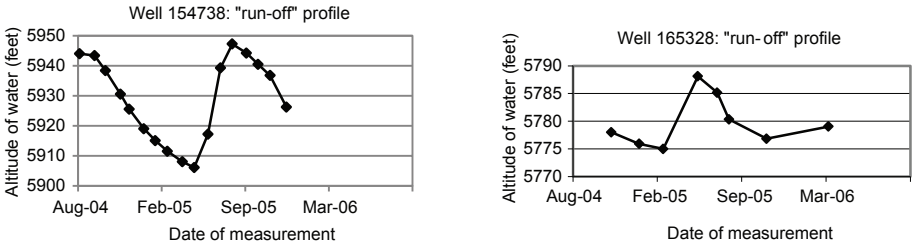

Figure 7b. Wells with this profile have water levels that rise to a point with the snow melt discharge.

c

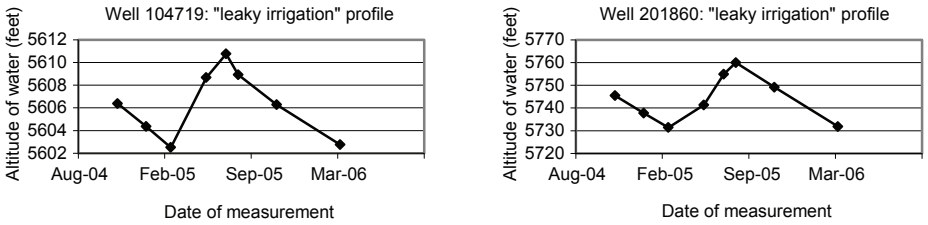

Figure 7c. Wells with this profile have water levels that rise to a point but fall slowly, suggesting some irrigation input.

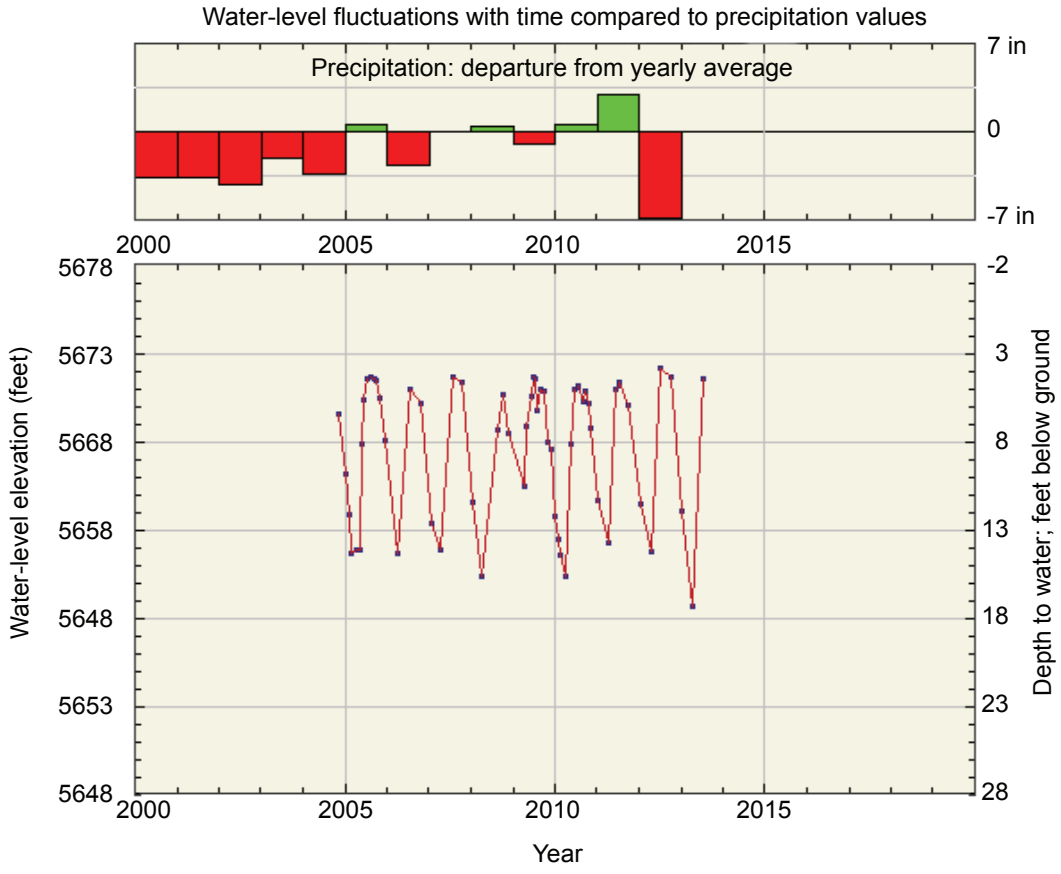

Figure 8. Hydrograph for state-wide monitoring network well GWIC ID 170571 shows no decline over time.

Water Quality

Water quality in the West Bench alluvial aquifer is very good, with low total dissolved solids (TDS). Field conductivity measurements from 22 wells ranged between 70 and 480 μmhos (estimated TDS 40–288 mg/L). Water-quality samples from five wells (GWIC IDs 104689, 170571, 176387, 154738, and 104684) ranged from 52 to 144 mg/L TDS, with an average of 81 mg/L. The water is a calcium-bicarbonate type, with minor amounts of sulfate (fig. 9). Nitrate concentrations were low; results from the five sampled wells were less than 1.0 mg/L or not-detected. Field tests from 15 additional wells detected nitrate at concentrations less than 1.0 mg/L in 4 wells and non-detect in the other 11.

Well 104689 (sampled in 2002) had an elevated chloride level. A resample in March 2007 had a chloride concentration similar to other samples collected in the area (fig. 9).

Only one of the five samples (176387) was analyzed for tritium and contained 11.3 ± TUs. This value is consistent with water that has been recharged within the past 5 years (LaFave, 2002), and supports local recharge for the glacio-fluvial deposits.

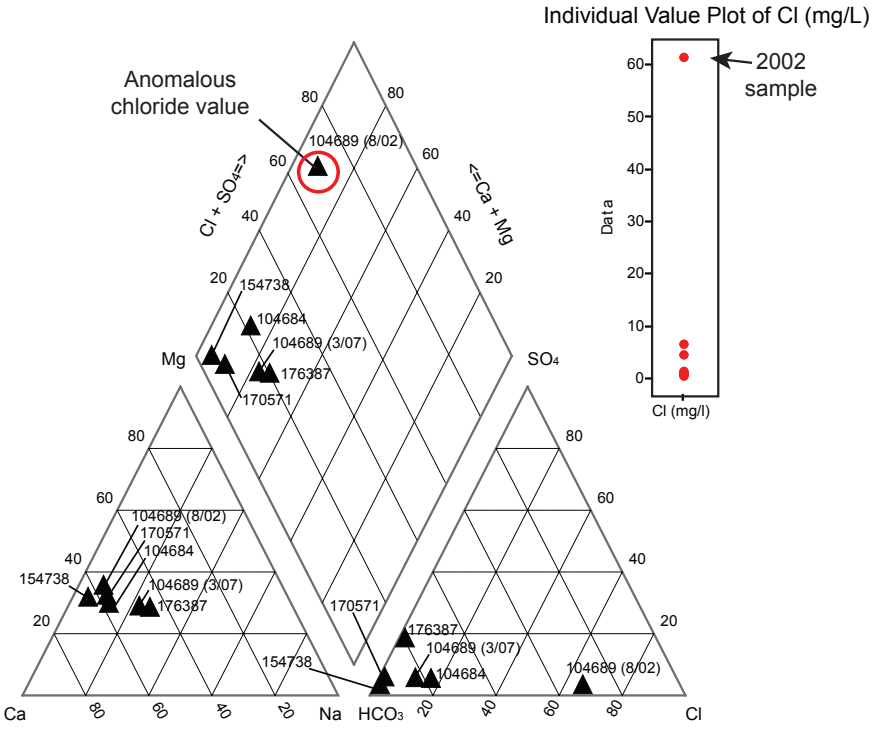

Figure 9. The alluvial aquifer has very good water quality, low in dissolved solids. Well 104689 was sampled twice because of a high chloride value in the first sample. Second sample results were back in the normal range (see inset plot of individual chloride concentrations).

Summary

At the time of sampling, water quality in the alluvial aquifer is very good, despite the dense development on the Upper West Bench. TDS and nitrate concentrations are low. The aquifer is dependent upon canal leakage for a large part of its recharge (also a finding of Waren, 2000). While there were no signs of aquifer-wide depletion, the Ground Water Assessment Program retained well 170571 as a state-wide monitoring network well. Based on data from this well, there are no indications of long-term water-level decline (fig. 9).

References

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Photo, by Camela Carstarphen, captures late winter light illuminating an outcrop of the Sliderock Mountain Formation just outside of Nye, Montana. A typical landscape for the Carbon-Stillwater study area: arid grassland, aspen stringers, and great geologic exposures.