Groundwater Levels at the South End of the Red Lodge Bench Near Red Lodge, Montana

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Introduction

The Montana Department of Natural Resources and Conservation (DNRC) conducted a limited-scope investigation during 1999 of groundwater conditions at the south end of the Red Lodge Bench. The Red Lodge Bench, also known as the West Bench, is one of a series of gravelly terraces or benches associated with Rock Creek and other streams emanating from the Beartooth Mountains. This bench parallels the Rock Creek valley on its west side. Our investigation focused on the uppermost portion of the bench, from the mountain front to about five miles north of Red Lodge. The purpose of this study is to briefly summarize available information on the Red Lodge Bench aquifer, and to measure and document seasonal groundwater levels in the terrace gravel.

The area of interest has historically been an irrigated, rural setting. In recent years, the area has been subject to subdivision, and land use on portions of the bench near Red Lodge has become increasingly residential and commercial. Many, if not all, of the new houses and businesses located on the bench rely on groundwater for their water supply. Most wells on the bench draw groundwater from the gravelly terrace deposits.

Numerous irrigation ditches traverse the upper part of the Red Lodge Bench servicing irrigated areas further north. Leakage from these canals and excess irrigation water are believed to be principal sources of recharge to the terrace gravel aquifer. As the land use shifts from irrigated agricultural use to residential and commercial use, groundwater conditions in the shallow, gravelly terrace deposits may change.

Groundwater-level data collected from the study can be used in the future to help determine whether changes in land use or in the operation of the canals impact groundwater levels in the terrace gravel. If so, steps could be taken in an effort to maintain the artificial recharge provided by canals to the terrace gravel aquifer. The well inventory data and water level measurements collected as part of this project will be permanently stored at the Ground Water Information Center (GWIC) maintained by the Montana Bureau of Mines and Geology (MBMG) in Butte.

Acknowledgements

This work was conducted at the request Keith Kerbel, Regional Manager of the Billings Water Resources Regional Office. Marty Van Cleave, also with the Billings office, assisted with groundwater level measurements in the area. Special thanks to area residents for their interest in the project and permission to access wells.

Geologic setting

The bedrock below the Beartooth Mountain front consists of layered sedimentary rocks. The Fort Union Formation underlies the Red Lodge vicinity. This formation is made up of layers of shale, clay, sandstone, and coal.

During the glacial ages, glaciers formed in the Beartooth Mountains, carving and eroding them. During several major warming periods, the glaciers melted, and huge quantities of water, boulders, gravel and sand were discharged. Streams carrying these sediments flowed out of the canyons onto the eroded landscape. As the streams slowed on the flatter terrain, the heavy sediments were deposited, forming thick accumulations of boulders, gravel, and sand near the main stream channels. Over time, several terrace levels or benches developed alongside area streams.

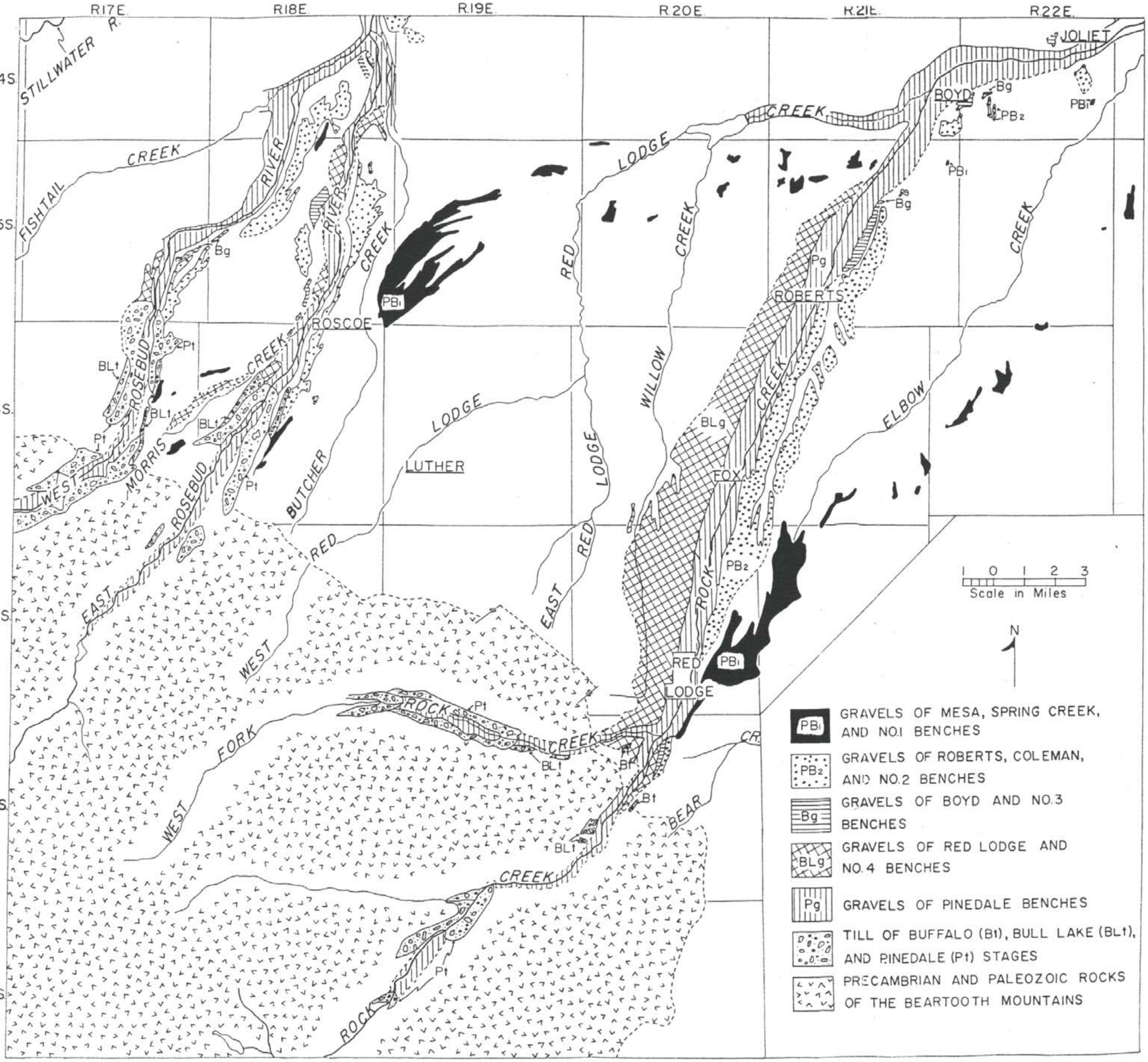
Dale F. Ritter (1967) studied and mapped the terraces, or benches, in this area in detail. Figure 1 is a map showing the distribution of the terraces. The terrace remnants furthest from the present day streams, shown in black, are the oldest and generally the highest terraces. The benches are arranged from oldest to youngest in the legend. The youngest terraces (Pinedale Bench) along Rock Creek form the valley floor.

Figure 2 is a shaded-relief map at about the same scale as the map in Figure 1. The shaded-relief map was generated from digital elevation data from the US Geological Survey. On this map, older, rugged bedrock topography is apparent in the vicinity of Luther and in the southeastern part of the map. The oldest terraces appear as isolated plateaus. The younger terrace gravel forms a tongue of smoother topography on both sides of Rock Creek that extends outward from the mountains. This is also apparent on Figure 3, a print of an aerial photograph near Red Lodge.

Groundwater conditions

The Groundwater Inventory - Carbon County Montana, assembled by the Montana Water Resources Board in 1969 provides some basic information about the geology and groundwater of the area. This report includes information on all area aquifers, including descriptions, groundwater quality data, maps, and photographs. In the description of the terrace gravel, this report points out that while the upper surfaces of the benches are relatively flat, sloping in a downstream direction, the buried bedrock topography undoubtedly has abrupt variations in relief due to erosion prior to gravel deposition. In other words, the thick gravel buries a landscape similar to that formed on bedrock to the west of the terraces as shown in Figures 2 and 3. Consequently, the depth to bedrock from the surface of the bench is variable.

The study area, shown in both Figures 2 and 4, includes the part of Red Lodge Bench within Township 7 South, Range 20 East (T07S R20E). Groundwater beneath this portion of the Red Lodge Bench has been developed largely in the past 30 years. There are about 70 well records within the study area available from the Montana Bureau of



DISTRIBUTION OF GLACIAL AND TERRACE DEPOSITS OF THE MAIN STREAMS HEADING IN THE EAST FLANK OF THE BEARTOOTH MOUNTAINS, SOUTHERN MONTANA

Deposits of the tributary streams are not shown (*see* Fig. 1 for location).

Figure 1. Map of terrace deposits from Ritter, 1967.

Figure 2: Shaded relief map of the vicinity of Red Lodge showing terrace gravels and the study area. Generated from 1:250,000 scale DEM data from the US Geological Survey.

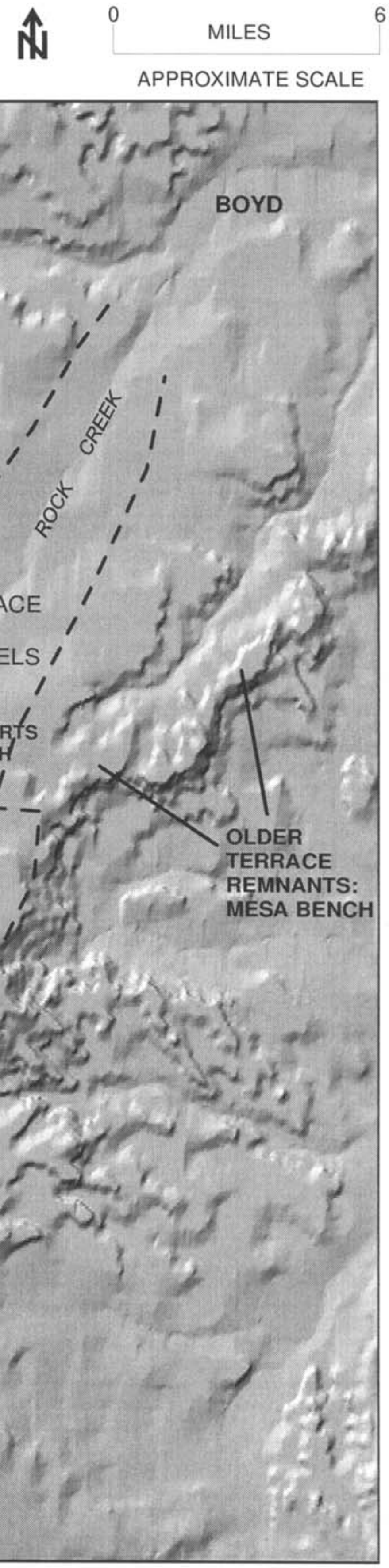


Figure 3. Aerial photograph of the Red Lodge area.

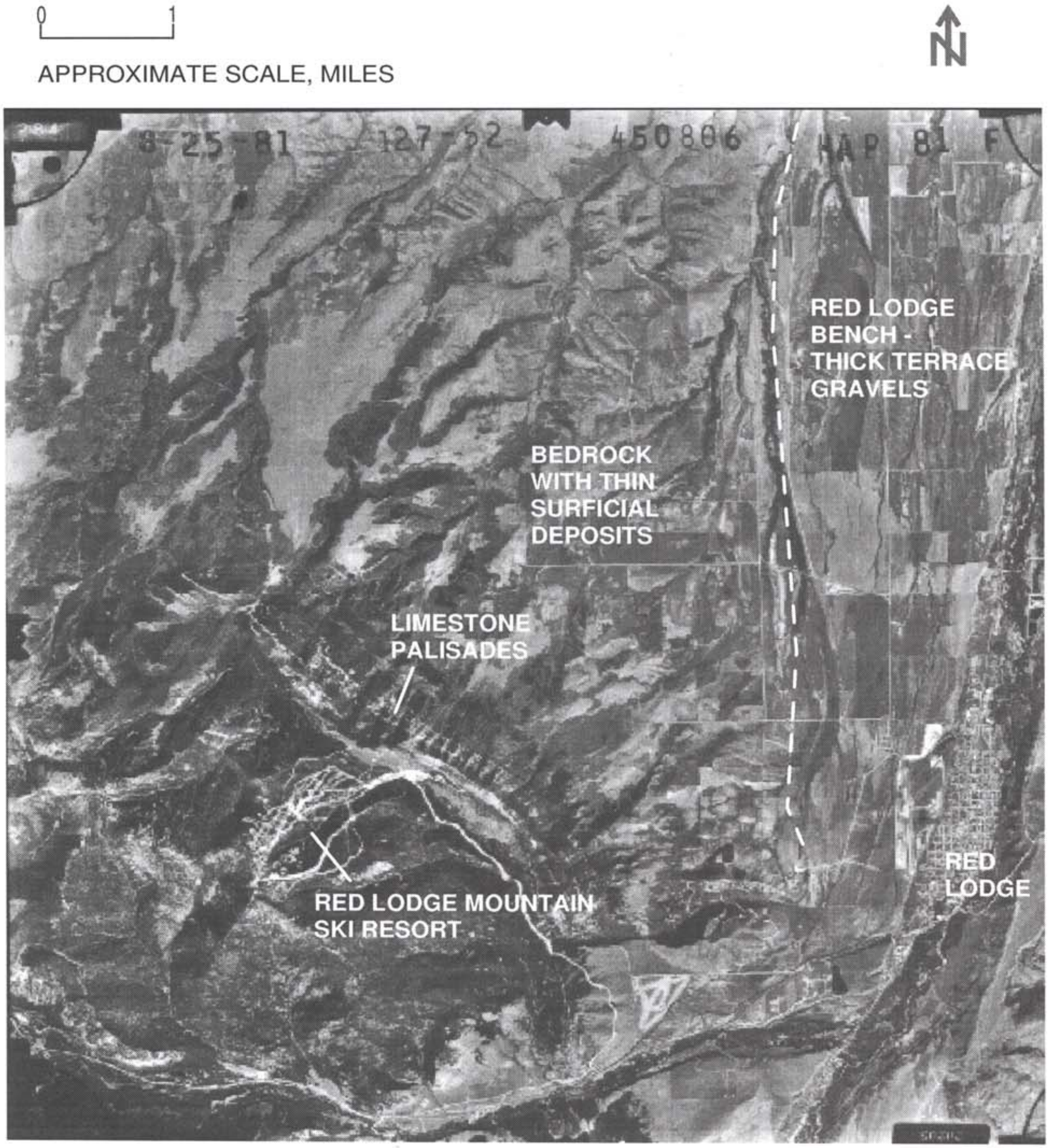
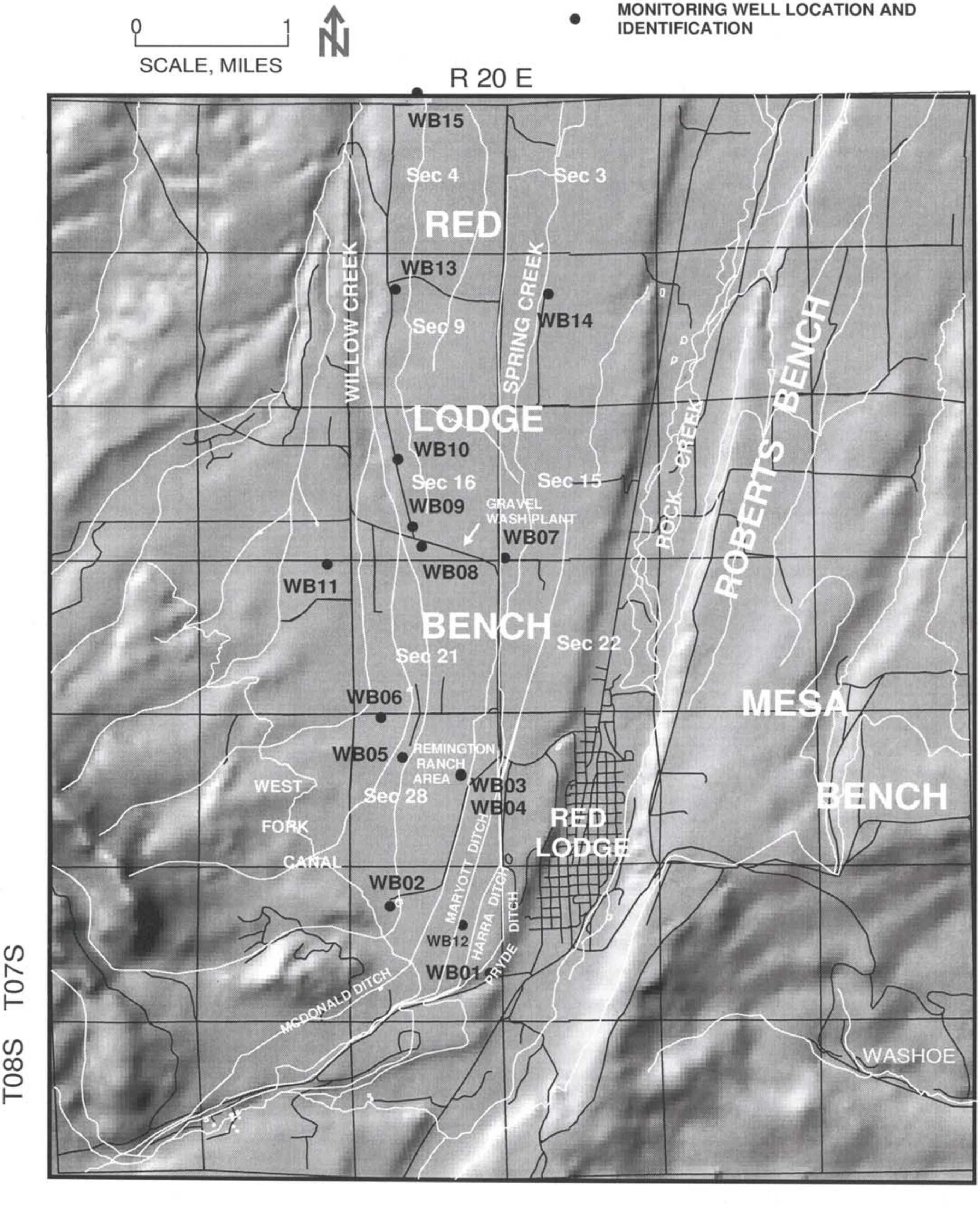


Figure 4. Map of the study area near Red Lodge. Water features are shown in white.



Mines and Geology (MBMG), where well reports are stored. Of these 70 records, only three predate 1970. Most of these wells tap the terrace gravel aquifer, and most were not drilled to the bottom of the aquifer. Some wells did encounter bedrock, commonly shale, sandstone, and coal. As expected, the depth to bedrock on the bench is variable, ranging from 15 to over 100 feet. Based on the records, wells on the Red Lodge bench average about 50 feet deep, and depths to groundwater reported are largely in the range of 10 to 30 feet. Four wells yield over 300 gallons per minute (gpm). The average well yield of all other wells on the bench is 37 gpm.

In contrast, some 120 well records are available for the area west of the terrace gravels in the same township. These wells, many of which tap bedrock aquifers, have an average depth of 146 feet, and the average reported well yield is 14 gpm.

Pumping tests have been conducted at several sites in 07S, R20E, on the terrace gravel aquifer. These include one conducted by Harrison (1987) at a Red Lodge Country Club Estates well, (NE ¼, SW ¼, Section 22), and two tests conducted by McKee Engineering, one at a set of test wells on the Remington Ranch (SW ¼, NE ¼ Section 28), and one at the Beartooth Redi-Mix gravel wash plant (SW ¼, SE ¼, Section 16) (Smith, 1997). The results of these tests indicate the transmissivity of the terrace gravel aquifer is in the range of about 77,000 to 94,000 gallons per day per foot (gpd/ft). The wells were tested with pumping rates in the range of 300 to 400 gpm. In general, the aquifer is able to sustain pumping rates of this magnitude readily without any adverse effects to nearby wells.

Groundwater level monitoring network

To gain further information about the aquifer, a set of wells was selected in which to measure groundwater levels periodically over the course of a year. Most of these were existing domestic and stock wells. Two were test wells for the Remington Ranch subdivision. A field inventory was conducted at each selected well. Well records, if available, were matched with the wells. Measuring points were established at each well, typically either the top of casing or an access port, and their relation to land surface was measured and recorded. Approximate elevations for the wells were obtained from topographic maps. The locations of these wells are shown in Figure 4. Table 1 provides some general information for these wells.

Groundwater levels were measured in the selected wells from December 1998 through December 1999 about once a month. A water level and temperature-recording device was installed in one of the Remington Ranch test wells (well WB04). The device is a submersible pressure transducer and data logger that recorded pressure and temperature every 6 hours.

Results

Groundwater level measurements are summarized in Table 2. Figure 5 shows the configuration of the groundwater surface in the terrace gravel in February and July, 1999.

Table 1. Water wells monitored during the study

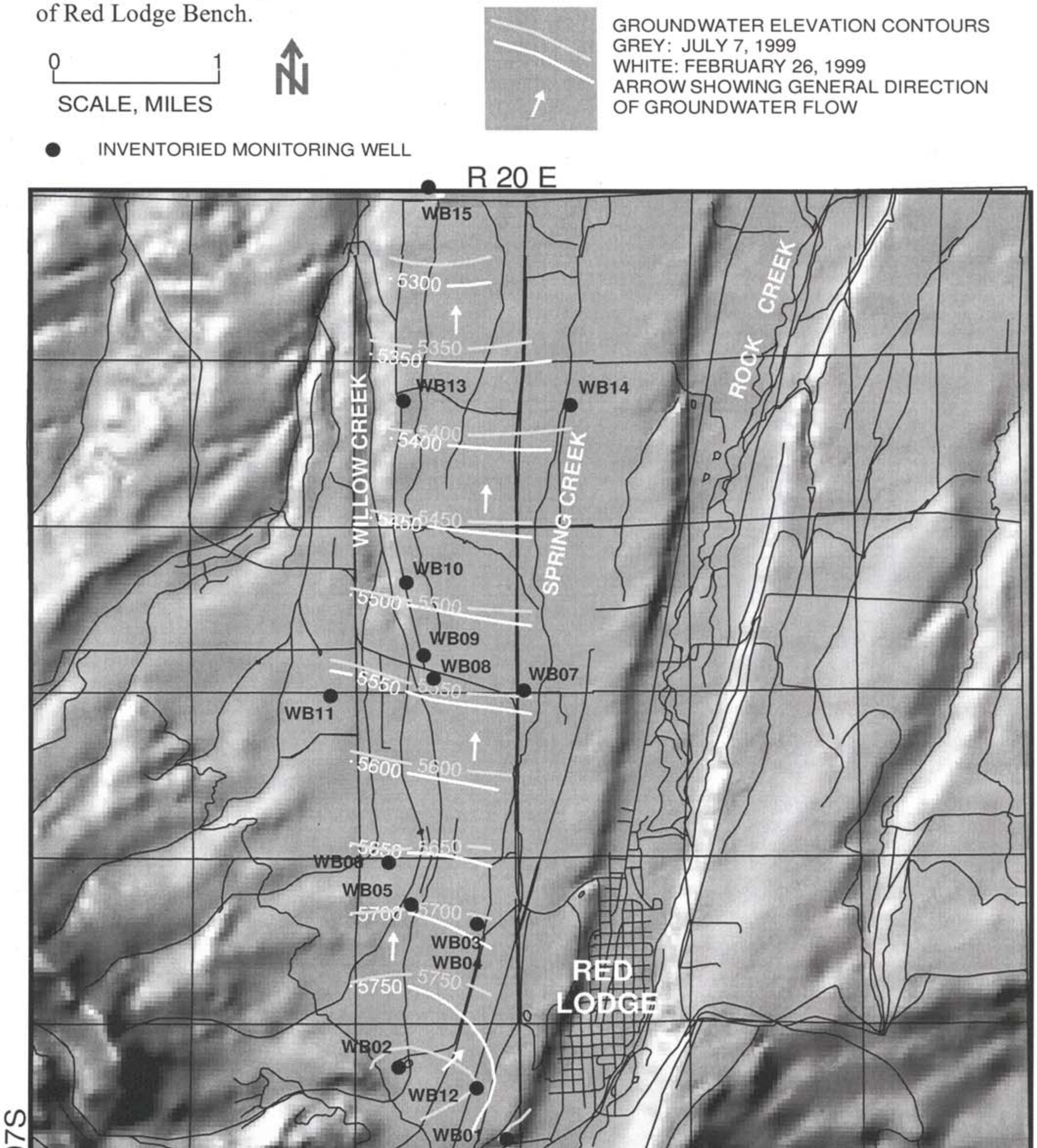
WELL ID	LOCATION	NAME	DEPTH (FT)	MAP ELEV (FT)	MBMG #
WBO1	07S20E33DADB	DANIELS	98	5805	M:153455
WB02	07S20E33BCAA	FARLEY	50	5830	M:138852
WB03	07S20E28ACDA 1	PALMER	67	5710	M:157949
WB04	07S20E28ACDA 2	PALMER	41	5710	
WB05	07S20E28BDBD	BECK	35	5700	
WB06	07S20E28BBAA	FOX	120	5670	M:138849
WB07	07S20E15CCCC	PRATHER	59	5550	M:104676
WB08	07S20E16CDDA	NORWEST	?	5555	
WB09	07S20E16CDAB	MURPHY	?	5550	
WB10	07S20E16BDCD	ROYAL	64	5510	M:104683
WB11	07S20E20AABA	KANE	?	5580	
WB12	07S20E33ACDA	LEGNINI	?	5820	
WB13	07S20E09BACC	DRAPER	130	5405	M:131617
WB14	07S20E10BDBB	LANTTA	?	5395	M:147446
WB15	06S20E33CDDB	SEIFFERT	?	5260	

Table 2. Groundwater level measurements for the Red Lodge Bench area

WELL:	WB01	WB02	WB03	WB04	WB05	WB06	WB07	WB08
MP HEIGHT:	1.0	1.8	2.1	2.0	1.5	2.1	0.3	2.2
DATE	DEPTH TO WATER FROM MEASURING POINT (FEET)							
06/04/98								
11/05/98			7.49	8.10				
11/06/98	79.23	22.24			3.78	17.20	7.50	18.68
01/06/99		22.38						
01/07/99			16.23	16.88	4.62	17.33	11.52	21.60
02/26/99	88.42	24.53	20.86	21.55	6.37	17.42	13.45	22.59
04/27/99	89.28	21.25	22.27	22.94	5.23	19.32	10.53	20.56
06/02/99	78.40	22.05	15.71	16.36	4.96	13.45	5.62	18.90
07/07/99	65.15	19.33	4.63	5.25	3.53	15.99	4.33	15.90
08/24/99	70.32	23.00	5.08	5.69	3.55	15.78	5.61	15.92
09/16/99	75.17	23.45	6.03	6.56	3.65	16.23	6.00	15.94
10/14/99	79.86	23.46	7.74	8.39	3.69	16.36	6.48	17.51
11/16/99	83.71	24.65	11.39	12.02	3.84	16.84	8.21	19.30
12/17/99	87.96	26.15	15.28	15.93	4.45	17.85	10.44	20.85

WELL:	WB09	WB10	WB11	WB12	WB13	WB14	WB15
MP HEIGHT:	1.70	1.00	1.70	1.00	2.00	2.50	1.50
DATE	DEPTH TO WATER FROM MEASURING POINT (FEET)						
06/04/98	19.15	23.00					
11/05/98							
11/06/98		22.68	12.64				
01/06/99				50.85	29.61		
01/07/99	20.70	23.82	13.88			19.50	23.15
02/26/99	21.60	24.52	14.75	55.84	31.50	21.39	24.12
04/27/99	20.29	24.61	6.02	59.30	31.98	18.93	23.88
06/02/99	22.21	22.63	12.63	55.62	27.91	17.88	23.62
07/07/99	19.42	22.38	5.28	17.40	25.28	9.32	7.32
08/24/99	17.08	24.21	14.34	31.12	24.58	8.16	11.42
09/16/99	17.10	22.75	12.57	35.46	24.15	12.42	13.53
10/14/99	17.75	23.25	14.33	39.63	25.49	13.52	16.79
11/16/99	20.92	23.11	14.79	44.74	27.62	16.65	19.99
12/17/99	21.42	23.22	15.34	49.40	29.18	19.23	22.06

Figure 5. Map of the groundwater surface in the terrace gravels of Red Lodge Bench.



These dates correspond to the lowest and highest seasonal groundwater levels in most of the wells measured during 1999. The groundwater surface slopes in the direction of the terraces, generally to the north and parallel to Rock Creek. Groundwater would be expected to move generally downgradient to the north based on the groundwater surface map, as shown by arrows. However, this mapped surface shows only the most general slope, or configuration, of the water table in the terrace gravel west of Spring Creek. Note that at the uppermost end of the bench, where wells are available close the east edge overlooking the Rock Creek valley, the water table surface slopes dramatically to the east. It likely does so along the entire east edge of the bench, somewhere east of Spring Creek. At many localities along the terrace edge, bushes and small trees grow along the base of, and up the side of the steep terrace edge, probably accessing seasonal groundwater seeps from the terrace gravel (Figure 6).

Figure 7 is a graph of groundwater levels measured in the monitored wells. Wells WB01 and WB12 stand out due to their deeper groundwater levels and large seasonal fluctuations. These two wells are at the upper end of the bench.

Well WB01 is about 30 yards from the edge of the terrace, at a site overlooking the Rock Creek valley, about 100 feet below. The Pryde Ditch, one of the irrigation canals, is nearby, within perhaps a few hundred yards to the northwest. The groundwater level declines throughout the winter, to a depth of nearly 90 feet as groundwater drains out of the terrace, approaching the level of the Rock Creek Valley below. During the irrigation season, the water level rises over 20 feet. This rise is almost certainly a result of water leaking from canals, and any irrigation that may occur nearby.

Well WB12 shows a similar response, although this well is approximately a quarter mile from the edge of the bench. Here, groundwater levels also continue to decline throughout the winter, although approaching a depth of 60 feet rather than 90. This well is sandwiched between two canals, perhaps explaining its anomalous seasonal rise of nearly 40 feet.

The remaining wells all have groundwater levels less than 35 feet deep. Figures 8 and 9 show the data from these wells at an expanded scale. These wells are separated into two categories, those with distinct seasonal trends (Figure 8), and those with relatively minor or less consistent seasonal fluctuations (Figure 9).

The water level data shown in Figure 8 all have a distinct seasonal trend of rising groundwater levels in the late spring, high groundwater levels during the summer, and falling groundwater levels from about October to March. These wells are all located on the Red Lodge Bench. Notice that the declining trend of water levels in most of the wells during winter continues until groundwater levels start rising in the spring.

The water level measurements from wells shown in Figure 9 do not fluctuate much over the seasons, or the fluctuations deviate from the pattern of those shown in Figure 8 (i.e. well WB11). These wells are all either near or west of Willow Creek at the upper end of the bench, where the west edge of the terrace gravel aquifer abuts bedrock to the west and Willow Creek is not in a deeply incised channel.

Figure 6. Photograph of the east edge of the Red Lodge Bench, overlooking the city of Red Lodge. View looking northeast. Note the vegetation growing on the terrace edge.-

Figure 7. Groundwater Depths: All wells monitored

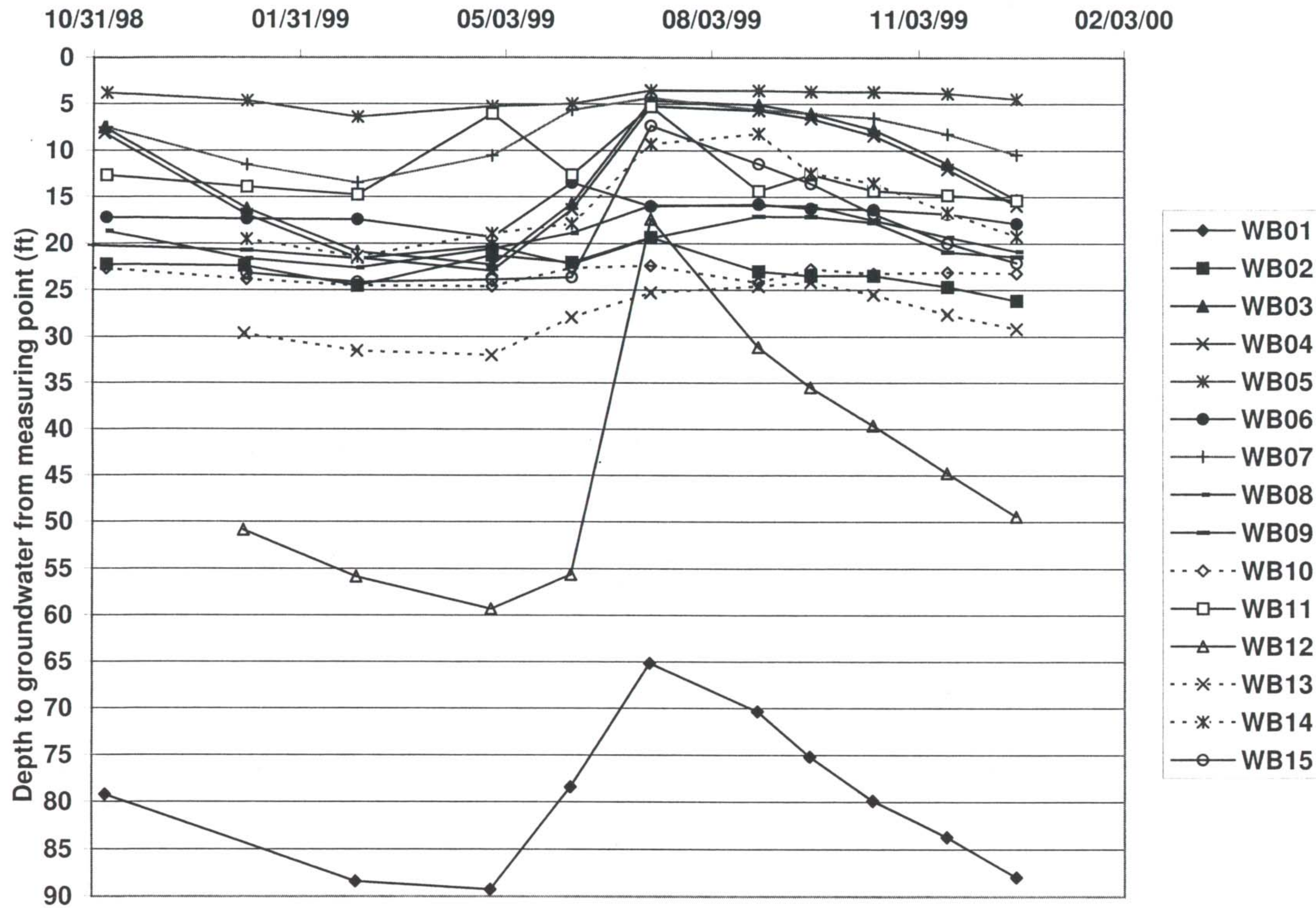


Figure 8. Groundwater levels - selected wells with shallow groundwater levels

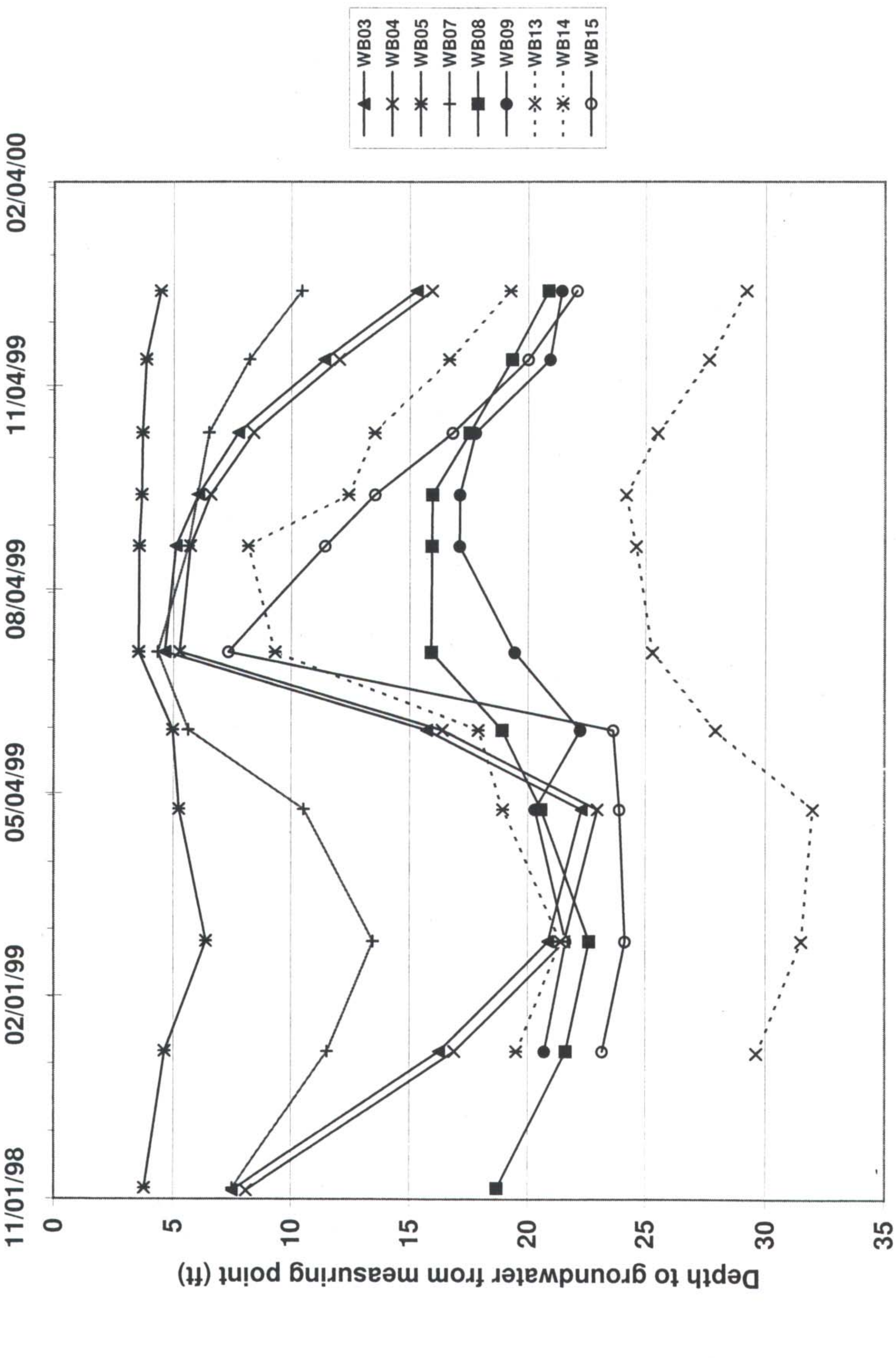


Figure 9. Groundwater levels - wells near or west of Willow Creek

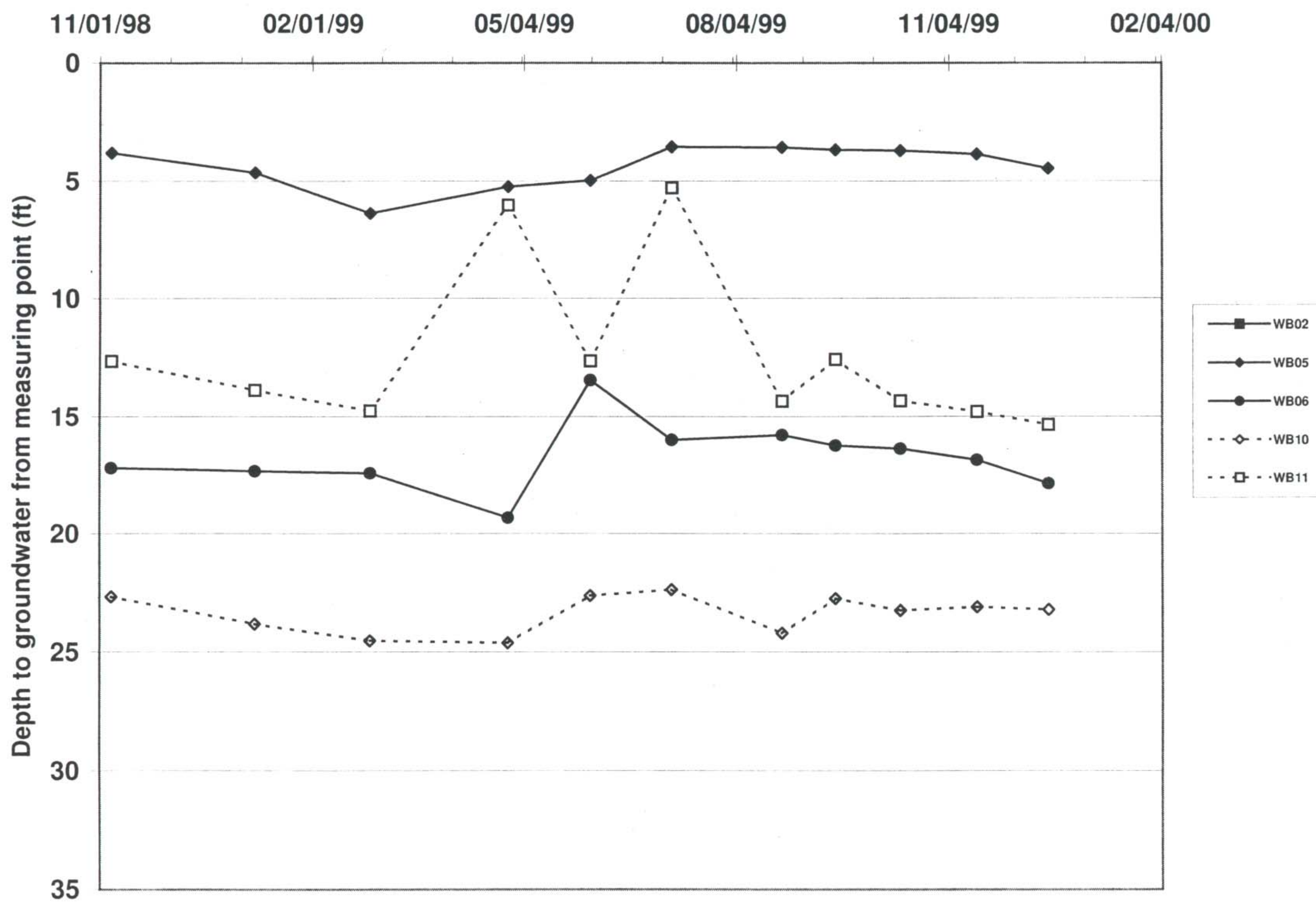


Figure 10 is a map showing the difference between groundwater levels measured in late February and those measured in early July. This provides a general impression of how groundwater levels fluctuate seasonally in different parts of the terrace gravel aquifer. Generally, as demonstrated by the graphs, wells with the smallest seasonal changes are typically close to Willow Creek at the upper end of the bench, while those with the largest fluctuations are closer to the east edge of the bench.

According to Carl Lantta, who owns well WB07, Spring Creek gains water and flows for 11 ½ months most years between the location of well WB07 and WB14. However, he stated that before 1918, it only flowed about 6 months per year. This suggests that presently, groundwater elevations must be slightly higher than Spring Creek most of the year in this reach, and that at one time, groundwater levels dropped seasonally to a level lower than Spring Creek.

Graphs showing the data collected by the recording instrument placed in well WB04 are shown in Figure 11. The upper graph shows groundwater-level data. Note that the measurements made during well visits are indicated as small gray squares. This graph provides a much more detailed record of water levels than available for other wells. It verifies that the monthly measurements provided a reasonable record of seasonal groundwater level changes for this well. Note the substantial rise in groundwater levels beginning around May 1st.

Figure 12 is a cross-sectional view of the terrace gravel aquifer just north of Red Lodge (the location is shown in Figure 10). The land surface profile is drawn from topographic maps. As noted earlier, the water table within the terrace gravel is generally about 10 to 30 feet deep.

Discussion

The terrace gravel aquifer is highly influenced by the presence of canals and irrigation on the bench. This is evident by the timing of groundwater level fluctuations in area wells, and has been long recognized by many area residents as well as hydrologists. The measurements made in 1999 provide a set of seasonal groundwater level records for the upper part of the Red Lodge Bench that can be used as baseline data to assess any changes that may occur as conditions change in the area.

It is uncertain what the natural configuration of the water table in the terrace gravel aquifer would look like without any irrigation activities or canals on the bench. As noted previously, groundwater levels near the southwest edge of the bench near Willow Creek tend to be relatively stable year-round. Groundwater levels near the east edge of the bench, and to the north, where Willow Creek occupies a more deeply incised channel, are subject to larger seasonal fluctuations. The water level in well WB12, located at the extreme southeast corner of the bench, declines in April to near the level of the Rock Creek valley floor. Groundwater levels in most wells located in the central parts of the

Figure 10. Map indicating the difference between February and July groundwater elevations.

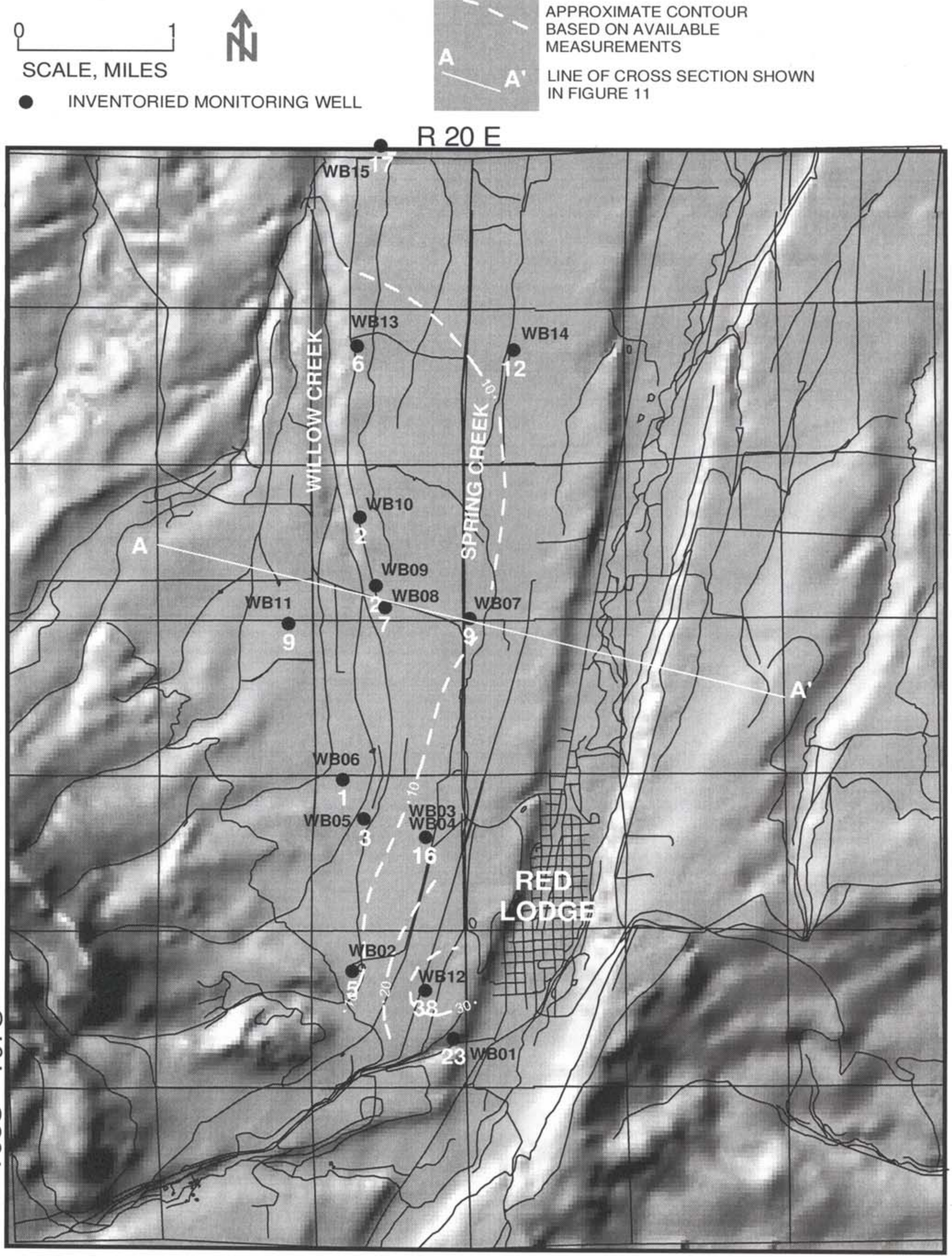
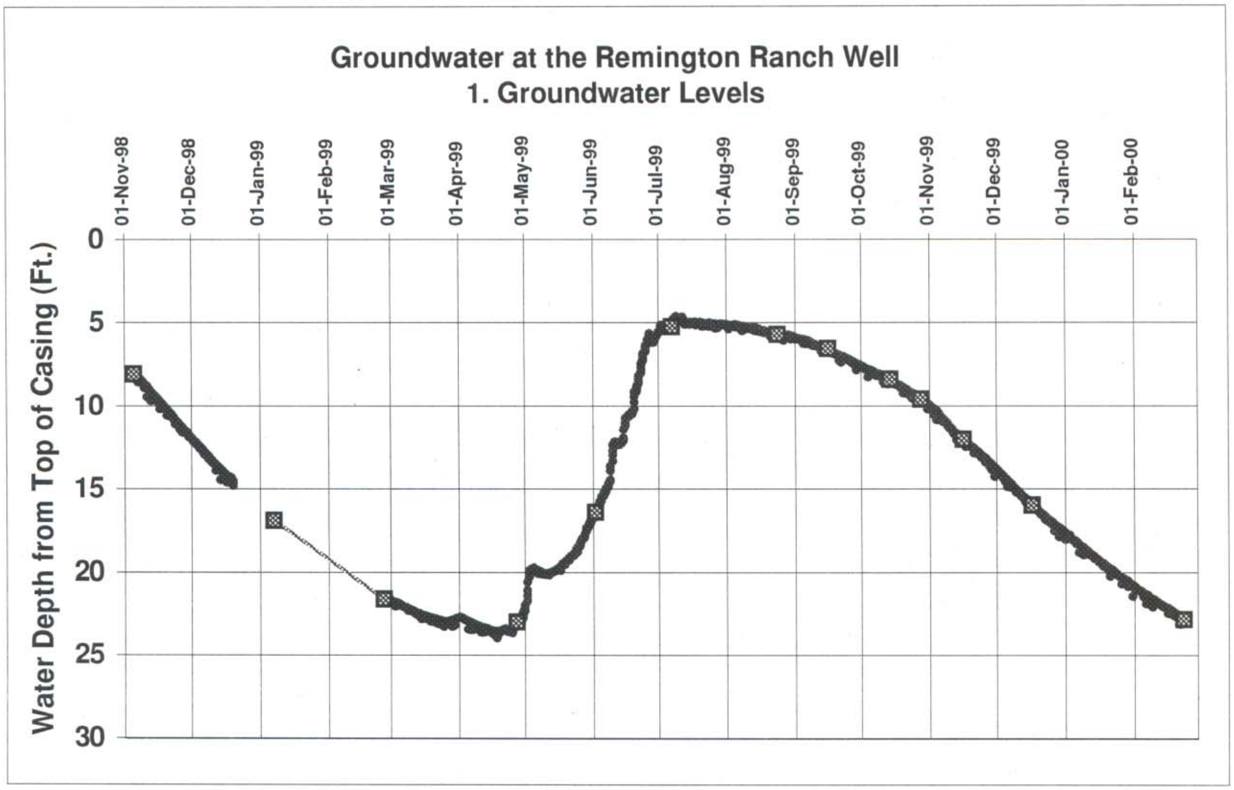
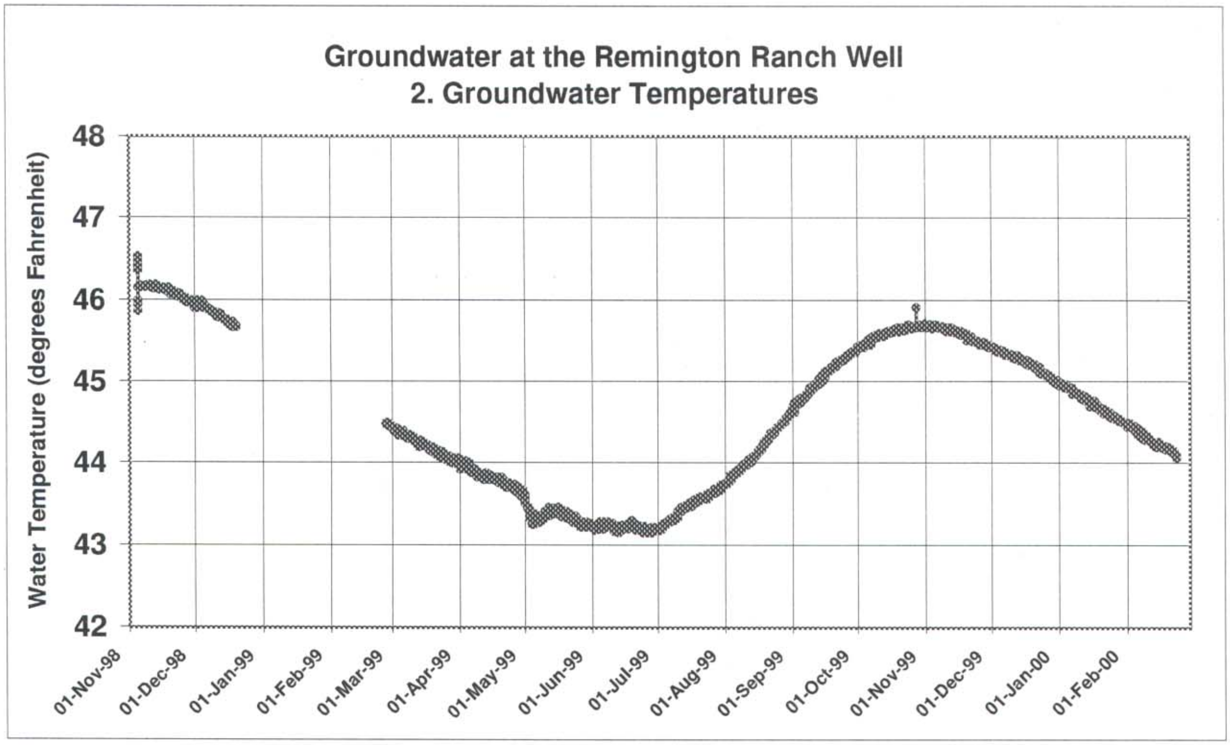


Figure 11. Graphs of water level and temperature data recorded at well WB04.





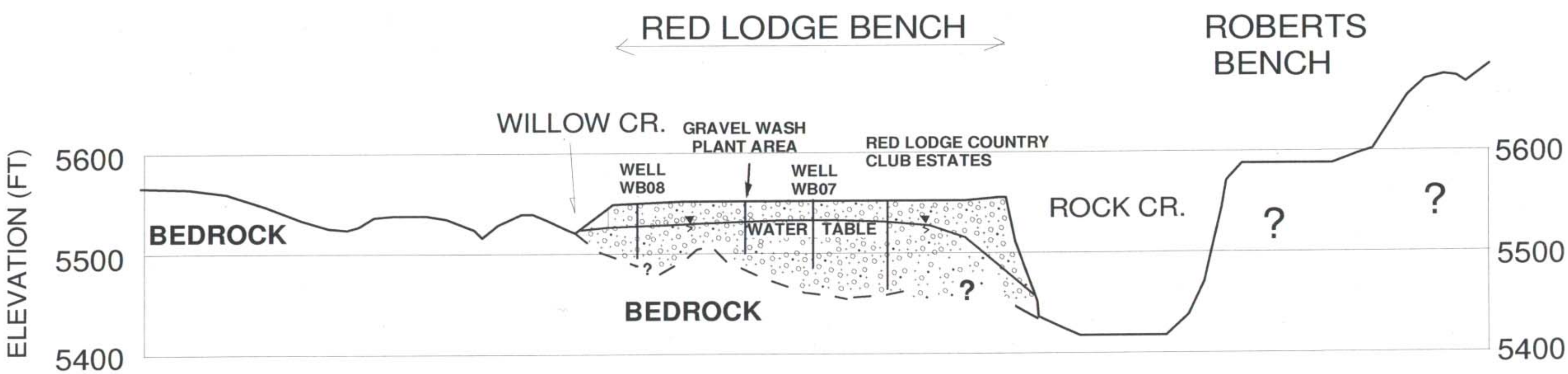


Figure 12. Cross Section across the Red Lodge Bench (Location shown on Figure 10).

bench continue declining each winter and spring until irrigation canals start operating again. Therefore, it seems likely that without any canals or irrigation on the bench, groundwater levels would subside considerably. The level of the Rock Creek valley would be a likely minimum level to which groundwater would fall along the east edge of the bench. Water levels near Willow Creek, where it does not occupy a deeply incised channel, may be less affected. Any springs that issue from the terrace gravel aquifer would be expected to diminish.

Conclusions

Groundwater beneath the high terrace, or bench west of Red Lodge is a readily accessible fresh water supply for the growing number of residents and businesses located on the bench. At this time, this sand and gravel aquifer is in part artificially recharged by the irrigation canals traversing the area, and by irrigation. This aquifer is preferable in some ways to deeper bedrock aquifers. It is shallower and less expensive to reach with wells, it is highly productive, and groundwater may be less mineralized than that in deeper aquifers. If this aquifer can be maintained, more expensive water supply systems – deeper wells or piped water - may never be needed on the bench.

The future of the irrigation canals should be of great interest to anyone using the terrace gravel aquifer and to anyone involved with planning urban expansion. Leakage of water from these canals may be the principal source of water in the terrace aquifer. If canals are ever abandoned because all the lands serviced by them come out of irrigation, it would be wise to tentatively plan to keep the canals, easements, and structures in place, at least temporarily. If the aquifer receives adequate groundwater recharge from other sources, such as other canals or natural recharge, the canal could be abandoned. If not, then the canal could be used to artificially recharge the aquifer either by continuing normal operations and routing the water back to its source, or by developing a more sophisticated artificial recharge system.

In either case, a water right could be established on the amount of water lost from the canal through leakage, which recharges the terrace gravel aquifer. This could be a new water right, or preferably, a part of one of the irrigation rights could be sought to maintain an older priority date. Canal maintenance would have to be taken over by some entity.

References:

Harrison, Brian J., 1987. An Evaluation of the Potential for Adverse Impacts from the Development of Ground Water by the Red Lodge Country Club Carbon County, Montana. Montana Department of Natural Resources and Conservation file: Permit No. P062455-43D.

Montana Water Resources Board, 1969. Groundwater Inventory Carbon County Montana. Montana Water Resources Board publication, 36 pages, 1 plate. January, 1969.

Ritter, Dale F., 1967. Terrace Development along the Front of the Beartooth Mountains, Southern Montana. Geological Society of America Bulletin, v. 78, p. 467-484, April, 1967.

Smith, Matthew S., 1997. Hydrogeological Report for Beartooth Redi-Mix (Draper Ranch), October 1997. Montana Department of Natural Resources and Conservation file: Permit No. P102189-43D.